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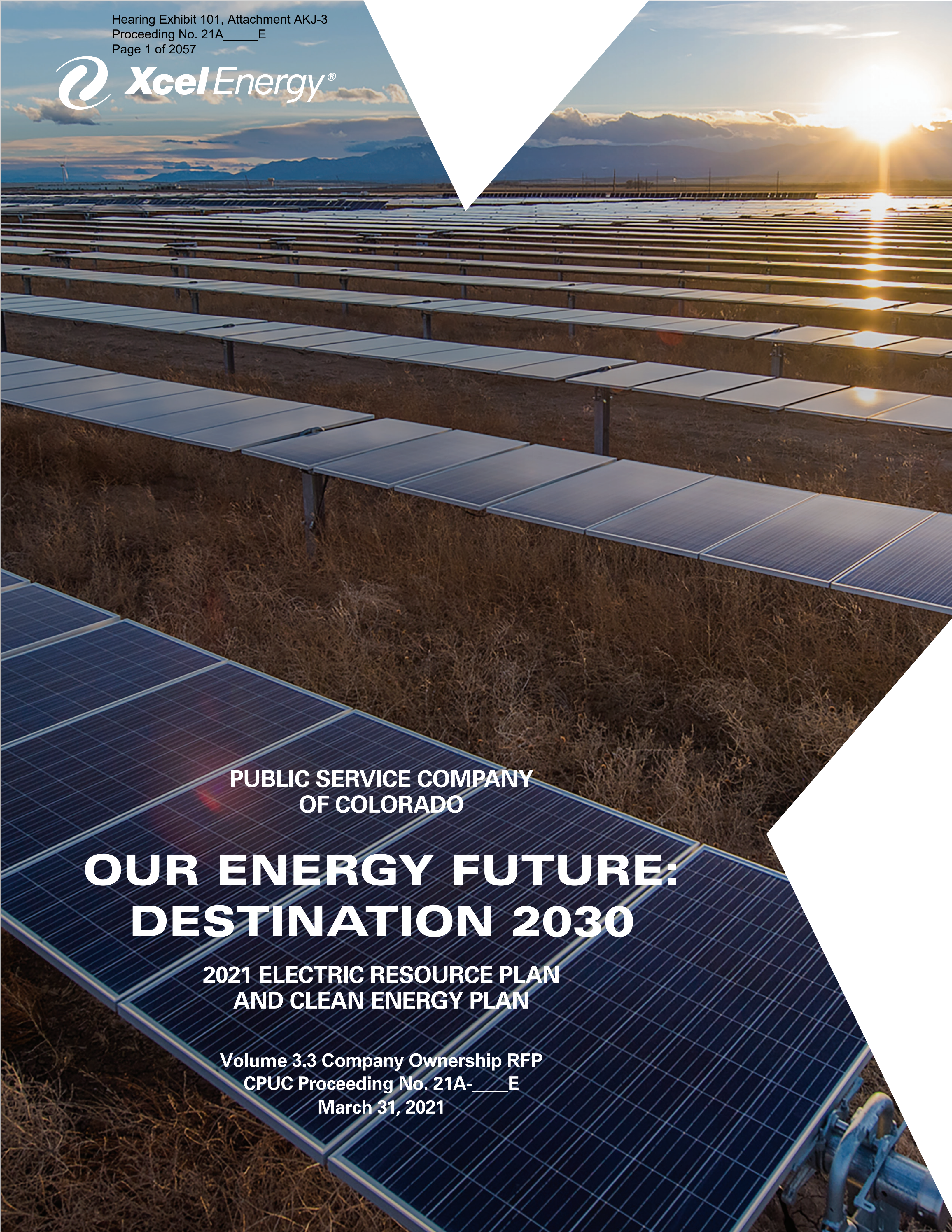

PUBLIC SERVICE COMPANY
OF COLORADO

OUR ENERGY FUTURE: DESTINATION 2030

2021 ELECTRIC RESOURCE PLAN AND CLEAN ENERGY PLAN

Volume 3.3 Company Ownership RFP
CPUC Proceeding No. 21A-____E
March 31, 2021

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TABLE OF CONTENTS

3.3 COMPANY OWNERSHIP RFP

Attachment 3.3-1 Company Ownership RFP Document

Public Service's 2021 ERP Company Ownership RFP.

Attachment 3.3-2 Company Ownership RFP Bid Forms

The Forms that are referenced in Appendix A of the 2021 ERP Company Ownership RFP.

Attachment 3.3-3 Gas Term Sheet

The Term Sheet for the Purchase and Sale of Natural Gas-Fired Energy Generation Project referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-4 Solar Term Sheet

The Term Sheet for the Purchase and Sale of a Solar Photovoltaic Electric Generation Project referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-5 Solar + Storage Term Sheet

The Term Sheet for the Purchase and Sale of a Solar Photovoltaic Electric Generation Project and Battery Energy Storage System referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-6 Stand-Alone Storage Term Sheet

The Term Sheet for the Purchase and Sale of a Battery Energy Storage System System referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-7 Wind Term Sheet

The Term Sheet for the Purchase and Sale of a Wind Electric Generation Project referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-8 Gas Technical Specifications

The Technical Specifications for Combustion Turbine projects referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-9 Solar Technical Specifications

The Technical Specifications for Solar Generation projects referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-10 Stand-Alone Storage Technical Specifications

The Technical Specifications for Battery Energy Storage System projects referenced in Appendix D of the 2021 ERP Company Ownership RFP.

Attachment 3.3-11 Wind Technical Specifications

The Technical Specifications for Wind Generation projects referenced in Appendix D of the 2021 ERP Company Ownership RFP.

PUBLIC SERVICE COMPANY OF COLORADO

2022 All-Source Solicitation

Company Ownership
Request for Proposals

Date Issued To Be Determined ("TBD")

Table of Contents
Public Service Company of Colorado
2022 Company Ownership RFP

Appendices

Appendix A
Proposal Forms and Instructions

Appendix B
General Planning Assumptions

Appendix C
Transmission Costs

Appendix D
Model Asset Purchase Term Sheets and Generators Technical Specifications

Appendix E
All-Source Solicitation Timeline

Appendix F
Commission Confidentiality Order

Index of Appendix A Forms

Form A	Notice of Intent to Respond
Form B	Bid Certification
Form C	Bid Cover Sheet
Form D1A	Pricing and Quantity for BOTs or Sale of Existing Asset
Form D1B	FOM, VOM, Maintenance, Ongoing Capital Expenses
Form D2	Electrical Interconnection Cost Estimates
Form E	Construction Milestones
Form F1	Capacity for Thermal Resources
Form F2	Facility Performance
Form F3	Heat Rates
Form F4	Heat Rate Degradation
Form F5	Technical Description | Solar Photovoltaic
Form F6	Technical Description | Battery Energy Storage I
Form F7	Technical Description | Battery Energy Storage II
Form F8	Technical Description | Wind
Form F9	Technical Description | Other Tech
Form F10	Energy Production Profile - Annual and Monthly
Form F11	Section 123 Qualifications
Form G	Natural Gas and Backup Fuel Supply
Form H	Emission Rates
Form I	Interconnection Information Forms

Notice of Disclaimer

The information contained in this Request for Proposals ("RFP") for energy and capacity resources has been prepared solely to assist bidders in deciding whether or not to submit a proposal. Public Service Company of Colorado ("Public Service" or "Company") does not represent this information to be comprehensive or to contain all of the information that a respondent may need to consider in order to submit a proposal. None of the Company, its affiliates, or their respective employees, directors, officers, customers, agents and consultants makes, or will be deemed to have made, any current or future representation, promise or warranty, express or implied, as to the accuracy, reliability or completeness of the information contained herein, or in any document or information made available to a respondent, whether or not the aforementioned parties knew or should have known of any errors or omissions, or were responsible for their inclusion in, or omission from, this RFP.

The Company reserves the right to modify, supplement or withdraw this RFP at any time, whether due to changes in law or otherwise, and including by issuing one or more addenda to this RFP during this solicitation, which addenda shall become a part of this RFP. No part of this RFP and no part of any subsequent correspondence by the Company, its affiliates, or their respective employees, directors, officers, customers, agents or consultants shall be taken as providing legal, financial or other advice or as establishing a contract or contractual obligation. Contractual obligations on the part of the Company will arise only if and when definitive agreements have been approved and executed by the appropriate parties having the authority to approve and enter into such agreements. The Company reserves the right to request from a respondent (a.k.a., bidder) information that is not explicitly detailed in this document, obtain clarification from bidders concerning proposals, conduct contract development discussions with selected respondents, conduct discussions with members of the evaluation team and other support resources as described in this RFP and in compliance with all FERC Code of Conduct rules and provide data to and conduct discussions with the Independent Evaluator ("IE") as necessary for the IE to satisfy the IE's role as defined by the Colorado Public Utilities Commission ("CPUC" or "Commission") under rules 3612 and 3613 and Decision No. C17-0316.

The Company will, in its sole discretion and without limitation, evaluate proposals and proceed in the manner the Company deems appropriate, which may include deviation from the Company's expected evaluation process, the waiver of any requirements and the request for additional information. The Company reserves the right to reject any, all or portions of any proposal received for failure to meet any criteria set forth in this RFP or otherwise and to accept proposals other than the lowest cost proposal. The Company also may decline to enter into any agreement with any bidder, terminate negotiations with any bidder or abandon the RFP process in its entirety at any time, for any reason and without notice thereof. Respondents that submit proposals agree to do so without legal recourse against the Company, its affiliates, or their respective employees, directors, officers, customers, agents or consultants for rejection of their proposals or for failure to execute an agreement for any reason. The Company and its affiliates shall not be liable to any respondent or other party in law or equity for any reason whatsoever for any acts or omissions arising out of or in connection with this RFP. Except as otherwise provided in the rules and orders of the Public Utilities Commission of the state of Colorado, by submitting its proposal, each respondent waives any right to challenge any valuation by the Company of its proposal. By submitting its proposal, each respondent waives any right to challenge any determination of the Company to select or reject its proposal. Each respondent, in submitting its proposal, irrevocably agrees and acknowledges that it is making its proposal subject to and in agreement with the terms of this RFP.

Each respondent shall be liable for all of its costs incurred to prepare, submit, respond or negotiate its proposal and any resulting agreement and for any other activity related thereto, and the Company shall not be responsible for any of the respondent's costs.

Public Service Company of Colorado
2022 Company Ownership RFP

Section 1. Introduction

Public Service Company of Colorado ("Public Service" or the "Company"), an operating company subsidiary of Xcel Energy Inc., is issuing this Request for Proposals ("RFP") as a component of Public Service's 2021 Electric Resource Plan. This RFP is one of three RFPs to be issued. These three requests for proposals are:

- 2022 Company Ownership RFP (this RFP)
- 2022 Dispatchable Resources RFP
- 2022 Renewable Resources RFP

Segmenting the Solicitation into these categories is driven by the contracting requirements for different generation technologies. As a result, each RFP contains a model contract(s) or term sheet(s) that has/have been tailored to address certain issues associated with each technology or ownership structure.

Examples of the types of projects which would be applicable to each RFP are shown in Table 1 below. This non-comprehensive list is intended to provide guidance as respondents develop their proposals; more detailed information may be found in the specific RFP documents. Respondents who are uncertain as to which RFP would apply to their project should contact the RFP Project Manager (Section 1.4) for clarification.

Table 1. Example Resource Types for the Various RFPs

RFP Document	Resource Types	Commercial Structure
2022 Company Ownership RFP	• New or existing simple cycle gas turbines • New or existing solar, wind or stand-alone storage system • New or existing solar with storage	• Build-Own Transfer (BOT) • Existing Resource Sale • Company Self-Build
2022 Dispatchable Resources RFP	• Combined cycle gas turbines • Simple cycle gas turbines • Stand-alone storage	• PPA
2022 Renewable Resources RFP	• Biomass • Geothermal • Hydroelectric • Recycled Energy • Solar • Solar/wind with storage • Wind	• PPA

1.1 Regulatory Context

The CPUC's Resource Planning Rules ("RP Rules") establish a process that jurisdictional electric utilities must follow to determine the need for additional electric resources and to procure needed resources. Public Service filed its 2021 Electric Resource Plan ("ERP") on March 31st, 2021 in accordance with the RP Rules ("Phase I"). In its 2021 ERP, Public Service identified a need for future generation resources and presented the Commission with multiple portfolios of generic resources that could be used to meet that need. As part of its 2021 ERP, the Company proposed to solicit proposals through a competitive solicitation ("Phase II"). The CPUC heard arguments by multiple parties concerning Public Service's resource need and acquisition plans. The CPUC approved the issuance of this Solicitation as part of Public Service's 2021 ERP in Decision No. **TBD**.

The RP Rules 3612 and 3613 require that an Independent Evaluator ("IE") conduct a review of Public Service's evaluation of proposals received in response to the Solicitation. The Company will work cooperatively with the IE and shall provide the IE immediate and continuing access to all documents and data reviewed, used, or produced by the utility in this Solicitation and evaluation.

Additionally, the RP Rules require that Public Service: 1) make a communication to bidders concerning bid disclosure and bid model representation dispute resolution; 2) provide the Commission's order or orders specifying the form of nondisclosure agreement; and 3) require of bidders that they provide bidder contact and employment metric information.

Commission Required Communications

Bid Information Disclosure
Public Service notifies bidders that, upon completion of the competitive acquisition process begun with this RFP,[1] Public Service will post on its website the following information from all bids and utility proposals: bidder name; bid price and utility cost; generation technology type; size of project; contract duration or expected useful life of facility for utility proposals; and whether the proposed purchased power agreement includes an option for the utility to purchase the bid facility during or at the end of the contract term.

In addition Public Service notifies bidders that, pursuant to RP Rule 3614(b), a reasonable number of attorneys and a reasonable number of subject matter experts representing a party to the Company's 2021 ERP docket can, upon the execution of the appropriate non-disclosure agreement, request access to all Phase II information regarded by the Company as highly-confidential. The Company has claimed that bid information of any sort should be treated as highly-confidential, thus any bid information provided to the Company is subject to release to such individuals regardless of a bidder's claim of confidentiality.

Model Representation and Dispute Resolution
Public Service will, within 45 days of bid receipt, provide notice in writing by electronic mail to the bidder whether its bid is advanced to computer-based modeling to evaluate the cost or the ranking of the bid resource, and, if not advanced, the reasons why Public Service will not further evaluate

[1] Completion of the resource acquisition process is defined as the execution of all PPAs and/or completion of asset purchase negotiations and certificate of public convenience and necessity approvals, if any, for the solicited resources.

the bid using computer-based modeling.[2] With its notice Public Service will also provide bidders the modeling inputs and assumptions that reasonably relate to their bid resource or to the transmission of electricity from their proposed facility to Public Service; these inputs and assumptions may include, among other things, costs related to transmission interconnection, gas supply, and resource integration. Public Service will request that the bidder execute a highly confidential nondisclosure agreement prior to receiving the information. The form of the agreement is included as Appendix F.

For those bids advanced to computer-based modeling, within seven calendar days after receiving the modeling inputs and assumptions the bidder will notify Public Service in writing by electronic mail the specific details of any potential dispute regarding its bid's modeling inputs and assumptions. The bidder must attempt to resolve any dispute with Public Service. If the bidder and Public Service cannot resolve the dispute within three calendar days, Public Service will immediately notify the Commission with a filing in the 2021 ERP docket. If the bidder is not already a party to the 2021 ERP, the bidder will file a notice of intervention as of right pursuant to paragraph 1401(b) of the Commission's Rules of Practice and Procedure, within one business day of Public Service filing the notice of dispute to the Commission, for the limited purpose of resolving the disputed modeling inputs and assumptions.

An Administrative Law Judge ("ALJ") will expeditiously schedule a technical conference at which Public Service and the bidder shall present their dispute for resolution. The ALJ will enter an interim order determining whether corrections to the bid's modeling inputs and assumptions are necessary. If the ALJ determines that corrections to the bid's modeling inputs and assumptions are necessary, Public Service will, within three business days of the issuance of the ALJ's interim decision, provide the corrected information to both the bidder and the Independent Evaluator. In its 120-Day Bid Evaluation Report, Public Service will confirm, by performing additional modeling as necessary, that the bid resource is fairly and accurately represented.

Required Bidder Information
Public Service requires that each bidder in its Form C provide the contact name of the owner or developer designated to receive notice of whether the bid is advanced to computer-based modeling.

Public Service requires that bidders provide employment metric information for the bid to be eligible for this RFP. See the requirements for the Employment Metrics Narrative Topic.

1.2 Resource Needs Assessment

This RFP is part of a Solicitation process whose purpose is to acquire sufficient resources to meet the Company's forecasted electric demand (plus reserves) over the resource acquisition period ("RAP") of 2021 through 2030. Table 2 illustrates the general timing of resource need.[3] The Company will update Table 2 prior to issuance of this RFP.

[2] See exceptions discussed in Section 5.1, Step 4.
[3] The Company will review bids for resources that propose to be operational before the Company shows a capacity need in Table 2.

Table 2. Resource Capacity Need by Year (Cumulative)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity Need with announced retirements long/(short)	**102**	**296**	**210**	**61**	**17**	**(203)**	**(672)**	**1,452)**	**1,684)**	**(1,747)**

In any year, the Company may acquire more or fewer resources than is shown in Table 2 and the final level of resource need by year may change from that shown due to changed circumstances. While Table 2 shows an estimated capacity need for years beginning 2026, the Company will review bids for resources that become commercially operational prior to this period.

1.3 Resources Sought through this RFP

Through this Company Ownership RFP, the Company seeks proposals for the sale of new or existing generation assets. The Company is primarily interested in natural gas-fired, photovoltaic solar, storage, and wind generation assets. As such, indicative term sheets for these asset types are included as part of this RFP. The Company will, however, review all bids for any generation type other than coal-fired generation submitted as part of this RFP. All resources for new generation assets offered through this RFP must achieve commercial operation no later than May 1st, 2030; all existing asset sales must be completed by May 1st, 2030 also.

The amount of generation that the Company may acquire from this RFP depends, among other things, on the quality of bids received in response to the Solicitation, on economic comparison to other RFP responses and Company Ownership proposals, on updates to the Company's forecasts, on regional transmission availability, and on changes to regulatory or legal requirements.

Potential respondents should be aware that the Company intends to submit its own Company-ownership proposals in the 2022 All-Source Solicitation.

1.4 RFP Project Manager and RFP Website

The primary point of contact for all communications between the Company and potential bidders is the RFP Project Manager. This individual may be contacted at **TBD**.

All communications between potential bidders and the Company must be conducted through this email account. See Section 4.7 for more information.

The Public Service 2022 Solicitation website can be found at **TBD**.

1.5 Section 123 Resources

Colorado Revised Statutes ("C.R.S.") 40-2-123(1)(a) states as follows:

> "The commission shall give the fullest possible consideration to the cost-effective implementation of new clean energy and energy-efficient technologies in its

> consideration of generation acquisitions for electric utilities, bearing in mind the beneficial contributions such technologies make to Colorado's energy security, economic prosperity, insulation from fuel price increases, and environmental protection . . . ."

These "new clean energy and energy-efficient technologies" are referred to as "Section 123 resources."

The Commission clarified in Decision No. C13-0094 ("Decision") that a Section 123 resource must be both *new* and *clean* pursuant to the statute. In its Decision the Commission further defined the terms "new" and "clean":

> A new project shall either: (1) incorporate one or more technologies, representing a substantial portion of its overall installed cost, that have not been regularly commercially demonstrated,[4] up to the point in time that the resource is formally bid, or if not bid, acquired; or (2) be a project used to demonstrate the feasibility of a technology not before implemented in its proposed configuration.
>
> A clean project must demonstrate that it would likely cause a decrease in greenhouse gas emissions (e.g., carbon dioxide) or significantly reduce other pollutants. A clean project may also result in reduced water usage.

Respondents to this RFP who believe their proposal meets the definition of a Section 123 resource should indicate in the Beneficial Contributions/Section 123 Resources Bid Narrative Topic why the respondent believes the resource qualifies as a Section 123 resource. Public Service will identify in its 30-Day Report to the Commission a listing of all bids that claim Section 123 status along with its opposition to any claimed Section 123 status and provide the Commission, under seal, a copy of the disputed bids. The Commission will determine whether the disputed bids qualify for further evaluation as a Section 123 resource.

Section 2. Eligible Project Information

2.1 Eligible Project Structures

Company Ownership RFP proposals will be for the purchase of a currently existing asset, Company self-build assets, or the purchase of a newly-constructed facility through a build-own-transfer transaction. The Company will also consider acquiring wind and/or solar sites for Company self-build proposals to be submitted into this RFP. Respondents interested in selling wind and/or solar sites are encouraged to submit inquires to the RFP Project Manager via email (see section 1.4) as soon as possible to initiate discussions with the Company's Corporate Development group re: key terms and conditions and allow as much time as possible for due diligence, assessment of any potential sites, and negotiation of a purchase and sale agreement prior to the bid submission deadline.

[4] The Commission's Decision indicated its review of a Section 123 resource would consider the commercial demonstration both within the State of Colorado and elsewhere.

2.2 Eligible Generation Resources

For a project to be eligible under this RFP, it must: 1) have a nameplate electric rating greater than 2 MW, 2) meet all or a portion of the Company's resource needs during the RAP, 3) be located in the State of Colorado, and 3) interconnect to the Company's transmission system. The Company will not accept Company Ownership proposals from coal-fired generation.

A proposal may be for a new, yet to-be-built resource, or an existing resource.

2.3 Pricing

Forms D1A and D1B provide the pricing template for asset purchase proposals. All pricing should be consistent and compliant with the applicable PSCo Technical Specification (gas CTs, solar, storage, and wind projects) and Model Term Sheet (all projects). To the degree the respondent desires to propose exceptions to either the applicable Technical Specification or Model Term Sheet, respondents are to address such as described below in Section 4.3 Proposal Content Requirements. Pricing must be in terms of current year dollars, also referred to as escalated or nominal dollars. For example, a $5,000,000 asset purchase price for 2023 means that in 2023 the facility will be purchased for $5,000,000.

Proposal pricing must include initial cost estimates for any new or upgraded interconnection facilities required for the electrical interconnection of the proposed project to the Public Service transmission system, and must include the cost of any dedicated radial transmission line(s) from the generation facility to the proposed point of interconnection. See Form D2.

The Company will pay any costs required to upgrade or reinforce the Public Service electric transmission system beyond the Point of Delivery, as a consequence of adding a respondent's project to the Public Service system. All pricing in respondents' proposals should reflect those costs (to the extent applicable) at the time of submittal.

2.4 Regulatory Approvals

At the completion of the evaluation process, pursuant to RP Rule 3613(d), the Company will file a report with the Commission at the completion of the evaluation process that describes the cost-effective resource plans that conform to the Commission's Phase I decision and other Commission decisions that impact the Phase II process. Upon Commission approval of Phase II of the Company's 2021 ERP, Company actions consistent with that approval are presumed prudent under RP Rule 3617(d).

Execution of any purchase agreement will ultimately be subject to Commission approval. This could include but is not limited to approval of a certificate of public convenience and necessity (CPCN) application from the Company. The Company reserves the right to: 1) inform the Commission that the Company could not reach agreement with the proponent of a selected resource; 2) request Commission approval of any agreements it enters into with successful respondents (e.g., CPCN applications); and 3) to terminate any agreement if the Company fails to receive Commission approval of submitted agreements or applications.

2.5 Hydrogen Capability Option

The Company encourages any proposal offering the sale of new CT facilities or new reciprocating engine facilities (i.e., bids proposing to construct a CT or construct reciprocating engines) to provide an option for the resource to be capable of burning, at a minimum, 30 percent hydrogen (by volume), while meeting emission permit requirements. Any hydrogen option should be accompanied by a separate set of bid forms where appropriate as well as any unique bidder-proposed terms and conditions associated with the hydrogen option. If the base generation equipment is capable of burning hydrogen at a 30% volume minimum while meeting emission permits with no incremental requirements, that should be clearly noted in the proposal and no additional option is needed.

Section 3. Delivery and Interconnection Information

3.1 General information

Bids that propose to interconnect to the Company's transmission system and that do not have an existing Large Generator Interconnection Agreement ("LGIA"), Small Generator Interconnection Agreement ("SGIA"), or an existing interconnection queue position will be studied by Public Service to estimate electric interconnection and delivery requirements and costs. These procedures, and associated respondent responsibilities, are detailed in Appendix C.[5]

Bids that propose to interconnect to the Company's distribution system will be studied pursuant to CPUC rules 3667 or 3900 depending upon facility size.[6]

If the Company has received a certificate of public convenience and necessity to construct a transmission upgrade, the cost of the upgrade will not be included in the evaluation and costing of bids and/or bid portfolios that use those upgrades; provided, however, that sufficient transmission transfer capability exists on the transmission project specified in the CPCN after accounting for other generation projects.

For bids that: 1) utilize a transmission project for which a CPCN has been filed and is pending, or 2) utilize a Commission approved "bid-eligible planned transmission project" identified in the Phase I decision, transmission upgrade costs will not be included in the bids for purposes of determining advancement to computer-based modeling. In computer-based modeling, transmission upgrade costs will be included in the costing of the bids. At the completion of computer-based modeling, the total cost of the transmission upgrade will be included in any portfolio with a bid or bids that would utilize that transmission upgrade for portfolio costing and comparison purposes.

Existing generation resources from which the Company currently purchases capacity and energy will not be burdened with any incremental electrical transmission interconnection or network delivery costs provided that the Company currently has sufficient transmission capacity to deliver

[5] Note that the Company will apply the appropriate study procedure (i.e. LGIP or SGIP) during any formal interconnection study process.

[6] The Company's "Safety, Interference and Interconnection Guidelines for Cogenerators, Small Power Producers and Customer-Owned Generation" is available at: http://www.xcelenergy.com/staticfiles/xe/Regulatory/Transmission/CO-DG-Tech-Manual.pdf

the entire generation to its load. For existing generation resources with inadequate transmission service, a projection of the purchase of sufficient transmission rights will be added to the bid for evaluation purposes.

3.2 Electric Transmission Injection Capability

Public Service performs transmission studies for Large Generator Interconnect Agreement ("LGIA") requests. The LGIA requests are made to determine the feasibility, cost, time to construct, and injection capability for the transmission system interconnection of an electric generating resource. The Company posts the results of these studies on its OASIS website.[7] The Company performs other transmission studies for purposes of transmission planning that determine like information.

The transmission system is interrelated and generation injection at one point on the system likely changes the injection capability at other points; e.g., incremental generation injections at Pawnee would decrease the generation injection capability at Missile Site and vice versa. The generation injection capability values provided below in Table 3 are approximations based on the stand-alone transmission studies performed for specific MW levels identified in LGIA requests. The generation injection capability values can change when Public Service performs additional specific resource and resource portfolio transmission studies whether for resource evaluation or an LGIA request.

Table 3. Transmission System Injection Capabilities

TBD

3.3 Transmission Corridor Preservation

The Company seeks to maintain transmission access into its existing and planned substations and switchyards to facilitate future interconnections to its system. The Company's goal is to avoid situations in which planned generation or storage facilities physically surround stations and effectively preclude the development of radial generation tie lines into the station.

For bids located adjacent to PSCo existing and planned substations and switchyards, developers must agree to coordinate with PSCo to determine if the Company deems the station to be a key point of interconnection for future resources. If such determination is made, developers will be required to work with PSCo to identify transmission corridors of adequate size and location as part of their planned generation or storage facility layout. Agreeing to these terms is a threshold bid requirement; see Section 4.2 "Minimum Requirements for Proposals".

Section 4. Proposal Content Requirements and Submission Procedure

4.1 Schedule Estimate

[7] Information regarding posted studies may be found on a public site: http://www.rmao.com/public/wtpp/psco_studies.html.

An indicative schedule for this RFP process is provided below.[8] A graphical timeline is provided in Appendix E.

Table 4. Solicitation Schedule

Activity	Date
RFP Issued	**TBD**
Pre-Bid Conference	**TBD**
Notice of Intent to Respond Due	**TBD**
Proposals Due	**TBD**
120-Day Report to Commission	**TBD**
Commission Phase II Decision	**TBD**

4.2 Minimum Requirements for Proposals

This section describes the minimum requirements that all proposals must satisfy to be eligible for consideration in this Solicitation. Unless the Company in its sole discretion elects otherwise, proposals that do not comply with these requirements will be deemed ineligible and will not be considered further. The Company reserves the right to reject any bid and all bids.

- Proposals must include all applicable content requirements described in Section 4.3, including clear and complete written descriptions of all information requested and completed forms.
- Proposals must clearly specify all pricing terms in accordance with Section 2.3.
- Proposals must clearly demonstrate compliance with all power delivery requirements listed in Appendix C, CPUC 3667, or CPUC 3900 as applicable.
- Proposals must demonstrate an acceptable level of development and technology risk, as determined by the Company's evaluation team.
- Wind Turbine Cold-Weather Package Requirement. All proposed new or repowered/refurbished wind resources must be equipped with the appropriate cold-weather packages that will allow the turbines to reliably operate down to temperatures of negative 30 degrees Celsius or negative 22 degrees Fahrenheit.
- Cold-Weather Winterization Requirement. Any proposal offering the sale of new or existing gas-fired facilities are required to provide information detailing the bidders cold-weather/winterization processes and packages for the proposed facility
- On-Site Fuel Option Requirement. Any proposal offering the sale of new or existing gas-fired resources are required to provide an option for the storage of onsite fuel, such as fuel-oil, of sufficient quantity to power the unit at maximum unit output for 3 consecutive

[8] The Company reserves the right to adjust this schedule appropriately, including, but not limited to, for changes to the regulatory calendar.

days This on-site fuel option is to be accompanied by a separate set of bid forms where appropriate as well as any unique bidder proposed terms and conditions associated with the option.

- Work with the Company on Transmission Corridor Preservation as detailed in Section 3.3.
- For non-Section 123 proposals, the respondent's project development team must demonstrate that it has successfully completed the development, construction and commissioning of at least one utility-scale and utility-grade project with technology similar to the proposed project.
- For new-build Section 123 proposals, the respondent's project development team must demonstrate that it has successfully completed the development, construction and commissioning of at least one utility-scale and utility-grade project.
- Respondents must demonstrate to the satisfaction of the Company that they can meet the security requirements contained in the Model Term Sheets.
- Proposals must clearly demonstrate any financing requirements and an indicative construction financing structure for any proposed resources that will be delivered under the proposals. Respondents should include a description of how current financial markets are likely to impact the respondent's ability to access the debt and tax equity markets, as applicable
- Each respondent must present clear and sufficient proof that it has or can secure an adequate and confirmed supply of generation equipment sufficient (at a minimum) to meet the required proposal.
- Respondents must provide the required bid fee (described in Section 4.8 below) for each proposal submitted.

4.3 Proposal Content Requirements

This section outlines the content and format requirements for all proposals submitted in response to this RFP. Unless the Company in its sole discretion elects otherwise, proposals that do not include the information requested in this section will be ineligible for further evaluation, unless the information requested is not applicable or relevant to a given proposal. The Company reserves the right to conduct any further due diligence it considers necessary to fully understand and evaluate proposals.

Proposal Format

The first section of each proposal must contain an Executive Summary that provides an overview of the proposed generating resource characteristics, including any unique aspects or benefits. The second section of the proposal must include a completed set of applicable forms included in Appendix A. These forms will contain essential information about each proposal. A separate set of forms and related information must be submitted with each proposal. The third section of the proposal must include additional information presented in narrative form under specific topic headings.

A complete proposal will include the following components:

1. Executive Summary
2. Complete set of applicable forms

3. Form attachments (as necessary to elaborate on form information)
4. Narrative Topics Discussion
5. Requested maps and electronic data
6. Land rights contracts and all supporting documentation, i.e. ALTA survey, title commitments, etc.

The proposal forms and topic headings are listed below.

Proposal Forms

Form A	Notice of Intent to Respond
Form B	Bid Certification
Form C	Bid Cover Sheet
Form D1A	Pricing and Quantity for BOTs or Sale of Existing Asset
Form D1B	FOM, VOM, Maintenance, Ongoing Capital Expenses
Form D2	Electrical Interconnection Cost Estimates
Form E	Construction Milestones
Form F1	Capacity for Thermal Resources
Form F2	Facility Performance
Form F3	Heat Rates
Form F4	Heat Rate Degradation
Form F5	Technical Description | Solar Photovoltaic
Form F6	Technical Description | Battery Energy Storage I
Form F7	Technical Description | Battery Energy Storage II
Form F8	Technical Description | Wind
Form F9	Technical Description | Other Tech
Form F10	Energy Production Profile - Annual and Monthly
Form F11	Section 123 Qualifications
Form G	Natural Gas and Backup Fuel Supply
Form H	Emission Rates
Form I	Interconnection Information Forms

The individual forms in Appendix A include additional instructions for completion.

Narrative Topics

Narrative topics should be organized under the following headings (with reasonably equivalent information provided for proposals involving existing generation assets):

- Development Experience
- Financial Information
- Project Description and Development Schedule
- Equipment Description
- Real Property Acquisition Description and Plan
- Permitting Plan
- Transmission Plan
- Community/State Reaction Assessment
- Operations and Maintenance Plan

- Exceptions to Model Term Sheet
- Beneficial Contributions/Section 123 Resources
- Employment Metrics

Development Experience. All proposals must describe the respondent's qualifications and experience in developing, constructing, commissioning and operating generation facilities similar to the proposed facility, including the experience, qualifications and safety record of key personnel who will manage development and an overview of utility scale and utility grade projects the respondent has developed during the last 5 years. If an EPC team is in place, the proposal should identify the members of the team; if such a group is not in place, the proposal must set forth the respondent's plan for assembling such team (including process and timing).

Financial Information. All proposals must provide detailed financial information about the proposed project. This information shall include two years of audited financial statements or the equivalent for respondents and other responsible parties (including any entities that would provide parent guaranties of the respondents' obligations), whether the project will be financed as a recourse or non-recourse project, the percentages of debt and equity financing, and the expected cost of debt. In addition, respondents shall provide a detailed plan for financing the proposed project during construction and operation including the financing commitments that the respondent has obtained. Proposals shall also explain in detail the plan for meeting the security requirements outlined in the Model PPA and must set forth the credit rating (if any) of any entities that would provide parent guaranties of the respondents' obligations. Proposals must include an organization chart showing the entities that own the respondent's organization and a description of the respondents' organization structure (including primary and secondary businesses). Detailed financial information about the bidder (e.g., 10-Ks or similar) should be provided in electronic format only.

Project Description and Development Schedule. All proposals for the construction of new generation facilities must set out a description of the proposed project, including a description and plans for the proposed site and rights of way, utilities services, equipment configuration, transmission and interconnection construction and procurement, supply of spare parts, opportunities for future expansion of the project, required permits, the nameplate capacity of the resource in MW, the respondent's key consultants (if known) for meteorological studies and permitting studies, and the respondent's construction contractors and prime subcontractors (if known). Such proposals must provide a detailed Gantt chart of project development activities developed using Microsoft Project or similar software (note that .pdf file-type is preferred for submittal) that includes (at a minimum) entering major equipment and construction subcontracts, target completion dates for financing, engineering, permitting, equipment procurement, construction, startup and commissioning, and guaranteed dates for substantial completion. Proposals must describe the overall development strategy that will ensure that the project can be developed in time to meet the proposed commercial operation date. Respondents proposing Section 123 resource generation projects should describe the risks associated with deploying such new technology specifically as those risks impact the proposed commercial operation date and the first years of operation.

Proposals for the sale of existing resources must include a description of the age of the equipment and remaining plant life; a summary of the pricing and term of existing fuel contracts; status of existing water rights (for natural gas-fired facilities); a summary of all material claims threatened or pending involving the facility; a description of the information available related to safety history, capital expenditure history, and operating and cost history (including heat rate, outage and availability record, fixed and variable costs fuel costs, and starts and cycling history). However, Respondents should not provide safety history, capital expenditure history and operating and cost history in their initial bid submissions. Upon request, respondents must be prepared to provide the Company with the foregoing information for evaluation purposes.

It is the Company's expectation it will have first rights to all proposed projects submitted into the RFP for the period during the proposal review and approval process. Respondents must also provide any information which would restrict the respondent from providing the Company with exclusive rights to negotiate a purchase agreement for the proposed project. Such restrictions could include, but are not limited to, prior active submission or participation in other RFPs, exclusivity rights granted to other parties, rights of first offer or refusal, purchase options, and active auctions for the project as applicable.

Equipment Description. At a minimum, proposals should indicate for all major equipment 1) the name of the manufacturer and other vendors, 2) models, 3) key metrics and characteristics of the equipment, 4) performance history of the equipment, 5) contracting status, and 6) planned delivery dates.

Real Property Acquisition Description and Plan. Proposals must provide a description of the status of real property acquisition and land use permitting for the project that is sufficient for the Company to assess the completeness and sufficiency of the respondent's real property rights, including but not limited to:

- Copies of all of the land right contracts secured to date, including any form agreements yet to be deployed,
- The status of current site control necessary to build, operate, and maintain any radial transmission line dedicated principally to the project, and the form(s) of land right contract being utilized to secure the right-of-way, if applicable,
- The plan for acquiring any and all currently uncontrolled necessary real property rights for the project,
- A list of parcels physically impacted by the Project, including parcel APN, owner name, tax ID, and County,
- Copy of title commitment(s) and ALTA Survey(s), if available,
- The plan for undertaking any necessary title curative work,
- Acreage of real property required for the project and a schedule for the completion of the real property acquisition process,
- A description of any subdivision or zoning modifications and all city, county, or state land use permits that will be required, such as conditional use, special use or other similar permits and approvals, which will be required for any phase of development, construction, or operations of the project, and
- A description of existing and planned land use in all directions surrounding the proposed site.

If the proposed site is adjacent to an existing or planned substation or switching station, the proposal must provide a preliminary site layout that indicates how access to the substation or switching station might be maintained for other transmission or radial generation tie lines after the proposed facility is built. For purposes of this Bid Narrative, adjacent includes a project which proposes a site directly across a road or similar barrier from the existing or planned substation or switching station.

Proposals must include a USGS-based map showing the location of the proposed site, and ESRI ArcGIS shapefiles depicting the Project boundary and any radial transmission line necessary to interconnect the project. Shapefiles must be provided in Colorado NAD 83 State Plan coordinate system.

For BOT projects yet to be constructed, the successful bidder(s) should expect to consult with Company personnel regarding land rights acquisition during the development phase/pre construction phase of the project.

For bidder's providing copies of land rights contracts, please see specific submission instruction in section 4.6.

Permitting Plan. Proposals should include a complete list of permits required and secured for the project. If permits have not yet been secured, a schedule for submitting and obtaining the required permits must be provided.

Proposals must describe all air quality permits that will be required for the project. State whether any air permits have been secured, and if not, whether applications have been filed. Report on the status of any pending applications and any feedback from permitting agencies. Describe the expected time frame to obtain the necessary air permits after application submittal to the State.

Describe all other federal, state and local permits and approvals that will be required for the project, but not limited to:

- Federal environmental assessments under the National Environmental Policy Act ("EA/EIS"),
- Water supply,
- Wastewater discharge permits,
- Hazardous waste permits, and
- No-hazard permits/determinations from the Federal Aviation Administration.

Describe the current status of obtaining these permits and any feedback from permitting agencies.

Describe the water supply strategy for the project, including a description of water requirements, water supply source(s), discharge plans, new water pipeline requirements, and any work completed to date on the water supply plan.

Explain any expected restrictions/limitations on operations due to air and/or water permits.

If the proposed site does not currently have the appropriate zoning designation, provide any rezoning requirements, plans to obtain the rezoning, and any known issues as to rezoning.

For projects proposing to utilize an eligible energy resource[9], proposals must also provide written documentation evidencing that consultation has occurred with appropriate governmental agencies (for example, the Colorado Parks and Wildlife or the U.S. Fish and Wildlife Service) responsible for reviewing potential project development impacts to state and federally listed

[9] Eligible energy resources are defined in the Commission's rules, section 3652, "Definitions".

wildlife species, as well as species and habitats of concern.

For BOT projects yet to be constructed, the successful bidder(s) should expect to consult with Company personnel regarding permitting during the development phase/pre construction phase of the project. If permits require the project to enter into agreements that will survive the transfer of ownership from bidder(s) to Company, the Company will be involved in such negotiations.

Transmission Plan. Provide a detailed description of the Point of Delivery to the Public Service electric system, including the location and voltage level of such point. All proposals should include a description of the respondent's plan to transmit power from the Project to the proposed Point of Delivery on the Public Service transmission system as described in Appendix C. The information should include a description and expected route of any radial transmission line dedicated principally to the Project if known, including a summary of the status of obtaining requisite easements and alternatives.

If any new FERC-regulated transmission or any upgrades to non-Public Service transmission will be required to deliver power from the Project to the proposed point of delivery ("New Transmission"), the proposal also should include a complete description of the required New Transmission including:

- The owner and developer of the New Transmission,
- The complete expected route for the New Transmission,
- The voltage and capacity of the New Transmission,
- The status of planning, permitting, financing and construction of the New Transmission, to the extent known to the respondent,
- The location of the interconnection of the Project into the New Transmission, and
- Whether the respondent's Project, if successful, would be sufficient for the New Transmission to be built without the participation of other power projects, and if not, what other projects would need to be built and in what time frame to allow the New Transmission to be built in time for the respondent to meet its scheduled in-service date.

For proposals that will require third-party transmission service(s) to deliver, on a firm transmission service basis, the capacity and energy to the Point of Delivery specified above, provide a detailed description of the interconnection, electric losses, transmission and ancillary service arrangements, by provider, that will be required, including:

- The identity of all third party providers,
- The location and voltage level of the interconnection point to the interconnection service provider's facilities,
- Any interconnection facilities that bidder owns or intends to construct and own,
- The specific services provided by each provider, and
- The line losses, point(s) of receipt and point(s) of delivery associated with each third party transmission service.

Provide documentation that the third party services discussed in the paragraph above will be available to bidder during the proposed contract term. This should include:

- Any associated transmission studies that directly examined delivery of the proposed energy to the point of delivery,
- Detailed information on any and all new transmission facilities and/or upgrades to existing

facilities that will be required to deliver the proposed energy to the point of delivery, and,

- A detailed discussion of the schedule for siting, permitting, and construction of such new facilities and/or upgrades.

Attach a USGS-based map that shows the location of the interconnection point with the third-party and the generation facility.

Community/State Reaction Assessment. Each respondent must present a current assessment of, and a plan for continuing to monitor, local community and state reaction to the project, and a plan to work with the local community on project issues. Such plan might include the following elements:

- A list of the references used to assess the community reaction, and the methodology used to draw conclusions,
- A list of key local contacts interviewed and their opinions,
- An assessment of the local community reaction at the time of the proposal,
- An action plan for working with the local community/state to successfully complete the project, and
- A description of the respondent's proposed conflict resolution methodology.

Operations and Maintenance Plan. Respondents shall summarize their proposed operations and maintenance plans for the generation facilities associated with their proposals.

Exceptions to Model Term Sheet. In support of the Company's efforts to complete project evaluation, and contract negotiations in a timely manner, respondents shall provide pricing that is consistent and compliant with the Model Term Sheet for the proposed resource type. To the extent that the validity of a respondent's proposal and/or the respondent's ability to execute a purchase agreement is contingent upon material changes to the language in the Model Term Sheet, respondents should specifically identify the terms in the Model Term Sheet they propose to change and should summarize their proposed changes to such terms. To the extent that a respondent wishes to propose changes to the Model Term Sheet that, if accepted by the Company, would reduce the respondent's proposed pricing the proposal should specifically identify such changes and the associated price reduction. To the extent practicable, respondents should develop exhibits, schedules, attachments and other supplemental documents required by the Model Term Sheet. Respondents proposing to sell existing generation facilities should propose changes to the Model Term Sheet for the proposed resource type reflecting the terms and conditions on which their proposal is based.

Exceptions taken to model Term Sheet terms must be clearly expressed such that the Company can reasonably understand the bidder's concerns. Statements containing language such as "To be discussed" do not provide the Company sufficient information to understand the bidder's concerns. Bidder's providing such comments will be required to more fully explain their concerns so that the Company can adequately conduct its due diligence activities.

Exceptions to Technical Specifications. Respondents shall provide pricing that is consistent and compliant with the applicable PSCo Technical Specifications. To the extent that the validity of a respondent's proposal and/or the respondent's ability to execute a purchase agreement is contingent upon material changes to the language in these technical specifications, respondents should specifically identify what they propose to change and should summarize their proposed changes to such specifications. To the extent that a respondent wishes to propose changes to the Technical Specifications that, if accepted by the Company, would reduce the respondent's proposed pricing the proposal should specifically identify such changes and the associated price reduction.

Exceptions taken to Technical Specifications must be clearly expressed such that the Company can reasonably understand the bidder's concerns. Statements containing language such as "To be discussed" do not provide the Company sufficient information to understand the bidder's concerns. Bidder's providing such comments will be required to more fully explain their concerns so that the Company can adequately conduct its due diligence activities.

Beneficial Contributions/Section 123 Resources. Respondents should indicate whether or not they believe their project meets the requirements of a Section 123 resource. Bidders claiming Section 123 status must complete Form F6. Regardless of claimed Section 123 status, **all bidders must provide information concerning the beneficial contributions of their proposed technology** including benefits associated with Colorado's 1) energy security, 2) economic prosperity, 3) environmental protection, and 4) insulation from fuel price increases.

This information is needed from **all bidders** in order to allow the Commission to consider whether certain benefits are common across proposals and whether certain benefits tie specifically to the implementation of a particular new and clean energy technology.

Employment Metrics. Respondents shall include descriptions of each best value employment metric ("BVEM") described below as it relates to the bid project.

Since the Company's last Electric Resource Plan proceeding, a change to §40-2-129, C.R.S. has been made from the utility previously being required to "request" best value employment metric ("BVEM") information to now the utility being required to "obtain and provide to the Commission" such information. The Company provides guidelines below for bidders on such when preparing responses to the 2022 All-Source Solicitation. The Company can and will disqualify bids that provide insufficient BVEM as part of their bid packages.

Best Value Employment Metrics - Information Guidelines

(a) The availability of training programs, including training through apprenticeship programs registered with the United States Department of Labor, Office of Apprenticeship and Training. The utility or bidder shall provide, for example and as applicable, the following information for each craft the utility anticipates will work on the project:

(I) availability of training programs;
(II) the names of specific training programs available;
(III) the curriculum of the specific training programs;
(IV) the cost of worker training;
(V) the duration of the training programs;
(VI) the total number of hours of on-the-job training required;
(VII) the total number of classroom hours required;
(VIII) the licenses and certifications obtained, if any;

(IX) a copy of training program standards for each training program; and

(X) a statement whether the training programs are United States Department of Labor registered apprenticeship programs and are accredited to award college credits.

(b) The employment of Colorado workers as compared to importation of out-of-state workers. The utility or bidder shall provide, for example and as applicable, the following information for each craft the utility anticipates will work on the project:

(I) estimated number of workers by job classification;

(II) estimated length of time of service, including total man hours, by job classification;

(III) percentage of Colorado workers by job classification; and

(IV) percentage of project man hours earned by Colorado workers by job classification.

(c) Long-term career opportunities. The utility or bidder shall provide, for example and as applicable, the following information for each craft the utility anticipates will work on the project: job classifications, licenses, certifications and skills that will be applied and the long-term career opportunities for each job classification; and

(d) Industry-standard wages, health care, and pension benefits. The utility or bidder shall provide, for example and as applicable, the following information for each craft the utility anticipates will work on the project:

(I) range of wages by job classification;

(II) healthcare benefits by job classification;

(III) pension benefits by job classification;

(IV) prevailing wages and fringe benefits (healthcare benefits, pension benefits and other compensation) based on industry standards and the current Colorado labor agreements by job classification; and

(V) wages and fringe benefits (healthcare benefits, pension benefits and other compensation) by job classification.

4.4 Pre-Bid Conference

Time: **TBD**
Date: **TBD**
Location: **TBD**

Public Service will webcast the meeting and will provide means for remote, electronic participation by potential RFP respondents. Public Service will post information concerning webcast access and remote participation on the RFP website once confirmed[10]. Interested parties are encouraged to provide written questions to the Company's RFP Project Manager by email prior to the pre-bid meeting. A summary of the bid conference proceedings, including submitted questions and

[10] See Section 1.4 of this RFP for website information

answers, and answers to any question remaining unanswered at the end of the meeting will be prepared by the Company and posted on the RFP website.

4.5 Notice of Intent to Respond (NOIR)

Respondents who intend to submit a proposal into the 2022 All-Source solicitation are strongly encouraged to also submit a non-binding Notice of Intent to Respond (NOIR), Form A in Appendix A. The Company requests that completed NOIR forms be emailed to the RFP Project Manager at the earliest date possible but no later than 4:00 P.M. Mountain Time on **TBD**. There is no fee required to submit a NOIR.

4.6 Proposal Submission Deadline

All proposals, including Company self-build proposals will be accepted until 4:00 P.M. Mountain Time on **TBD**. All proposals must be transmitted by express, certified or registered mail, or hand delivered to the following address:

TBD

Proposals received later than the submission deadline will be rejected and returned unopened, unless the Company determines, at its sole discretion, to consider such proposals. Two (2) bound hard copies of the proposal must be included in the submittal. In addition, respondents must submit two (2) electronic copies (USB flash drives) with completed forms in a Microsoft Office format.

Bidders that plan to submit copies of all land acquisition contracts, surveys, title commitments, etc., are encouraged to not include hard copies of these documents in their hard copy proposal submittal, but instead, include these files in the electronic copies. All files pertaining to land acquisition need to be organized and located in a separate folder in the electronic copies.

Proposals must be submitted in a sealed package with the following information shown on the package:

TBD

The respondent's company name and address must be clearly indicated on the package containing the proposal.

4.7 Information Policy

To obtain additional information about this RFP, potential respondents as well as all other parties may submit inquires only to the RFP Project Manager via email at **TBD**. Potential respondents as well as all other parties should not attempt to acquire information through any other means including telephone calls to the Company. The Company will maintain a log of all email inquiries and coordinate the preparation of written responses. Once a response is prepared, the Company will forward the response to the inquiring party. Questions and responses, when germane, will be periodically posted to the RFP Web Site in a FAQ. The Company has established this information policy to ensure that all respondents have the same timely access and knowledge about the bidding and evaluation process.

All bidders as well as all parties in the resource plan proceeding other than the utility are restricted from initiating contact with the IE pursuant to Commission rule.

4.8 Bid Evaluation Fees

All respondents are required to pay to the Company a bid evaluation fee with each proposal submitted; are determined by the nameplate capacity of the bid according to the Table below. Public Service may deem proposals that do not satisfy the requirements for a single proposal as multiple proposals, each of which would require a separate bid evaluation fee. For example, a proposal that triggers electric interconnection studies for multiple points or levels of interconnection would be deemed separate proposals for each such point or level. In addition, proposals offering multiple commercial operation dates for the same project or facility will be viewed as multiple proposals. If the Company deems a respondent's proposal to be multiple proposals, the Company will notify the respondent and allow it to elect to pay the incremental bid fee or to revise its proposal to comply with the Company's requirements for a single proposal.

Notwithstanding the above, respondents who submit proposals in this 2022 Company Ownership RFP may also submit a proposal for the same generation project/facility in one of the other RFPs in this Solicitation with no incremental bid fees.

Checks should be made out to "Public Service Company of Colorado" and must be included with the proposal. Bid evaluation fees are non-refundable.

Table 5. Bid Fees

MW Range	Bid Fee
>2 to 5 MW	$1,500
>5 to 10 MW	$3,000
>10 MW	$10,000

Any bidder(s) selected to begin negotiation of a Purchase & Sale Agreement shall be required to submit a Second Bid Fee of $1/kW (e.g. 100 MW Project * $1/kW = $100,000) to the Company prior to commencement of negotiations. Upon execution of a Purchase & Sale Agreement, the Second Bid Fee shall, be refunded to the bidder. However, if the bidder and the Company fail to execute a Purchase & Sale Agreement due to, in whole or in part, bidder's actions that do not reflect bidder's representations or commitments during the RFP bidding process, the Company shall have the right to retain the Second Bid Fee.

4.9 Clarification of Proposals

While evaluating proposals, the Company may request clarification or additional information about any item in the proposal. Such requests will be sent via email to respondents identified on Form C, by the RFP Project Manager, typically, and respondents are required to provide a written or electronic response back to the RFP Project Manager within five (5) business days, or the Company may deem the respondent to be non-responsive and either suspend or terminate evaluation of the proposal. Respondents are encouraged to provide an alternate point of contact to ensure a timely response to clarification questions.

4.10 Confidentiality

Respondents are allowed to identify any information in their proposals that respondents claim should be considered to be confidential or proprietary. Nonetheless, the Company reserves the right to release all proposals to its affiliates and to its and such affiliates' agents, advisors, consultants, and the IE for purposes of proposal evaluation. The Company will, to the extent required by law, advise each agent, advisor or consultant that receives such claimed confidential information of its obligations to protect such information. In addition, all information, regardless of its confidential or proprietary nature, will be subject to review by the Commission and other governmental authorities and courts with jurisdiction, and may be subject to legal discovery. It is not the Company's intent to enter into any separate confidentiality, non-disclosure, or similar agreements as a condition to receiving a respondent's proposal.

Notwithstanding the above paragraph and as indicated in Section 1.1, a reasonable number of attorneys and a reasonable number of subject matter experts representing a party to the Company's 2021 ERP docket can, upon the execution of the appropriate non-disclosure agreement, request and receive access to all bid information provided to the Company in response to this RFP regardless of a bidder's claim of confidentiality or propriety. In addition, upon completion of the competitive acquisition process Public Service will post on its website and thereby make publicly available the following information from all bids and utility proposals: bidder name; bid price and utility cost; generation technology type; size of facility; contract duration or expected useful life of facility for utility proposals; and whether the proposed purchased power agreement includes an option for the utility to purchase the bid facility during or at the end of the contract term.

4.11 Addenda to RFP

Any additional responses required from respondents as a result of an Addendum to this RFP shall become part of each proposal. Respondents must list all submitted Addenda at the bottom of the Bid Certification Form (Form B).

Section 5. Evaluation and Criteria

The objective of the Company's Solicitation evaluation is to identify portfolios of proposals that meet the resource needs identified in the solicitation in a reliable and cost-effective manner, while achieving the resource goals of the Commission-approved ERP.

As described below, the evaluation process will include an assessment of both economic and non-economic criteria.

5.1 Evaluation Process

An evaluation team made up of various groups within Xcel Energy Services and the Company will evaluate proposals; however, the Company reserves the right to retain the services of outside experts to assist in the evaluation of proposals. The RFP Project Manager may contact respondents directly at any point during the evaluation process for the purposes of clarifying proposals. The Company will also cooperate with, and provide access to information provided by respondents to, the Independent Evaluator as required by RP Rule 3612. All bidders as well as all parties in the resource plan proceeding other than the utility are restricted from initiating contact with the IE.

Proposals will be evaluated using a multi-step process as follows:

***Step 1* – Bid Eligibility Screening**

Each proposal will be reviewed to ensure it meets the minimum requirements outlined in Section 4.2. The Company will notify each proposal respondent within 15 days of bid receipt as to the Company's bid eligibility evaluation.

***Step 2* – Interconnection Assessment and Initial Economic Evaluation**

While not entirely concurrent, the activities described in Steps 2.A., 2.B. and 2.C. below will overlap to some extent.

A. Electric Interconnection Cost Estimates

The Company will determine or verify electric interconnection cost estimates provided by bidders. If substantial differences occur, the Company will provide its cost estimates to the applicable bidders so that they can update their bid pricing, as they deem appropriate. Such bidders must submit final bid pricing back to the Company within 5 calendar days of the date the interconnection cost estimates are provided.

B. Transmission and Distribution Upgrade Schedule Assessment

Some or all of the proposals will also be evaluated to assess the general siting, permitting, and construction time requirements associated with Public Service transmission and/or distribution network upgrades, including network upgrades for interconnection and network upgrades for delivery, that may be needed for each proposal to:

- Interconnect the proposed generation with the Public Service transmission or distribution system,
- Deliver the entire proposed capacity and energy to the Company's customers, and/or
- Deliver the entire proposed capacity and energy from a third party transmission system to the Public Service electric system.

The impact of these analyses on a respondent's proposed schedule will be a factor in the evaluation of its proposal.

C. Initial Economic Screening

The primary purpose of the initial economic screening is to rank each bid by technology so that the most promising bids can be forwarded to the subject matter experts for their review as quickly as possible and to identify those bids likely to be moved forward for computer modeling of bid portfolios. The initial economic screening consists of calculating an "all-in" levelized cost of energy ("LEC") or "all-in" cost of capacity ("LCC") depending upon the resource type proposed.

In addition to the costs provided in the bid, the Company will estimate incremental costs or benefits, as necessary, such as:

- Electrical interconnection costs and network upgrades not included in Form D1 pricing. These incremental capital costs are converted to a variable rate by assuming a levelized fixed charge rate of 0.08 and an annual capacity factor based on the type of generator proposed.
- Projects that propose to interconnect to the Public Service distribution system will be credited with an avoided line loss assumption in their LEC calculations.
- Estimates of the Company's cost to deliver fuel (e.g., natural gas) to a tolled facility.
- For bids proposing solar or wind generation, the Company will estimate resource integration costs as determined in the Company's most recent renewable resources integration cost study.
- Bids for energy storage will be credited with renewable integration credits, as applicable.

LCCs for stand-alone storage bids include an annual representation of proposed variable O&M costs and renewable energy credits in addition to proposed capacity payment rates. Variable O&M payment rates and renewable energy credits will be converted to a $/kW-mo metric by applying the annual throughput limit (MWh) proposed for the storage device. LCCs are converted to a generation capacity credit basis by dividing by the ELCC assigned to the project.

In addition to proposed capacity payment rates, LCCs for non-storage generation resources include a fixed cost representation of variable $/MWh costs by assuming an annual capacity factor and an average annual heat rate with which to estimate fuel volumes and costs. Gas-fired, peaking resources (defined as units with base capacity heat rates over 8,000 Btu/kWh) will be screened with an assumption of a 5% annual capacity factor. Gas-fired, intermediate resources (defined as units with base capacity heat rates of 8,000 Btu/kWh or lower) will be screened with an assumption of a 40% annual capacity factor. The average annual heat rate utilized in the LCC calculations will be the base capacity heat rates (i.e., heat rates without supplemental capacity) supplied on Form F3.

Start charges for dispatchable generation resources are converted to a fixed cost by assuming a set number of hours that a unit will run at full output once started; full output is defined as the net capability of the unit without supplemental capacity (e.g., duct firing on a combined-cycle power plant). For peaking resources, the Company assumes a four (4) hour run time per unit per start. For intermediate resources, the Company assumes a twelve (12) hour run time per unit per start and that all combustion turbines are started.

The Company will assume a 5% EFOR rating in its LCC estimates of capacity payments regardless of the EFOR rating provided in or the calculation shown in the Monthly Capacity Payment section of the bid forms. Bids for thermal generation resources will be screened both on primary (e.g., natural gas) and on on-site, secondary fuel sources (e.g., fuel oil).

Regardless of their LEC calculations all eligible bids from existing generators, all Company self-build projects, and any bid claiming Section 123 status that is unopposed by the Company or, if opposed by the Company but later qualified as Section 123 by the Commission, will be advanced to computer modeling of bid portfolios.

Step 3 – Non-Price Factor Analysis

The Company will assess the non-price characteristics of the proposals. Non-price factors that will be assessed include, as applicable and without limitation, the following:

- Financial strength of the respondent
- Financing plan, including ability to utilize tax advantages
- Development, construction and operation experience
- Generator technology, availability, and warranties
- Environmental permitting and compliance
- Land use permitting and zoning
- Other permitting
- Real property acquisition/site control progress and plan
- Project operational characteristics
- Scale of the project and whether or not it meets the Commission definition of an Eligible Energy Resource
- Community support for the project
- Transmission access plan feasibility and arrangements
- Transmission upgrade schedule assessment
- Construction and equipment supply plans and arrangements
- Project execution planning
- Accreditability of capacity to meet reliability needs
- Accounting assessment

Step 4 – Bidder Notification

Contingent upon the existence of sufficient bids passing through bid eligibility and due diligence screening, the Company shall pass forward to the computer modeling of bid portfolios a sufficient quantity of bids across the various resource types such that resource plans can be created that conform to the Commission's Phase I decision.

Pursuant to rule 3613(a), within 45 days after bids are received the Company will email each bidder and indicate whether its bid has or has not been advanced to computer-based modeling of bid portfolios and provide each bidder the modeling inputs and assumptions that reasonably relate to that potential resource or to the transmission of electricity from that facility to the Company.[11] For those bids not advanced to computer modeling, the Company will provide the reason(s) why the project will not be evaluated further.

Step 5 – Computer-Based Modeling of Bid Portfolios

[11] See Section 5.1 Step 5 for an exception to the notification policy for bids that are included in modeling after 45 days of bid receipt. See Section 5.1 Step 6 for an exception to the notification policy for bids smaller than 10 MW.

The costs and operational characteristics of any Company self-build proposal and each remaining bid equal to or greater than 10 MW will be input into the Company's EnCompass planning model.[12] The EnCompass model will be used to construct portfolios of bids that meet the capacity and energy projections of the Public Service system, as well as the various objectives of the resource plan and Commission decisions. The EnCompass model simulates operation of proposals together with the Company's existing resources (and to an extent, the regional power market), while keeping track of all associated fixed and variable costs of the Company's entire system.

EnCompass will be utilized to develop portfolios that minimize the net present value of revenue requirements through 2055. The model will also be used to develop alternative resource portfolios that represent the costs and benefits from increasing amounts of renewable technologies and/or Section 123 resources. Portfolios will be developed in accordance with the scenario analysis directives of the Commission.

To the extent initial results indicate that all bids of a specific generation resource type (e.g., all wind bids) passed to computer modeling appear in the least-cost portfolio(s), additional bids utilizing that generation resource type will be included in subsequent model runs. This iterative process will be followed until no incremental bids employing that generation resource type are selected in the least-cost portfolio. Bidders whose projects are passed forward to computer modeling of bid portfolios after the 45 day report will be notified of their project's advancement pursuant to rule 3613(a).

***Step 6* – Evaluation of Bids Between 100 kW and 10 MW**

As indicated in Step 5, bids must have nameplate capacity ratings equal to 10 MW or greater to be included in the computer-based portfolio modeling step. In general, bids between 100 kW and 10 MW ("Small Bids") will be evaluated after the computer-based portfolio modeling step. As indicated in Section 2.2, the Company will not entertain bids for Company ownership that are smaller than 2 MW.

At the conclusion of Step 5, the Company will review the least-cost portfolio from the base case run (that is, not from a sensitivity case) and determine each generation type selected in the portfolio. For each generation type selected, the Company will determine the all-in levelized energy cost of the most expensive bid. These all-in levelized energy costs will set the price against which Small Bids with similar generation technologies will be compared. The Company will include in all portfolios presented to the Commission each Small Bid with an all-in levelized energy cost less than the most expensive bid with similar technology selected in the least-cost portfolio.

A final check will be made to ensure that the inclusion of all cost-effective Small Bids does not provide excess capacity credit to the least-cost portfolio through the RAP to such an extent that it could replace another source(s) of capacity selected through the EnCompass modeling. If it does, two additional sets of ad hoc EnCompass runs will be conducted to determine which is most cost-effective: 1) include all cost-effective Small Bids in the final portfolio, or 2) include all cost-effective Small Bids and exclude the other generator(s) that could potentially be displaced. The final

[12] Depending upon the pool of proposed projects received, the Company may adjust the specific MW cutoff for various technologies instead of the 10 MW indicated here. Such an adjustment would be done in consultation with the Independent Evaluator.

portfolio would be the least-cost of these two runs assuming that both runs meet all reliability metrics.

To the extent the least-cost portfolio does not include a certain generation type (e.g. solar) but bids for that generation type were passed through to computer-based modeling and lower priced Small Bids exist, an ad hoc EnCompass run including these Small Bids would be conducted to see if the revenue requirements of the least-cost portfolio increases or decreases. If the revenue requirements decrease with the addition of the Small Bids, they would be included in the final portfolios.

For certain generation types (e.g. hydro or gas-fired micro-turbines), the Company would not typically expect to receive bids in excess of 10 MW. For such situations, the lowest all-in LEC proposals (up to a maximum of three per technology) would be advanced to computer modeling and portfolio development along with those bids >= 10 MW in Step 5 above. To the extent the EnCompass model selected all three of the lowest all-in LEC proposals and other proposals for the same technology were also received, then ad hoc EnCompass runs would be conducted to determine the cost-effectiveness of these other proposals.

Bidders whose Small Bid projects are passed forward to computer modeling of bid portfolios after the 45 day report will be notified of their project's advancement pursuant to rule 3613(a).

***Step 7* – Phase II Report to Commission**

Pursuant to rule 3613(d), the Company will file a 120-day report to the Commission describing the cost-effective resource plans that conform to the Commission's Phase I decision and other Commission decisions that impact the Phase II process.

5.2 Independent Evaluator Report

Within 30 days following the Company's 120-day report filing, the IE will report to the Commission its analysis of whether the Company conducted a fair bid solicitation and bid evaluation process, with any deficiencies specifically reported.

5.3 Phase II Commission Evaluation

Within 90 days of the Company's filing of its 120-day report, the Commission will issue a written decision approving, conditioning, modifying, or rejecting the Company's preferred cost-effective plan. The Company is required to complete this RFP process within 18 months after the receipt of bids unless the Company can show good cause for a requested deadline extension.

Appendix A

Proposal Forms and Instructions

As discussed in Section 4, the completed forms, attachments and narrative topic discussions, will comprise a complete proposal, except that Form I need not be completed by a bidder who has already entered into a formal interconnection process for their project. The contents of each form and any special instructions for completing the forms are described below. These forms can be downloaded from the RFP web site in a format appropriate for respondent input.

If additional space is needed to elaborate on information requested on any form, please attach additional sheets with the heading "Form [__] – Additional Information."

If certain information is requested that does not apply to the proposal, the respondent must indicate that the information is not applicable. If appropriate, the respondent should explain why the information is not applicable.

In addition to submitting two (2) hard copies of the proposal, respondents must also include two (2) electronic copies (USB flash drives) with all completed Forms in executable format, i.e. not PDF. The Company will provide the IE with one electronic copy of the proposal and, at their request, one hard copy. The Company will provide the Commission Staff with electronic access to the proposals.

Appendix B

General Planning Assumptions

The following planning assumptions will underlie the evaluation of proposals received in response to the Company's Solicitation. Note that the following is not a complete listing of all assumptions that will be applied in the evaluation process. Further note that the assumptions noted below represent "base case" assumptions. Sensitivity analyses will be performed in which certain of these assumptions are altered in accordance with Commission directives. To the extent any of these general planning assumptions are updated after release of this 2022 RFP, the updated values will be provided to the Commission and made available to all potential respondents and parties.

1. Capital Structure and Discount Rate

An after-tax weighted average cost of capital ("WACC") of 6.53% is used as the discount rate for levelized cost calculations and the present value calculations of modeled costs. Table B-1 shows the capital structure and cost of capital.

Table B-1

Discount Rate and Capital Structure				
	Capital Structure	**Allowed Return**	**Before Tax Electric WACC**	**After Tax Electric WACC**
Long-Term Debt	42.72%	4.09%	1.75%	1.32%
Common Equity	55.61%	9.30%	5.17%	5.17%
Short-Term Debt	1.67%	3.33%	0.06%	0.04%
Total			**6.97%**	**6.53%**

2. Gas Price Forecasts

The annual average Base gas price and relevant Low and High price sensitivities are summarized in Table B-2.

Table B-2

	Base Price Forecast						Low Price Forecast					High Price Forecast				
	Fuel Price ($/mmBTu)		Market Price ($/MWh)				Fuel Price ($/mmBTu)	Market Price ($/MWh)				Fuel Price ($/mmBTu)	Market Price ($/MWh)			
Year	Generic Coal	CIG RM	4C On-Peak	4C Off-Peak	Midway On-Peak	Midway Off-Peak	CIG RM	Minn Hub On-Peak	Minn Hub Off-Peak	Midway On-Peak	Midway Off-Peak	CIG RM	Minn Hub On-Peak	Minn Hub Off-Peak	Midway On-Peak	Midway Off-Peak
2021	$1.34	$2.73	$26.96	$24.10	$24.58	$20.21	$2.73	$26.96	$24.10	$24.58	$20.21	$2.73	$26.96	$24.10	$24.58	$20.21
2022	$1.36	$2.41	$24.09	$21.86	$21.56	$17.92	$2.41	$24.09	$21.86	$21.56	$17.92	$2.41	$24.09	$21.86	$21.56	$17.92
2023	$1.41	$2.64	$25.90	$24.05	$26.10	$21.56	$2.52	$24.77	$23.00	$24.96	$20.62	$2.75	$27.03	$25.10	$27.24	$22.50
2024	$1.41	$2.73	$25.84	$24.35	$26.15	$21.81	$2.57	$24.28	$22.88	$24.57	$20.49	$2.90	$27.44	$25.86	$27.77	$23.16
2025	$1.45	$2.85	$26.78	$25.21	$27.16	$23.00	$2.62	$24.64	$23.19	$24.99	$21.16	$3.09	$29.03	$27.32	$29.44	$24.93
2026	$1.49	$2.93	$28.79	$27.56	$28.20	$24.80	$2.66	$26.14	$25.03	$25.60	$22.52	$3.22	$31.62	$30.27	$30.97	$27.24
2027	$1.53	$3.02	$28.23	$27.63	$27.70	$24.97	$2.70	$25.24	$24.70	$24.76	$22.32	$3.37	$31.49	$30.82	$30.90	$27.85
2028	$1.57	$3.12	$28.05	$28.62	$28.22	$26.51	$2.75	$24.66	$25.16	$24.81	$23.31	$3.54	$31.79	$32.44	$31.99	$30.05
2029	$1.62	$3.29	$28.89	$30.11	$28.96	$27.76	$2.82	$24.76	$25.80	$24.81	$23.79	$3.83	$33.59	$35.00	$33.67	$32.28
2030	$1.65	$3.46	$29.02	$31.63	$30.12	$29.83	$2.89	$24.26	$26.45	$25.18	$24.95	$4.12	$34.54	$37.65	$35.85	$35.51
2031	$1.69	$3.61	$29.78	$32.13	$30.83	$30.81	$2.96	$24.37	$26.30	$25.23	$25.21	$4.39	$36.20	$39.07	$37.49	$37.45
2032	$1.73	$3.69	$30.90	$33.12	$30.68	$31.03	$2.99	$25.03	$26.83	$24.85	$25.13	$4.53	$37.96	$40.69	$37.69	$38.12
2033	$1.77	$3.84	$31.02	$34.03	$30.69	$31.75	$3.05	$24.65	$27.04	$24.39	$25.23	$4.80	$38.82	$42.60	$38.42	$39.73
2034	$1.81	$3.97	$31.24	$34.67	$30.52	$32.25	$3.10	$24.39	$27.07	$23.83	$25.18	$5.06	$39.78	$44.15	$38.87	$41.07
2035	$1.85	$4.11	$31.62	$35.32	$30.65	$32.57	$3.15	$24.30	$27.14	$23.55	$25.03	$5.31	$40.90	$45.69	$39.64	$42.13
2036	$1.92	$4.25	$32.37	$36.36	$30.83	$33.72	$3.21	$24.45	$27.46	$23.29	$25.47	$5.59	$42.58	$47.82	$40.55	$44.35
2037	$1.97	$4.31	$32.26	$36.49	$30.89	$34.07	$3.23	$24.19	$27.37	$23.16	$25.55	$5.71	$42.75	$48.36	$40.93	$45.14
2038	$2.02	$4.45	$32.47	$36.95	$31.01	$34.42	$3.29	$23.96	$27.26	$22.88	$25.40	$5.99	$43.71	$49.74	$41.75	$46.34
2039	$2.07	$4.62	$32.51	$37.23	$30.80	$34.81	$3.35	$23.56	$26.98	$22.32	$25.22	$6.33	$44.56	$51.02	$42.22	$47.71
2040	$2.11	$4.79	$32.72	$37.91	$31.18	$35.93	$3.41	$23.27	$26.96	$22.18	$25.56	$6.69	$45.67	$52.90	$43.51	$50.14
2041	$2.17	$4.91	$33.21	$38.58	$30.92	$36.10	$3.45	$23.35	$27.12	$21.73	$25.38	$6.93	$46.90	$54.47	$43.65	$50.97
2042	$2.23	$5.11	$33.46	$38.94	$31.34	$36.72	$3.52	$23.07	$26.84	$21.60	$25.31	$7.35	$48.17	$56.05	$45.11	$52.85
2043	$2.29	$5.31	$33.62	$39.46	$31.16	$37.17	$3.59	$22.73	$26.68	$21.07	$25.13	$7.79	$49.31	$57.88	$45.70	$54.52
2044	$2.35	$5.52	$34.58	$40.56	$32.16	$37.98	$3.66	$22.95	$26.92	$21.34	$25.20	$8.24	$51.66	$60.60	$48.05	$56.74
2045	$2.40	$5.68	$34.57	$41.37	$31.73	$38.48	$3.72	$22.61	$27.05	$20.75	$25.16	$8.61	$52.41	$62.71	$48.10	$58.34
2046	$2.46	$5.86	$35.06	$41.88	$32.02	$38.81	$3.77	$22.58	$26.97	$20.62	$24.99	$9.02	$53.97	$64.45	$49.29	$59.74
2047	$2.52	$5.99	$35.39	$42.90	$32.40	$39.86	$3.82	$22.55	$27.33	$20.65	$25.40	$9.31	$55.03	$66.71	$50.39	$61.99
2048	$2.58	$6.17	$35.81	$43.26	$32.53	$40.55	$3.87	$22.49	$27.17	$20.43	$25.46	$9.73	$56.50	$68.26	$51.32	$63.97
2049	$2.65	$6.28	$35.76	$43.61	$32.50	$40.19	$3.91	$22.25	$27.14	$20.22	$25.01	$10.00	$56.94	$69.44	$51.75	$63.99
2050	$2.72	$6.42	$36.59	$44.99	$32.66	$40.71	$3.95	$22.52	$27.69	$20.10	$25.05	$10.33	$58.89	$72.40	$52.56	$65.51

**Coal prices are delivered prices, while gas and market prices are hub prices.*

3. <u>Firm Fuel Charges</u>

A levelized charge of $11.98/kW-yr is applied to all new generic gas fired resources to represent an estimate of the fixed costs associated with acquiring firm fuel supply to these generators either through firm gas supply or on-site fuel infrastructure. Bids will be evaluated with the Company's estimated firm gas supply costs for the bid and/or the bidder's proposed costs for on-site fuel; see Section 4.2.

4. <u>Market Prices</u>

Annual average values for the Four Corners and Midway market price locations are summarized in Table B-2 and have zero CO_2 cost assumptions.

5. <u>Coal Price Forecasts</u>

The simple average annual coal price forecast is summarized in Table B-2.

6. <u>Planning Reserve Margin</u>

The Company will utilize a Planning Reserve Margin of 18.0% applied to the 50th percentile demand forecast.

7. Surplus Capacity Credit

During portfolio creation, for each year in which the modeled portfolio includes firm generation capacity in excess of the planning reserve margin (i.e., the periods in which the Company is long capacity), surplus capacity will be credited at the equivalent cost of the generic CT for all twelve months of the year up to an excess of 200 MW. The value of the surplus capacity credit is shown below in Table B-3.

Table B-3

Surplus Capacity Credit	
Year	**$/kw-yr**
2021	$82.19
2022	$83.56
2023	$84.97
2024	$86.40
2025	$87.85
2026	$89.34
2027	$90.86
2028	$92.41
2029	$93.99
2030	$95.60
2031	$97.25
2032	$98.92
2033	$100.63
2034	$102.37
2035	$104.16
2036	$105.97
2037	$107.82
2038	$109.71
2039	$111.63
2040	$113.60
2041	$115.60
2042	$117.65
2043	$119.73
2044	$121.86
2045	$124.02
2046	$126.24
2047	$128.50
2048	$130.80
2049	$133.14
2050	$135.54

8. CO_2 Price Forecasts

Base modeling assumptions are either a \$0/ton CO_2 proxy price or the Social Cost of Carbon ("SCC"). The SCC values are shown in Table B-4 below.

Table B-4

CO2 Costs ($ per short ton)		
Year	**$0 CO2**	**SCC**
2021	$0.00	$48.06
2022	$0.00	$50.19
2023	$0.00	$52.38
2024	$0.00	$54.64
2025	$0.00	$56.97
2026	$0.00	$59.38
2027	$0.00	$61.85
2028	$0.00	$64.40
2029	$0.00	$65.69
2030	$0.00	$68.37
2031	$0.00	$71.13
2032	$0.00	$73.98
2033	$0.00	$76.91
2034	$0.00	$79.93
2035	$0.00	$83.04
2036	$0.00	$86.24
2037	$0.00	$89.53
2038	$0.00	$92.93
2039	$0.00	$96.42
2040	$0.00	$100.01
2041	$0.00	$103.71
2042	$0.00	$105.79
2043	$0.00	$109.67
2044	$0.00	$113.67
2045	$0.00	$117.79
2046	$0.00	$122.02
2047	$0.00	$126.37
2048	$0.00	$130.85
2049	$0.00	$135.46
2050	$0.00	$140.20

9. Inflation / Construction Escalation Rates

The inflation rate used for construction (capital) costs, non-fuel variable O&M, fixed O&M and any other escalation factor related to general inflationary trends is 2.0% and will be applied throughout the entire planning period as a base assumption.

10. Demand Side Management Forecasts

Table B-5 reflects the Company's forecasted demand response capacity with and without adjustment for the assumed Planning Reserve Margin.

Table B-5

	Demand Response(MW)	
Year	Un-Adjusted For Reserve Margin	Adjusted For Reserve Margin
2021	527	622
2022	527	622
2023	561	669
2024	561	669
2025	561	662
2026	586	691
2027	586	691
2028	586	691
2029	586	691
2030	605	714
2031	605	714
2032	605	714
2033	605	714
2034	605	714
2035	605	714
2036	605	714
2037	605	714
2038	605	714
2039	605	714
2040	605	714
2041	605	714
2042	605	714
2043	605	714
2044	605	714
2045	605	714
2046	605	714
2047	605	714
2048	605	714
2049	605	714
2050	605	714

11. Transmission Network Upgrade Costs

See Section 3.

12. Transmission Interconnection Costs

See Section 3.

13. Generation Capacity Credit for Wind Resources

Wind resources existing at the start of 2023 receive 13.4% of nameplate capacity as generation capacity credit.

For initial portfolio selection purposes, individual, incremental wind generation resources will receive generation capacity credit consistent with Table B-6. ERZ-5 (50%) and ERZ-5 (44%) are the ELCCs determined for a 50% NCF and a 44% NCF wind generator in ERZ-5, respectively. ELCCs will be estimated using the best available meteorological information available for wind resource proposals not consistent with any ERZ shown in Table B-6. The Company will interpolate between Incremental MW as shown in Table B-6 to accommodate actual proposals.

Table B-6

Incremental MW	ERZ-1	ERZ-2	ERZ-3	ERZ-5 (50%)	ERZ-5 (44%)
250	15.9%	12.8%	33.6%	24.2%	17.6%
500	14.5%	12.1%	31.1%	22.6%	16.7%
1,000	12.3%	11.2%	26.9%	20.2%	15.1%
2,000	9.6%	9.9%	20.1%	16.5%	12.5%
3,000	8.1%	9.0%	15.4%	14.2%	10.8%

As the ELCC study documented the impact that generation technology, penetration, and geographic diversity has on portfolio ELCC, the actual ELCC afforded any particular bid in a final portfolio will likely differ from the values shown in Table B-6. Additionally, ELCC may be adjusted for resources that propose annual net capacity factors that materially differ from the 50% annual NCF assumed in the ELCC study. See Section 5.1 for further discussion of the process through which portfolio ELCC will be determined in modeling.

14. Generation Capacity Credit for Solar Resources

Utility solar resources existing at the start of 2023 receive 47.9% of MW_AC nameplate as generation capacity credit.

For initial portfolio selection purposes, individual, incremental utility solar generation resources will receive generation capacity credit consistent with the proposed nameplate capacity and solar zone as shown in Table B-7. ELCCs will be estimated using the best available meteorological information available for solar resource proposals not consistent with any resource zone shown in Table B-7. The Company will interpolate between Incremental MW as shown in Table B-7 to accommodate actual proposals.

Table B-7

Incremental MW	MTN	NFR	SE	SFR	SLV	WS
100	21.4%	33.5%	29.3%	15.4%	28.4%	36.3%
250	19.6%	31.7%	27.4%	14.5%	26.2%	32.8%
500	16.9%	29.0%	24.3%	12.8%	22.5%	28.6%
1,000	13.3%	23.9%	19.4%	10.5%	17.2%	22.6%
2,000	9.7%	16.8%	13.7%	8.1%	11.8%	15.4%
3,000	7.8%	12.5%	10.6%	6.8%	9.3%	11.4%

As the ELCC study documented the impact that generation technology, penetration, and geographic diversity has on portfolio ELCC, the actual ELCC afforded any particular bid in a final portfolio will likely differ from the values shown in Table B-7. ELCCs may be adjusted from the values in the table for resources that propose annual net capacity factors that materially differ from the assumed 30% annual NCF or for projects that are located distant from the metered resources used in the ELCC study. See Section 5.1 for further discussion of the process through which portfolio ELCC will be determined in modeling.

15. <u>Generation Capacity Credit for Hydro and Storage Resources</u>

Based on the Company's most recent ELCC study: 1) existing hydro generation resources receive 55.4%, 2) the Company's existing Cabin Creek pumped hydro facility receives 91.7%, and 3) the storage components of solar hybrid facilities existing at the start of 2023 receive 60.4% in generation capacity credit.

For initial portfolio selection purposes, incremental storage resources will receive generation capacity credit consistent with the proposed nameplate capacity and duration as shown in Table B-8. The Company will interpolate between Incremental MW and Duration values as shown in Table B-8 to accommodate actual proposals for initial portfolio selection purposes. These values will apply to both standalone storage proposals and the storage component of renewable hybrid proposals.

Table B-8

Incremental MW	2-Hour Duration	4-Hour Duration	8-Hour Duration
50	48.8%	68.1%	92.3%
100	45.9%	65.0%	90.4%
250	39.7%	58.8%	85.2%
500	32.8%	51.0%	75.1%
1,000	26.1%	39.9%	55.3%
2,000	20.0%	27.5%	35.2%
3,000	16.3%	21.3%	25.7%

As the ELCC study documented the impact that generation technology, penetration, and geographic diversity has on portfolio ELCC, the actual ELCC afforded any particular storage bid in a final portfolio will likely differ from the values shown in Table B-8. See Section 5.1 for further discussion of the process through which portfolio ELCC will be determined in modeling.

16. Resource Acquisition Period

The Resource Acquisition Period extends through 2030. Resources must be in-service no later than May 1, 2030.

17. Planning Period

The planning period is from March 31, 2021 – June 1, 2055.

18. SO_2 Effluent Costs and Allocations

The Company will assign no effluent costs or allocations to SO_2.

19. NO_x Effluent Costs and Allocations

The Company will assign no effluent costs or allocations to NO_x.

20. Mercury Effluent Costs and Allocations

The Company will assign no effluent costs or allocations to mercury.

21. Spinning Reserve Requirement

The level of spinning reserve modeled is consistent with Northwest Power Pool requirements. The cost of spinning reserve is inherently embedded in the EnCompass model by assigning a spin requirement and the spinning capability for existing and proposed resources.

22. Emergency Energy Costs

Emergency Energy Costs are included in the EnCompass model if there are not enough resources available to meet energy requirements. In the model, the cost will be set at $1M/MWh to ensure the model makes every effort to avoid emergency energy (which is synonymous with curtailed firm load). Emergency energy costs occur only in rare instances; however, it does appear in some plans in very small amounts. To ensure large swings in plan costs are not created by these small amounts, for purposes of determining portfolio net present value these $1M/MWh costs will be replaced in post-processing with a value of $2,000/MWh ($2020) escalating at 2%.

23. Wind/Solar Integration Costs and Storage Integration Credits

Table B-9 provides the wind and solar integration costs for existing and generic wind and solar resources assumed in modeling. Incremental storage resources receive an integration cost credit applied to the storage device's discharge MWh.

Table B-9

Integration Costs ($/MWh)					Integration Credit ($/MWh)
Year	Existing Wind	Generic Wind	Existing Solar	Generic Solar	Storage
2021	$1.84	$2.47	$0.30	$0.50	$2.98
2022	$1.68	$2.31	$0.20	$0.40	$2.72
2023	$1.80	$2.43	$0.27	$0.47	$2.90
2024	$1.85	$2.48	$0.30	$0.50	$2.98
2025	$1.91	$2.54	$0.34	$0.54	$3.07
2026	$1.94	$2.57	$0.36	$0.56	$3.14
2027	$1.99	$2.62	$0.39	$0.59	$3.21
2028	$2.04	$2.67	$0.42	$0.62	$3.29
2029	$2.13	$2.76	$0.47	$0.67	$3.43
2030	$2.21	$2.84	$0.52	$0.72	$3.56
2031	$2.29	$2.92	$0.57	$0.77	$3.68
2032	$2.33	$2.96	$0.59	$0.79	$3.74
2033	$2.40	$3.03	$0.63	$0.83	$3.86
2034	$2.47	$3.10	$0.67	$0.87	$3.97
2035	$2.53	$3.16	$0.71	$0.91	$4.07
2036	$2.60	$3.23	$0.76	$0.96	$4.19
2037	$2.64	$3.27	$0.78	$0.98	$4.24
2038	$2.71	$3.34	$0.82	$1.02	$4.35
2039	$2.79	$3.42	$0.87	$1.07	$4.49
2040	$2.88	$3.51	$0.92	$1.12	$4.63
2041	$2.94	$3.57	$0.96	$1.16	$4.72
2042	$3.03	$3.66	$1.01	$1.21	$4.88
2043	$3.14	$3.77	$1.08	$1.28	$5.04
2044	$3.24	$3.87	$1.14	$1.34	$5.20
2045	$3.32	$3.95	$1.19	$1.39	$5.34
2046	$3.41	$4.04	$1.24	$1.44	$5.48
2047	$3.47	$4.10	$1.28	$1.48	$5.58
2048	$3.56	$4.19	$1.33	$1.53	$5.72
2049	$3.62	$4.25	$1.37	$1.57	$5.82
2050	$3.69	$4.32	$1.41	$1.61	$5.93

24. Owned Unit Modeled Operating Characteristics and Costs

Company-owned units are modeled based upon their tested operating characteristics and historical or projected costs. Below is a list of operating and cost inputs for each Company-owned resource:

a. Maximum Capacity
b. Minimum Capacity Rating
c. Seasonal Deration
d. Heat Rate Profiles
e. Variable O&M
f. Fixed O&M
g. Maintenance Schedule
h. Forced Outage Rate
i. Emission rates for SO_2, NO_x, CO_2, Mercury and PM
j. Contribution to spinning reserve
k. Fuel prices
l. Fuel delivery charges

25. Thermal PPA Operating Characteristics and Costs

Power Purchase Agreements ("PPA") are modeled based upon their tested operating characteristics and contracted costs. Below is a list of operating and cost inputs for each thermal purchase power contract:

a. Contract term
b. Maximum Capacity
c. Minimum Capacity Rating
d. Seasonal Deration
e. Heat Rate Profiles
f. Energy Schedule
g. Capacity Payments
h. Energy Payments
i. Maintenance Schedule
j. Forced Outage Rate
k. Emission rates for SO_2, NO_x, CO_2, Mercury and PM
l. Contribution to spinning reserve
m. Fuel prices
n. Fuel delivery charges

26. Renewable Energy PPA Operating Characteristics and Costs

PPAs are modeled based upon their tested operating characteristics and contracted costs. Below is a list of operating and cost inputs for each renewable energy purchase power contract:

a. Contract term
b. Name Plate Capacity
c. Accredited Capacity
d. Annual Energy
e. Hourly Patterns
f. Capacity Payments

g. Energy Payments
h. Integration Costs
i. Emission rates for SO_2, NO_x, CO_2, Mercury and PM if applicable

Integration and cycling costs will be updated as addressed elsewhere in this document.

27. Base Native Load Forecast

Base native load forecasts (peak annual demand and energy) with and without assumptions of incremental electric vehicle load ("EV") are shown in Table B-10.

Table B-10

Demand and Energy Forecast				
	Demand (MW)		Energy (GWh)	
Year	Forecast with EV	Forecast without EV	Forecast with EV	Forecast without EV
2021	6,856	6,847	33,010	32,943
2022	6,973	6,962	32,929	32,793
2023	6,951	6,930	33,151	32,884
2024	6,978	6,944	33,766	33,328
2025	7,031	6,985	34,170	33,567
2026	6,906	6,847	33,737	32,968
2027	6,986	6,913	34,131	33,167
2028	7,063	6,972	34,685	33,470
2029	7,130	7,015	35,104	33,570
2030	7,219	7,075	35,627	33,690
2031	7,306	7,129	36,178	33,780
2032	7,413	7,201	36,895	34,016
2033	7,478	7,230	37,462	34,081
2034	7,558	7,273	38,118	34,216
2035	7,665	7,341	38,899	34,465
2036	7,774	7,412	39,805	34,833
2037	7,862	7,461	40,516	34,998
2038	7,963	7,523	41,313	35,243
2039	8,069	7,590	42,069	35,442
2040	8,159	7,639	42,823	35,622
2041	8,216	7,656	43,379	35,593
2042	8,285	7,685	44,002	35,643
2043	8,129	7,493	43,298	34,412
2044	8,195	7,523	43,969	34,573
2045	8,245	7,535	44,466	34,522
2046	8,313	7,562	45,091	34,559
2047	8,389	7,596	45,762	34,621
2048	8,461	7,628	46,520	34,798
2049	8,509	7,640	46,991	34,759
2050	8,576	7,701	47,645	35,242

28. Low Native Load Forecast

Low native load forecasts (peak annual demand and energy) with and without assumptions of incremental electric vehicle load are shown in Table B-11.

Table B-11

Demand and Energy Forecast				
	Demand (MW)		Energy (GWh)	
Year	**Forecast with EV**	**Forecast without EV**	**Forecast with EV**	**Forecast without EV**
2021	6,856	6,847	33,010	32,943
2022	6,973	6,962	32,745	32,608
2023	6,936	6,915	32,874	32,607
2024	6,944	6,910	33,341	32,903
2025	6,960	6,914	33,554	32,950
2026	6,799	6,740	32,965	32,196
2027	6,855	6,782	33,255	32,292
2028	6,896	6,804	33,652	32,437
2029	6,945	6,830	34,015	32,482
2030	7,012	6,868	34,470	32,533
2031	7,076	6,899	34,950	32,552
2032	7,148	6,936	35,535	32,657
2033	7,196	6,948	36,060	32,678
2034	7,251	6,965	36,635	32,734
2035	7,319	6,996	37,276	32,842
2036	7,379	7,017	37,980	33,007
2037	7,437	7,036	38,592	33,075
2038	7,500	7,060	39,249	33,180
2039	7,573	7,093	39,889	33,262
2040	7,631	7,112	40,537	33,335
2041	7,679	7,119	41,084	33,297
2042	7,731	7,131	41,668	33,309
2043	7,555	6,919	40,917	32,030
2044	7,593	6,922	41,485	32,089
2045	7,636	6,926	41,976	32,032
2046	7,686	6,936	42,561	32,029
2047	7,741	6,948	43,180	32,038
2048	7,783	6,949	43,824	32,101
2049	7,822	6,954	44,286	32,053
2050	7,869	6,996	44,883	32,486

29. High Load Forecast

High native load forecasts (peak annual demand and energy) with and without assumptions of incremental electric vehicle load are shown in Table B-12.

Table B-12

Demand and Energy Forecast				
	Demand (MW)		Energy (GWh)	
Year	Forecast with EV	Forecast without EV	Forecast with EV	Forecast without EV
2021	6,875	6,856	33,188	33,010
2022	7,002	6,973	33,352	32,929
2023	6,996	6,951	33,819	33,151
2024	7,042	6,978	34,702	33,766
2025	7,120	7,031	35,452	34,170
2026	7,023	6,906	35,421	33,737
2027	7,133	6,986	36,234	34,131
2028	7,237	7,063	37,181	34,685
2029	7,328	7,130	37,951	35,104
2030	7,441	7,219	38,826	35,627
2031	7,558	7,306	39,883	36,178
2032	7,697	7,413	41,162	36,895
2033	7,798	7,478	42,351	37,462
2034	7,917	7,558	43,695	38,118
2035	8,067	7,665	45,238	38,899
2036	8,224	7,774	46,972	39,805
2037	8,363	7,862	48,575	40,516
2038	8,519	7,963	50,333	41,313
2039	8,686	8,069	52,122	42,069
2040	8,840	8,159	53,976	42,823
2041	8,962	5,659	54,858	43,379
2042	9,005	5,585	55,778	44,002
2043	8,855	5,422	55,382	43,298
2044	9,195	5,529	56,346	43,969
2045	9,419	5,639	57,071	44,466
2046	9,702	5,815	57,839	45,091
2047	9,795	5,794	58,623	45,762
2048	9,690	5,682	59,516	46,520
2049	9,882	5,751	60,181	46,991
2050	10,001	5,837	60,984	47,612

30. CO2 Tonnage Cap

Table B-13

CO2 Ton Cap		
Year	ERP	CEP
2021	-	-
2022	-	-
2023	-	-
2024	-	-
2025	-	-
2026	11,671,259	11,671,259
2027	11,671,259	11,671,259
2028	11,671,259	11,671,259
2029	11,671,259	11,671,259
2030	11,671,259	5,486,746
2031	11,224,864	5,349,577
2032	10,778,470	5,212,408
2033	10,332,076	5,075,240
2034	9,885,682	4,938,071
2035	9,439,287	4,800,902
2036	8,992,893	4,663,734
2037	8,546,499	4,526,565
2038	8,100,104	4,389,396
2039	7,653,710	4,252,228
2040	7,207,316	4,115,059
2041	6,486,584	3,703,553
2042	5,765,853	3,292,047
2043	5,045,121	2,880,541
2044	4,324,389	2,469,036
2045	3,603,658	2,057,530
2046	2,882,926	1,646,024
2047	2,162,195	1,234,518
2048	1,441,463	823,012
2049	720,732	411,506
2050	-	-

31. Market Purchases and Sales Carbon Rate

In order to estimate emissions rates associated with market purchases, the Company assumes an annual average carbon emissions pounds/MWh rate, as shown in Table B-14. For market sales, the carbon tons and costs are deducted from the Company's emissions using the annual average of the system's carbon intensity on a scenario-by-scenario and year-by-year basis in post-processing.

Table B-14

Market Purchase CO2 Rate															
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
lbs/MWh	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
lbs/MWh	450	450	450	450	450	405	360	315	270	225	180	135	90	45	0

32. Distributed Solar

Assumed levels of behind-the-meter solar and community solar gardens (MW_AC) in the Base Native Load Forecast are shown in Table B-15.

Table B-15

Distributed Solar (Nameplate MW)			
Year	Behind the Meter	Community Gardens	Total
2021	496	118	614
2022	561	185	747
2023	629	252	882
2024	686	319	1,005
2025	726	385	1,111
2026	769	451	1,220
2027	815	516	1,331
2028	872	582	1,454
2029	950	646	1,596
2030	1,046	711	1,757
2031	1,134	775	1,910
2032	1,211	839	2,050
2033	1,291	901	2,192
2034	1,374	961	2,335
2035	1,460	1,019	2,480
2036	1,549	1,079	2,628
2037	1,641	1,135	2,776
2038	1,735	1,184	2,919
2039	1,831	1,225	3,056
2040	1,928	1,268	3,196
2041	2,023	1,293	3,316
2042	2,114	1,293	3,407
2043	2,205	1,293	3,498
2044	2,297	1,293	3,590
2045	2,387	1,293	3,680
2046	2,473	1,293	3,766
2047	2,556	1,293	3,849
2048	2,636	1,293	3,929
2049	2,715	1,293	4,008
2050	2,791	1,293	4,084

Appendix C

Transmission Costs

C.1 Power Delivery Requirements

Proposals must specify delivery of capacity and energy to the Public Service system at a point of delivery within or at the boundary of the Public Service Balancing Authority Area and at a Public Service-owned transmission facility.

C.2 Proposals Requiring Third-Party Transmission Service

For proposals that will require third-party transmission service(s) for the delivery of capacity and energy to the bid-specified point of delivery on the Public Service system, respondents are responsible for any interconnection, electric losses, transmission and ancillary service arrangements required to deliver the proposed capacity and energy to the bid-specified point of delivery on a firm basis. Such proposals must identify all third-party interconnections, electric losses, transmission and ancillary service providers, components and costs, provide a complete description of those service arrangements and provide documentation that such service(s) will be available to a RFP respondent or the Company during the full term of service proposed. The cost of all such third-party services, for which an RFP respondent intends to seek compensation from the Company, must be included in the bid prices provided on the applicable forms. Respondents should recognize that wheeling and other costs associated with such services may adversely affect the cost-effectiveness of their proposals.

C.3 Interconnection Facilities and Costs

a. Generator Interconnection Facilities: Termed “Interconnection Customer’s Interconnection Facilities” in the OATT, Generator Interconnection Facilities are all facilities and equipment, including the gen tie line, located between the Facility and the Point of Change of Ownership which is typically located at the delivery substation fence.

   As discussed in Section 5.1 of this RFP, proposal-specific cost estimates of Generator Interconnection Facilities provided by bidders in Form D2 will be reviewed by the Company and, if required, the Company may request that the bidder provide additional information or update its cost estimates as needed. Such bidders must submit final bid pricing back to the Company within00205 calendar days of the date the Generator Interconnection Facilities cost estimates are provided.

b. Transmission Provider Interconnection Facilities (“TPIF”): Proposals that will require a new or upgraded electrical interconnection to the Public Service transmission system should include in their proposal pricing an estimated cost for TPIF. These are PSCo-required facilities that PSCo will own and the generator will fund. These facilities connect the Generator Interconnection Facilities to the delivery substation and facilitate the metering, relay and communications etc., between the two. Because these facilities are not considered a part of the transmission system, they are part of the cost of the generation project and must therefore be incorporated in the proposal pricing. The following table includes an estimated cost at each voltage level that should be considered if the TPIF cost has not been otherwise estimated for the project, e.g., in an interconnection study report from the Transmission Provider.

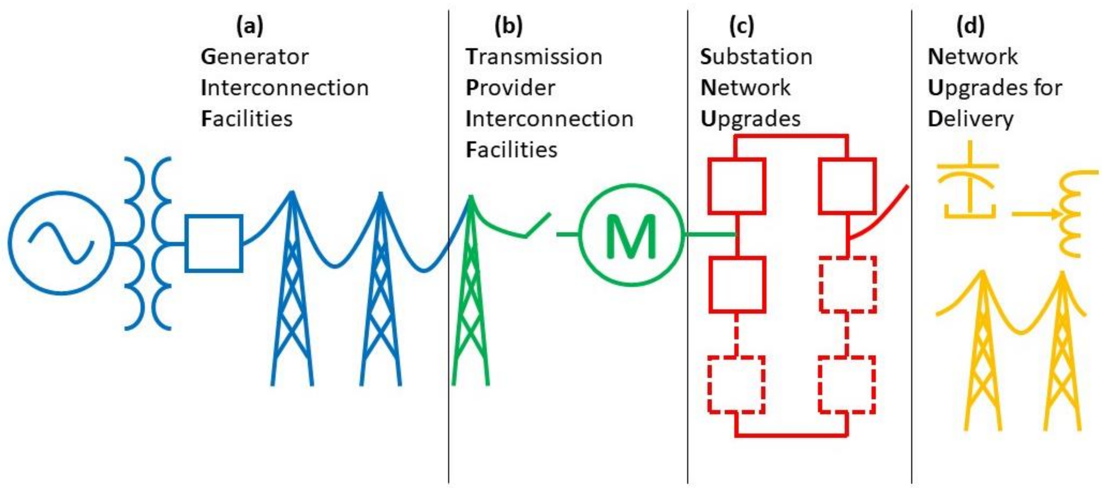
Table 3C.1 TPIF Estimated Cost

Voltage	Transmission Provider's Interconnection Facilities Estimated Cost
69 kV	$720,000
115 kV	$850,000
230 kV	$1,400,000
345 kV	$2,400,000

c. Station Network Upgrades: These are either new switchyards or additions to existing switchyards or substations that are built to interconnect the generator to the PSCo transmission system. In addition, Substation Network Upgrades become a component of the integrated PSCo transmission system and are incorporated into the PSCo transmission tariff. Respondents are not required to provide cost estimates of Substation Network Upgrades.

d. Network Upgrades for Delivery (not Interconnection Facilities, *per se*): These are upgrades to the PSCo transmission network that will be required for individual and groups of projects. These upgrades will be incorporated into the PSCo transmission tariff. Respondents are not required to provide cost estimates of Network Upgrades for Delivery.

Figure 3C.1 This illustration shows the components of each of the terms described in a-d above.



e. If the bidder has an active LGIP request, the bidder should provide the LGIP or identifier(s) (the "queue position" listed as GI-20XX-XX) associated with its project in its proposal. If the project identified in the proposal was in the queue but has since withdrawn, the bidder should provide that queue position even though it is no longer active. Bidders are urged not to submit a generation interconnection request or transmission service request pursuant to the Xcel Energy Open Access Transmission Tariff ("OATT") to receive interconnection or transmission service cost estimates for purposes of responding to this RFP, as there will be insufficient time to have studies performed and completed prior to bid selection.

C.4 Application of the Xcel Energy OATT

The Company anticipates that all transmission usage rights associated with bids selected through this RFP will be "network" use rights held by the Company. Under FERC Order No. 888[13] where the Company will hold the transmission service rights, the Company must provide non-discriminatory access to its transmission system and must designate network resources in the same manner as a similarly situated OATT customer. In addition, under FERC Order No. 2003 (August 2003), Order No. 2003-A (March 2004), Order No. 2003-B (January 2005)[14], all new requests for interconnection of a large generator (larger than 20 MW) to the Public Service transmission system, including interconnection requests associated with this RFP, must be administered in a non-discriminatory manner in compliance with the LGIP contained in the Xcel Energy OATT. Likewise, under FERC Order No. 2006 (May 2005), Order No. 2006-A (November 2005), and Order No. 2006-B (July 2006)[15], all new requests for interconnection of a small generator (less than 20 MW) to the Public Service transmission system, including interconnection requests associated with this RFP, must be administered in a non-discriminatory manner in compliance with the SGIP contained in the Xcel Energy OATT.

C.5 LGIP and SGIP Interconnection Studies

Given the short period of time available to evaluate bids, the Company's evaluation team, including the Company's Transmission Access group and Transmission Function will employ an abbreviated process for estimating the transmission Network Upgrades, associated costs and construction timeframes necessary to deliver power from proposed facilities to customer loads. In general, this abbreviated process will consist of four stages:

Stage 1 – The Transmission Access group will rely on existing LGIP or SGIP studies posted on the Public Service OASIS website to determine/verify bid-specific interconnection and delivery facilities and costs.

Stage 2 – The evaluation team will develop a number of portfolios of bids that will meet the Company's needs and the various Commission directives. The Transmission Access group will provide estimates of the Station Network Upgrades and Network Upgrades for Delivery (if known) required for each portfolio and provide that information to the Transmission Function.

Stage 3 – The Transmission Function will review the Transmission Access group's estimates of Station Network Upgrades and Network Upgrades for Delivery and modify as deemed

13 Promoting Wholesale Competition Through Open Access Non-Discriminatory Transmission Services by Public Utilities and Transmitting Utilities, Order No. 888, F.E.R.C. Stats. & Regs. 31,036, (1996) ("Order No. 888"), order on reh'g, Order No. 888-A, F.E.R.C. Stats. & Regs. 31,048 (1997), order on reh'g, Order No. 888-B, 81 F.E.R.C. ¶ 61,248 (1997) ("Order No. 888-B"), order on reh'g, Order No. 888-C, 82 F.E.R.C. ¶61,046 (1998), *aff'd* New York, et al. v. FERC, 122 S.Ct. 1012 (2002).

14 *Standardization of Generator Interconnection Agreements and Procedures*, Order No. 2003, 68 Fed. Reg. 49,845 (Aug. 19, 2003); FERC Stats. & Regs. ¶ 31,146 (2003); *reh'g granted*, Order No. 2003-A, 106 FERC ¶ 61,220 (March 5, 2004), 69 Fed. Reg. 15932 (March 26, 2004); Order No. 2003-B, 109 FERC ¶ 61,287, 70 Fed. Reg. 264 (January 4, 2005).

15 Standardization of Small Generator Interconnection Agreements and Procedures, Order No. 2006, 70 FR 34100 (Jun. 13, 2005), FERC Stats. & Regs. ¶ 31,180 (2005), (Order No. 2006), order on reh'g, Order No. 2006-A, 70 FR 71760 (Nov. 30, 2005), FERC Stats. & Regs. ¶ 31,196 (2005).

appropriate. The resulting cost information will be used to determine the bid's levelized energy cost in initial economic screening and will be included in the computer-based modeling in the event the bid is advanced to computer-based modeling.

Stage 4 – Final bid portfolios may also be entered into a Resource Solicitation Cluster as defined in the OATT. Bidders will be informed if their project is going to be represented in a Resource Solicitation Cluster and be required to provide the site control, monetary deposits and other information required under Attachment N of the OATT.

When the Resource Solicitation Cluster reaches the Facilities Study phase, the bidder will be individually responsible to comply with the OATT to bring the project through the balance of the LGIP process and execute an LGIA[16].

C.6 Network Designation and Funding of Transmission System Upgrades For Interconnection

Network Resource Designation: As indicated above, the Company anticipates that it will declare each proposal selected through this RFP as a Network Resource of the Company, and that the Company will bear the cost of any network transmission service on the Public Service system (whether or not procured under the OATT) for a proposal that is selected and achieves commercial operation. Each selected proposal not requiring a new transmission interconnection (e.g., either a generator already connected to the Public Service transmission system or each off-system generator not connected to the Public Service transmission system) and each portfolio of bids requiring new or expanded generation interconnections will be evaluated as proposed designated Network Resources pursuant to Part III of the OATT.

Funding of Network Upgrades for Interconnection: For purposes of achieving an interconnection, the Company's LGIP provides for the option of the Transmission Provider funding the network upgrades or the interconnection customer (i.e., the respondent) to fund such upgrades and receive revenue credits based on future transmission services used by the interconnection customer or through some other refunding mechanism.

Public Service's policy as the transmission provider requires the respondent to provide financial security for the upgrades identified in the LGIP studies that are conducted in connection with this RFP. If the Company determines that certain infrastructure costs are to be funded by respondents, any financing arrangements will be negotiated as part of the LGIA.

[16] Respondents that are not part of the Resource Solicitation Cluster, must work directly with the Transmission Provider to have their individual interconnection request processed through the OATT.

Appendix D

Model Asset Purchase Term Sheets and Generators Technical Specifications

Gas Term Sheet

Solar Term Sheet

Solar + Storage Term Sheet

Stand-Alone Storage Term Sheet

Wind Term Sheet

Gas Technical Specifications

Solar Technical Specifications

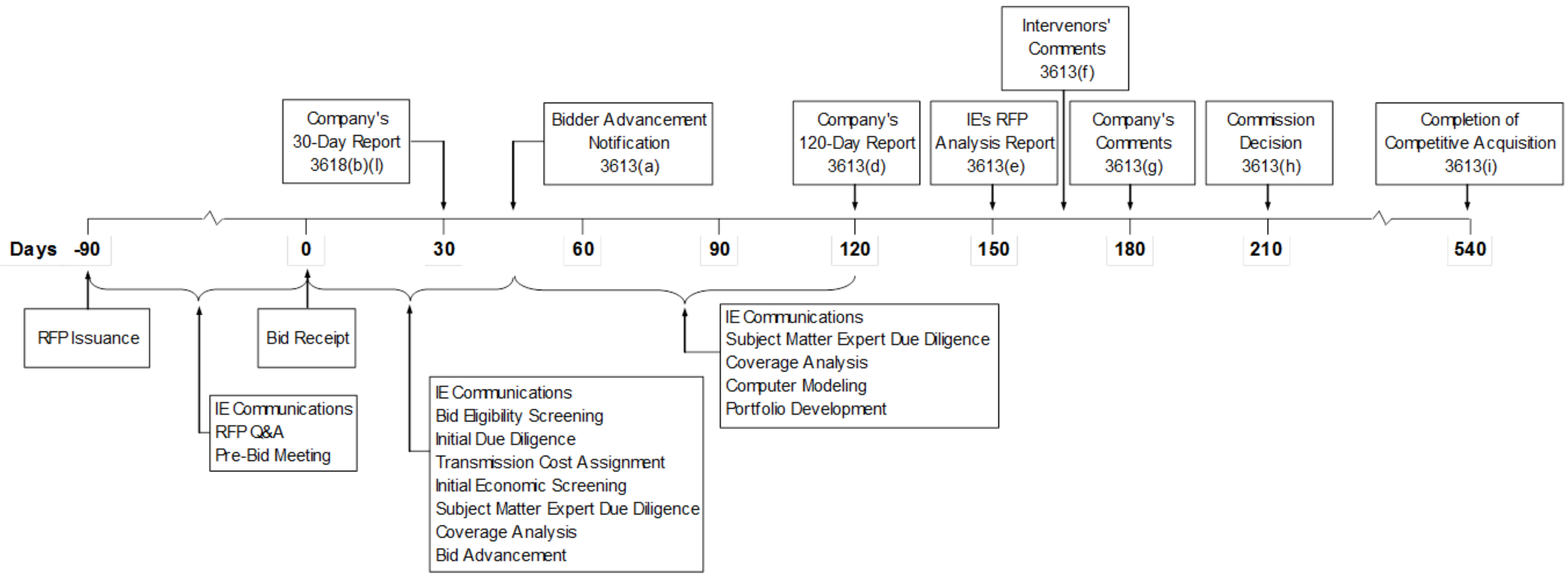
Stand-Alone Storage Technical Specifications

Wind Technical Specifications

Note for solar + storage projects reference both the solar and storage technical specifications.

Appendix E

All-Source Solicitation Timeline



Appendix F

Commission Confidentiality Order

BIDDER HIGHLY CONFIDENTIAL NONDISCLOSURE AGREEMENT

I, _______________________, state that I am employed by a bidder in Public Service Company of Colorado's 2022 All-Source Solicitation.

For purposes of this highly confidential nondisclosure agreement "Potential Resource" means the new or existing resource of the bidder by which I am employed.

For purposes of this highly confidential nondisclosure agreement "Highly Confidential Information" means highly confidential modeling inputs and assumptions that reasonably relate to the Potential Resource or to the transmission of electricity from that Potential Resource to Public Service.

I understand that I may obtain Highly Confidential Information for the sole purpose of assisting the bidder to identify modeling errors or omissions concerning its Potential Resource so that the modeling errors or omissions may be corrected before the competitive acquisition process is completed.

I hereby state that I have read the protective provisions relating to confidential information contained in 4 Code of Colorado Regulations 723-1-1100 through 1104. With respect to all Highly Confidential Information that may be provided to me, I agree to be bound by the terms of the protective provisions contained in 4 Code of Colorado Regulations 723-1-1100.

I hereby state that I will properly implement and maintain extraordinary confidentiality provisions for the Highly Confidential Information I receive.

I hereby state that the Highly Confidential Information I receive shall not be used or disclosed for any purpose other than assisting the bidder to identify modeling errors or omissions concerning its Potential Resource so that the modeling errors or omissions may be corrected before the 2022 All-Source Solicitation competitive acquisition process is completed.

I hereby state that I will not disclose or disseminate any Highly Confidential Information I receive to any third party other than to those who are specifically authorized to review such Highly Confidential Information and who have signed a highly confidential nondisclosure agreement. At the conclusion of the 2022 All-Source Solicitation competitive acquisition process, I agree to return all Highly Confidential Information to Public Service Company of Colorado.

____
Name

____
Title

____
Employer or Firm

____
Business Address

____
Bidder Represented

____
Date

____
Signature

Form A – Notice of Intent to Respond (NOIR)

PSCo All-Source 2022 Company Ownership RFP

Company Name
Street Address
City, State Zip
Company Representative Name & Title
Signature
Email
Phone Number
Project Name
Generation Technology (e.g., CT, wind, solar, storage)
Nameplate Capacity (MW)
Annual Capacity Factor (% Nameplate)
Summer Full Load Heat Rate (Btu/kWh)
Project Location (City, County, State)
Proposed Commercial Operation Date
PPA Contract Term (years)
Project Proposed as a Section 123 Resource (yes/no)
Notes (as appropriate)

Submit the NOIR by email to **TBD** by **TBD**.

Form B - Bid Certification

The bidder hereby certifies that all of the statements and representations made in this proposal are true to the best of the bidder's knowledge and belief, and agrees to be bound by the representations, terms, and conditions contained in the RFP including restrictions on the bidder's claim of confidentiality. The bidder accepts the Model PPA included in the RFP, except as specifically noted in writing. The bidder certifies that (i) the bidder has considered applicable accounting standards in regard to capital lease and variable interest entities, (ii) to the bidder's knowledge and belief, the bidder's proposal should not result in capital lease or VIE treatment to Public Service, and (iii) the bidder agrees to work with PSCo on Transmission Corridor Preservation as detailed in section 3.3 of the RFP document. The bidder acknowledges that the officer whose signature appears below is able to contractually commit the bidder for its proposal.

1)	**Submitted By:**	*(exact legal name of firm)*
2)	**Bidder:**	*(if different than above)*
3)	**Signature of an Officer of Bidder:**	
4)	**Name of Officer:**	
5)	**Title:**	
6)	**Date Signed:**	

Form C - Bid Cover Sheet

1) **Project / Facility Name** ______

2) **Project Location**
City: ______
County: ______
State: ______
Latitude: ______ °N
Longitude: ______ °W
(Lat/Long decimal format and accurate to three decimal places)

3) **Bidder Contact**
Name: ______
Company: ______
Address: ______
Phone / Fax: ______
Email: ______

4) **Alternate Contact**
Name: ______
Company: ______
Address: ______
Phone / Fax: ______
Email: ______

5) **Technology Type:** ______ (drop down list to select)
If Tech Type is Gas Thermal or Other,
Please Describe: ______
Net Capability / Nameplate Capacity (kW): ______ kW*
Solar PV Nameplate Capacity (kW-DC): ______ kW-DC**
Storage Nameplate Capacity (kW): ______ kW
Storage Duration of Nameplate Capacity (hours): ______ hours

6) **Fuel Type**
Primary: ______
Secondary: ______

7) **Capacity Factor (%):** ______

8) **Proposed Commercial Operation Date (COD):** ______

9) **Point of Delivery At:** ______

10) **Point of Delivery Is On The:** ______ (drop down list to select)

11) **Sale Type (if multiple apply, describe):** ______
(drop down list to select)
Other/Multiple Description: ______

12) **Est. Useful Life of Facility at COD (years):** ______ years

13) **Utility Providing Retail Service at Proposed Location:** ______

Unless noted otherwise--kW, kWh, MW, MWh refer to AC power and energy.
***Standard Test Conditions: 25 °C, 1 kW/m^2, AM 1.5.*

Form D1A - Pricing and Quantity for BOTs or Sale of Existing Asset

All pricing is expected to be fully compliant with applicable Technical Requirements and Model Term Sheet for the Purchase and Sale of an operational Gas, Solar, Solar with Storage, Stand-Alone Storage, or Wind Project.

1) Expected Generation (Renewables Only) - Provide expected generation levels for each year of the project's expected life, net of expected degradation impacts, if any. Expected generation should be estimated at the Point of Interconnection.

2) Schedule of Payments - Provide a schedule and amount of payments from PSCo to the bidder that seperately identifies payments for a) engineering, procurement & construction, b) land easement costs, and c) all other project related payments to be made by PSCo. Payments can be made in periodic or a single lump sum manner. All dollar amounts should be entered in nominal dollars.

3) Notes - Include pricing assumptions related to this bid. This should include assumptions regarding federal tax incentives applicable to the proposed project on the proposed in-service date. Also identify if these incentives are due to expire or decline during the term of the proposed agreement. Additionally identify if the bid includes a service management agreement or SMA. Subjects covered should also be included in bid narrative.

1) EXPECTED GENERATION		2) SCHEDULE OF PAYMENTS				
Year	Expected Generation (MWh)	Payment Date (mm/dd/yyyy)	Engineering, Procurement & Construction Payments ($)	Land and Easement Payments ($)	All Other Project Related Payments to be Made ($)	Total Payments ($)
1						$ -
2						$ -
3						$ -
4						$ -
5						$ -
6						$ -
7						$ -
8						$ -
9						$ -
10						$ -
11						$ -
12						$ -
13						$ -
14						$ -
15						$ -
16						$ -
17						$ -
18						$ -
19						$ -
20						$ -
21						$ -
22						$ -
23						$ -
24						$ -
25						$ -
26						$ -
27						$ -
28						$ -
29						$ -
30						$ -
31						$ -
32						$ -
33						$ -
34						$ -
35						$ -
36						$ -
37						$ -
38						$ -
39						$ -
40						$ -

3) Notes to Ownership Generation and Pricing:

Form D1B - FOM, VOM, Maintenance, Ongoing Capital Expenses

This form is not required for bids proposing Build-Own-Transfer proposals, as it will be completed by the Company. For bids proposing the sale of an existing asset, bidders may use this form to fill in their estimates for ongoing expenses; but should note that those estimates may be amended based on the Company's projections.

Enter for each operating year the Fixed Operation & Maintenance (FOM), Variable Operation & Maintenance (VOM), Non-Capital Maintenance Expenses, and Ongoing Capital Costs (CapX), if any, estimated to be expended. Provide the assumptions for annual generation and number of annual turbine starts used to generate the annual cost estimates. Costs should reflect expenditures necessary to reach, but not exceed, the useful life specified in Form D1A. Provide cost estimates in real dollar terms and provide the base year in the Year Dollars field.

Notes on Cost Allocations
- FOM - Costs associated with operating the plant which are independent of operational hours.
- VOM - Costs should be limited to those which are directly tied to the operation of the plant. Examples include water, chemicals or other consumables.
- Non-Capital Maintenance Expenses - Costs which are operationally dependent but do not increase in *direct* proportion to generation. For example, maintenance or overhaul costs tied to operational hours or number of starts.
- Ongoing CapX - Capitalized expenses associated with plant maintenance or overhauls.

Each column should contain non-duplicate costs such that a sum across all four columns would yield the total expected costs for that year.

Annual Generation (MWh)	0	**Number of Unit Starts per Year**		**Year Dollars**	

Operating Year	FOM ($/yr)	VOM ($/yr)	Non-Capital Maintenance Expenses ($/yr)	Ongoing CapX ($/yr)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
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39				
40				

Notes

Form D2 - Electrical Interconnection Cost Estimates

1) Electric Interconnection Costs Included in Form C1 Pricing

LGIP Identifier (or source of estimate if no LGIP):	
Generator Interconnection Facilities (including Radial Lines) ($):	
PSCo-Owned, Generator-Funded Interconnection Facilities ($):	
Interconnection Cost Price Adjustment ($/MWh)*:	

**Change in Energy Payment Rate ($/MWh) per $100,000 change in estimated cost assumption.*

2) 3rd-Party Transmission Costs Included in Form C1 Pricing

3rd-Party Transmission Provider:	

Wheeling and Ancillary Charges

OATT Schedule 1 ($/kW-mo):	
OATT Schedule 2 ($/kW-mo):	
OATT Schedule 7 ($/kW-mo):	

3) Electric Interconnection Costs Not Included in Form C1 Pricing

LGIP Identifier (or source of estimate if no LGIP):	
PSCo-Owned, PSCo-Funded Interconnection Facilities ($):	
Network Upgrades for Delivery ($):	

List, if known; else, Public Service will estimate and complete.

4) Wheeling Losses

Wheeling Losses:	

If the facility is not located at the Point of Delivery (POD), provide an estimate of the wheeling losses between the facility and the POD.

Form E - Construction Milestones

Insert the proposed date for each milestone shown here as would be found on the detailed Development Schedule provided with the proposal. Milestones should be based on the requirements to achieve the proposed commercial operation date.

Construction Milestones (Date)	Outcome
	Seller and all required counterparties shall have executed such Construction Contracts as are needed to construct the Facility.
	Seller and the Transmission Authority shall have executed the Interconnection Agreement.
	Seller shall have achieved closing on financing for the Facility or provided Company with proof of financial capability to construct the Facility.
	Seller shall have laid the foundation for all Facility buildings, generating facilities and step-up transformation facilities.
	The turbine(s)/generator(s)/step-up transformer shall have been delivered to, and installed at, the Site.
	Seller's Interconnection Facilities shall have been, and such facilities are capable of being energized.
	Start-up testing of the Facility commences.
	Commercial Operation Milestone.

Form F1 - Capacity for Thermal Resources

Provide estimated summer and winter Contract Capacities and Net Capability (in MW) that would be available to PSCo over the proposed contract term. The values should reflect the average summer and winter capacities during the commercial operating year at the Point of Delivery and must be net of all parasitic loads and house power requirements. Neither the summer or winter Contract Capacity should exceed the Net Capability.

If the proposal includes any supplemental capacity (whether from duct-firing, steam injection, or any other type), indicate the amounts available under summer and winter conditions. Note any limitations including, but not limited to, emission permitting limitations on the availabilty of such supplemental capacity. The Base and Supplemental Contract Capacity values should match the values provided on Form F3 for 100% summer and winter unit loadings.

Summer Contract Capacity should be based on an ambient temperature of 95 degrees Fahrenheit, 30% relative humidity, and altitude adjusted. Winter Contract Capacity should be based on an ambient temperature of 6 degrees Fahrenheit, 68% relative humidity, and altitude adjusted.

	SUMMER CONTRACT CAPACITY		WINTER CONTRACT CAPACITY		
Commercial Operating Year	Base (MW)	Supplemental (MW)	Base (MW)	Supplemental (MW)	Net Capability (MW)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
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24					
25					

Notes to Contract Capacity:

Form F2 - Facility Performance

1) Outages

Annual Expected Forced Outage Rate (%):		Expected Average Annual Maintenance Requirements (days/year):	

2) Manual Control

Lowest stable operating point on manual control (% of full load):		Highest stable operating point on manual control (% of full load):	
Normal Up Ramp Rate on manual control (MW/min):		Normal Down Ramp Rate on manual control (MW/min):	
Emergency Up Ramp Rate on manual control (MW/min):		Emergency Down Ramp Rate on manual control (MW/min):	

3) Automatic Generation Control (leave blank if no AGC capability)

Lowest stable operating point on AGC (% of full load):		Highest stable operating point on AGC (% of full load):	
Maximum Up Ramp Rate on AGC (MW/min):		Maximum Down Ramp Rate on AGC (MW/min):	

4) Start Times (time to start unit, sync to grid, and reach minimum load)

Off-line for 6 hours (minutes):		Off-line for 8 hours (minutes):	
Off-line for 12 hours (minutes):		Off-line for 3 days (minutes):	
Maximum load achievable in 10 minutes (% of full load):			
Maximum load achievable in 15 minutes (% of full load):		Maximum load achievable in 30 minutes (% of full load):	

5) Minimum Up Time (min. time between generator breaker close and re-open) (minutes):	
6) Minimum Down Time (min. time generator must be off-line before restarting) (minutes):	
8) Consumptive Water Use (gallons/MWh at 100% annual average base capacity)	

Notes to Facility Performance:

Form F3 - Heat Rates

For proposals involving tolling or other fuel-indexed arrangements, enter the average summer and winter heat rates at the unit loading levels indicated. Heat rates must be stated at the higher heating value (HHV), ambient air pressure of 14.7 psi at sea level adjusted to site elevation, and 95° F and 30% RH for summer conditions and 6° F and 68% RH for winter conditions.

	SUMMER		WINTER	
Unit Loading	**Capacity (MW)**	**Heat Rate (Btu/kWh)**	**Capacity (MW)**	**Heat Rate (Btu/kWh)**
Lowest stable operating point				
Lowest stable operating point on AGC				
25% of base capacity				
50% of base capacity				
75% of base capacity				
100% of base capacity				
100% of base capacity, plus 100% of supplemental capacity				

Notes to Heat Rates:

Form F4 - Heat Rate Degradation

For proposals involving tolling or other fuel-indexed arrangements, enter the predicted percentage degradation in the facility's HHV heat rate at ambient summer conditions (95° F, 30% RH, and ambient air pressure of 14.7 psi at sea level adjusted to site elevation).

Bidders should indicate if predicted heat rates are tied to unit maintenance, and if so, provide details. If Form F3 shows flat heat rates with no degradation, the proposal should indicate that bidder does not want the guaranteed heat rate to change over the life of the project.

Operating Hour Range			
Period Start (Hrs)	Period End (Hrs)	Percentage Degradation	Heat Rate (Btu/kWh)
-			
-			
-			
-			
-			
-			
-			
-			
-			
-			
-			

Notes to Heat Rates:

Form F5 - Technical Description | Solar Photovoltaic

1) Module Level Information

Manufacturer:		
Model #:		
Cell Material:		
Total # of Modules:		

2) Array Level Information

# Modules per String:		
Strings in Parallel:		
Total Active Surface Area (m^2):		m^2

3) Inverter Information

Manufacturer:		
Model #:		
Total # Inverters:		

4) Mounting/Orientation

Fixed or Track:		(drop down list to select)
Azimuth (degree):		degree
Elevation (degree):		degree

Azimuth & Elevation inputs apply to only Fixed or 1-Axis Tracking only.

5) Facility Level Information

Annual Plant Availability (%):		
Ground Coverage Ratio (%):		
Estimated Land Area (acres):		acres
Consumptive Water Use (gallon/MWh):		gallon/MWh

Notes to Technical Description | Solar PV:

Form F6 - Technical Description | Battery Energy Storage I

1) **Battery Information**

Manufacturer: ____________________

Battery Storage Chemistry: ____________________

2) **Availability During Outage (hours):** ____________ hours

3) **Annual Throughput:**

Annual Throughput Limit (MWh): ____________

Excess Annual Throughput Limit (MWh): ____________ (Optional)

Excess Throughput Charge ($/MWh): ____________ (Optional)

Annual Throughput Banking (MWh): ____________ (Optional)

Annual Throughput Borrowing (MWh): ____________ (Optional)

(If any, else leave blank. See section 8.5-6 Solar + Storage Model PPA for details)

4) **Compliance Period:** ____________ (drop down list to select)

5) **Operational Limitations**

a. State of Charge

a.1 - YTD Upper Limit in 2nd 1/2 of Op Year (%): ____________

a.2 - If a.1 Exceeds, Annual Average (%): ____________

a.3 - Limitation Released When YTD Avg. Is Less Than (%): ____________

b. Discharge

b.1 - Subsequent Discharge of Greater Than (MWh): ____________

b.2 - No Additional Discharge Greater Than (MWh): ____________

b.3 - Until Battery Idle Time Of (hours): ____________

Notes to Energy Storage Projects:

Form F7 - Technical Description | Battery Energy Storage II

1) **Guaranteed Round Trip Efficiency % (RTE):**

Commercial Operating Year	RTE (%)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
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24	
25	

2) **Performance Metrics**

Guaranteed Storage Capacity (MWh): ____________

Self-Discharge Rate (MWh/month): ____________

Guaranteed Minimum Charging Time (minutes): ____________

Guaranteed Maximum Charging Rate (MW): ____________

Guaranteed Minimum Discharging Time (minutes): ____________

Guaranteed Maximum Discharging Rate (MW): ____________

Maximum Ramp Rate (MW/second): ____________

Guaranteed Response Time (seconds): ____________

Notes to Energy Storage Projects:

Form F8 - Technical Description | Wind

1) Turbine Level Information

Manufacturer:		
Model #:		
Nameplate per Turbine (MW):		MW
Rotor Diameter (meters):		meters
Tower Height (meters):		meters
Turbines Meet the Cold-Weather Package Requirement:		(drop down list to select)

(THAT ALLOW THE TURBINES TO RELIABLY OPERATE DOWN TO TEMPERATURES OF -30 DEGREES CELSIUS (-22 DEGREES FAHRENHEIT))

2) Facility Level Information

Number of Turbines:		
Annual Plant Availability (%):		
Estimated Land Area (acres):		acres

Notes to Technical Description | Wind:

Form F9 - Technical Description | Other Tech

For bids proposing projects utilizing a primary energy source other than solar, wind or biomass (e.g., geothermal, hydro, recycled energy), complete this form. Ensure that other relevant, quantitative information is included in the Project Description Bid Narrative Topic.

1) **Consumptive Water Use (gallons/MWh):** ______________________ gallons/MWh

(AT 100% ANNUAL AVERAGE BASE CAPACITY)

Notes to Technical Description | Other:

Form F10 - Energy Production Profile - Annual and Monthly

Estimate (information below should be absent of any dispatch of storage) annual energy production for calendar years 2018 through 2022 utilizing whatever historical meteorological data are available for the site or a nearby site with similar meteorological characteristics. Explain fully in the Energy Production Profile Narrative Topic the meteorological data used for the annual estimates. Indicate the average expected hourly generation from the proposed project by month and time of day. Provide the month's total expected average generation, not just the generation from a single day. To the extent the sum of the values in the grid are different from the first year Expected Energy value on Form D1, explain fully the cause of the difference in the Energy Production Profile Narrative Topic. Estimated energy production should be gross of any expected plant degradation over time. Time is hour ending, Mountain Standard Time (i.e. do not adjust for daylight savings time).

Enter the annual expected global horizontal irradiance for the Solar Facility.

1) **Est. Annual Energy Production (MWh):**

Year	MWh
2018	
2019	
2020	
2021	
2022	

2) **Annual Expected Global Horizontal Irradiance (kWh/m²/yr):**

_______________ kWh/m²/yr

3) **Monthly Maximum Expected Hourly Generation (MWh):**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max (MWh)												

4) **Average (P50) Expected Hourly Generation (MWh):**

HE (MST)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
Sum	-	-	-	-	-	-	-	-	-	-	-	-
% of Total												
Total	-											

Notes to Energy Production Profile:

Form F11 - Section 123 Qualifications

In Decision C13-0094, the Colorado Public Utilities Commission set out its criteria for a proposed project to qualify as a Section 123 resource. For those bids claiming Section 123 status, to meet the Commission's definitions of "New" indicate in Question 1 under Method 1 and/or Method 2 below the attributes of the proposed project for which Section 123 status is claimed. To meet the Commission's definition of "Clean" complete Question 2.

1) **Qualification as New**

Method 1

List the proposed technology or technologies that have not been regularly commercially demonstrated, within Colorado or elsewhere, for which Section 123 status is claimed:

Percent of the overall installed cost is represented by this technology or technologies (%):

Method 2

List the proposed technology that has not before been implemented in the proposed configuration:

2) **Qualification as Clean**

List the attributes of the proposed project that demonstrate that it would likely cause 1) a decrease in greenhouse gas emissions or significantly reduce other pollutants and/or 2) result in reduced water usage:

Form G - Natural Gas and Backup Fuel Supply

1) Natural Gas Supply:

Identify whether the proposal is for a tolling arrangement or an electric energy sale arrangement. For tolling bids, identify the pipeline to which the bidder plans to interconnect. For energy sale (non-tolling) bids in which bidder plans to acquire and manage the fuel supply, describe supply plan and identify all contracts that support the supply of firm gas transportation and firm supply to the proposed plant.

2) Natural Gas Interconnection:

Describe the gas interconnection facilities that have been included in the Form D1 bid price, including the size, length and location of the lateral interconnection and fuel delivery point. State the capital cost estimates included in the Form D1 pricing and the change in that pricing for a $100,000 change in the capital cost estimate. Attach a USGS-based map showing the gas pipeline delivery point, the location of any lateral lines, compressors and meters.

Gas Interconnection Capital Costs Included in Form D1 Pricing ($):		
Impact on Form D1 Prices for a $100k Change in Capital Cost Estimate ($/kW-mo, levelized):		$/kW-mo

3) Natural Gas Pressure

Minimum Pressure Required at Gas Interconnection Point:		psig
Maximum Pressure Required at Gas Interconnection Point:		psig
Minimum Pressure Required at Plant Burner Tip:		psig
Gas Delivery Pressure Guaranteed by the Interconnecting Pipeline at the Fuel Delivery Point:		psig

4) Natural Gas Quantities

Indicate the maximum daily and hourly gas consumption at the proposed plant.	**Summer**	**Winter**
Maximum Daily Consumption for Electrical Generation (MMBtu/day):		
Maximum Hourly Consumption for Electrical Generation (MMBtu/hour):		

Describe any ancillary equipment which may utilize fuel when the facility is off-line and describe who is responsible for the ancillary gas usage costs. Indicate the maximum ancillary volumes:

	Summer	Winter
Maximum Daily Consumption for Ancillaries (MMBtu/day):		
Maximum Hourly Consumption for Ancillaries (MMBtu/hour):		

5) Natural Gas Quality

Indicate if any of the following pipelines have unacceptable gas quality:
(IF YES, INDICATE IN NOTES WHY)

(drop down list to select)

6) Secondary Fuel Supply:

If secondary, on-site fuel storage is proposed, describe the fuel type, including quality specifications, quantity, and maximum number of full-load run hours on secondary fuel.

Proposed Secondary Fuel, On-Site Storage Volume (gallons):		gallons
Estimated, Net Capability Run Hours On Secondary Fuel (hours):		hours

Notes to Gas Supply:

Form H - Emission Rates

Provide emission rate information for the proposed generator(s), including fuel requirements for base and supplemental capacity and/or freeze protection.

1) Emission Rates on Primary Fuel:

	Full Load on Base Capacity (lbs/MMBtu)	Full Load on Base and Supplemental Capacity (lbs/MMBtu)
Oxides of Sulfur:		
Oxides of Nitrogen:		
Carbon Dioxide:		
Carbon Monoxide		
Volatile Organic Compounds:		
Particulate Matter - PM10:		
Particulate Matter - PM2.5:		
Lead:		
Mercury:		

Maximum NO_x emission rate (in parts per million):	
Maximum CO emission rate (in parts per million):	
Maximum Permitted/Permittable Annual Capacity Factor: *(% of Net Capability)*	

2) Emission Rates on Secondary Fuel (if applicable):

	Full Load on Base Capacity (lbs/MMBtu)	Full Load on Base and Supplemental Capacity (lbs/MMBtu)
Oxides of Sulfur:		
Oxides of Nitrogen:		
Carbon Dioxide:		
Carbon Monoxide		
Volatile Organic Compounds:		
Particulate Matter - PM10:		
Particulate Matter - PM2.5:		
Lead:		
Mercury:		

Maximum NO_x emission rate (in parts per million):	
Maximum CO emission rate (in parts per million):	
Maximum Permitted/Permittable Annual Capacity Factor: *(% of Net Capability)*	

Notes to Emissions:

Public Service Company of Colorado

2022 All-Source Solicitation

Additional Appendix A Forms

Form	Title
I1	Small Generator – Distribution Interconnection
I2	Small Generator – Transmission Interconnection
I3	Large Generator – Transmission Interconnection

Form I1

Small Generator Interconnection Information – Distribution Interconnection

SMALL GENERATOR INTERCONNECTION INFORMATION

This Form should be completed by those bidders proposing to interconnect to the Company's distribution system. This is not a formal request to interconnect.

OWNER/APPLICANT INFORMATION		
Company:		
Representative:	Phone Number:	FAX Number:
Title:	Email Address:	
Mailing Address:		

PROPOSED LOCATION OF GENERATING PLANT AND PROPOSED INTERCONNECTION
Address:

PROJECT DESIGN / ENGINEERING		
Company:		
Representative:	Phone:	FAX Number:
Mailing Address:	Email Address:	

ELECTRICAL CONTRACTOR		
Company:		
Representative:	Phone:	FAX Number:
Mailing Address	Email Address:	

ESTIMATED LOAD INFORMATION			
The following information will be used to help properly design the Xcel-Customer interconnection. This information is not intended as a commitment or contract for billing purposes.			
Minimum anticipated load (generation not operating):		kVA:	Time:
Maximum anticipated load (generation not operating):		kVA:	Time:

Existing Electric Service:

Capacity:___________Amperes Voltage:____________Volts
Service Character: o Single Phase o Three Phase

Estimated In-Service Date: ____________________

Site Control Documentation: Documentation of site control must be submitted with the interconnection request as required by Code of Colorado Regulations, CCR 4 723-3, Rule 3667.

Site Control: o Ownership of Site o Option to Purchase Site o Other – Specify _______________

SMALL GENERATOR INTERCONNECTION INFORMATION

Energy Producing Equipment/Inverter Summary:

Manufacturer: ____
Model No.: ______________________ Version No.: ___________________________
o Synchronous o Induction o Inverter o Other ________________________
Rating: _______________kW Rating: __________________kVA
Generator Connection: o Delta o Wye Ungrounded o Wye Grounded
Generator Voltage: _______________ Volts
System Type Tested (Total System): o Yes o No; attach product literature
Equipment Type Tested: o Yes (i.e. Inverter, Protection System) o No; attach product literature
(Type Tested per IEEE 1547.1 or IEEE 929; i.e., Pre-certified)

(Complete all applicable items, Copy this page as required for additional generators)		
SYNCHRONOUS GENERATOR DATA		
Unit Designation:	Total number of units with listed specifications on site:	
Manufacturer:		
Type:	Date of manufacture:	
Serial Number (each):		
Phases: 1 or 3	Speed: RPM:	Frequency: Hz
Rated Output (each unit) Kilowatt: kW	Kilovolt-Ampere: kVA	
Rated Power Factor: %	Rated Voltage: V	Rated Current: A
Field Voltage: V	Field Current: A	Motoring Power: kW
Synchronous Reactance (X_d):	% on	kVA base
Transient Reactance (X'_d):	% on	kVA base
Subtransient Reactance (X''_d):	% on	kVA base
Negative Sequence Reactance (X_s):	% on	kVA base
Zero Sequence Reactance (X_o):	% on	kVA base
Neutral Grounding Resistor (if applicable): Yes No	Resistance: Ohms	
I^2t or K (heating time constant):		
Exciter data:		
Governor data:		
Additional Information:		
INDUCTION GENERATOR DATA		
Rotor Resistance (R_r): Ohms	Stator Resistance (R_s): Ohms	
Rotor Reactance (X_r): Ohms	Stator Reactance (X_s): Ohms	
Magnetizing Reactance (X_m): Ohms	Short Circuit Reactance (X_d''): Ohms	
Design Letter:	Frame Size:	
Exciting Current:	Temp Rise (deg C°):	
Rated Output: kW		
Reactive Power Required:	kVAr (no Load)	kVAr (full load)
For a wound-rotor machine, describe external equipment to be connected (resistor, rheostat, power converter, etc.) to rotor circuit, and circuit configuration. Describe ability, if any, to adjust generator reactive power output.		

SMALL GENERATOR INTERCONNECTION INFORMATION

PRIME MOVER (Complete all applicable items)

Unit Designation:	Type:		
Manufacturer:			
Serial Number:		Date of Manufacture:	
H.P. Rated:	H.P. Max:	Inertia Constant:	lb.-ft.^{2}
Energy Source (hydro, steam, wind, etc.):			
Additional Information:			

Type of Interconnected operation

Long term Parallel operation: Yes No

Closed momentary transition: Yes No Transition Closed Time: seconds

Other (describe):

TRANSFORMER (If applicable)

Manufacturer:		kVA:	
Date of Manufacture:	Serial Number:		
High Voltage: V	Connection: ☐ delta ☐ wye		Neutral solidly grounded? Yes No
Low Voltage: V	Connection: ☐ delta ☐ wye		Neutral solidly grounded? Yes No
Transformer Impedance (Z):	% on		kVA base
Transformer Resistance (R):	% on		kVA base
Transformer Reactance (X):	% on		kVA base
Neutral Grounding Resistor (if applicable) Yes No Resistance: Ohms			
Additional Information:			

INVERTER DATA (If applicable)

UL Pre-certified per UL 1741 and IEEE 929? Yes No Certification Number:

Manufacturer: Model:

Rated Power Factor (%): Rated Voltage (Volts): V Rated Current (Amperes): A

Inverter Type (ferroresonant, step, pulse-width modulation, etc.):

Type of Commutation: ☐ forced ☐ line | Minimum Short Circuit Ratio required:

Minimum voltage for successful commutation:

Current Harmonic Distortion: Maximum Individual Harmonic (%):
Maximum Total Harmonic Distortion (%):

Voltage Harmonic Distortion: Maximum Individual Harmonic (%):
Maximum Total Harmonic Distortion (%):

Describe capability, if any, to adjust reactive output to provide voltage regulation:

Additional Information:

NOTE: *Attach all available calculations, test reports, and oscillographic prints showing inverter output voltage and current waveforms.*

SMALL GENERATOR INTERCONNECTION INFORMATION

POWER CIRCUIT BREAKER (if applicable)		
Manufacturer:		Model:
Rated Voltage: kV		Rated Ampacity (Amperes): A
Interrupting Rating: A		BIL Rating: kV
Interrupting Medium (vacuum, oil, gas, etc.):		Insulating Medium (vacuum, oil, gas, etc.):
Control Voltage (Closing): (Volts) ☐ AC ☐ DC		
Control Voltage (Tripping): (Volts) ☐ AC ☐ DC ☐ Battery ☐ Charged Capacitor		
Close Energy: ☐ Spring ☐ Motor ☐ Hydraulic ☐ Pneumatic ☐ Other		
Trip Energy: ☐ Spring ☐ Motor ☐ Hydraulic ☐ Pneumatic ☐ Other		
Bushing Current Transformers (Max. ratio):		Relay Accuracy Class:
Multi Ratio? ☐ No ☐ Yes: (Available taps):		
Construction Schedule:	Start date:	Completion date:

MISCELLANEOUS (Use this area and any additional sheets for applicable notes and comments)

ADDITIONAL REQUIREMENTS: In addition to the items listed on this form, please attach:

1) Detailed One Line Diagram: o Yes
2) Installation Test Plan: o Yes
3) Site plan: o Yes
4) Major equipment (generators, transformers, inverters, circuit breakers, protective relays, isolation disconnect, etc.) specifications: oYes
5) Relaying detail: o Yes Date: ________
6) Metering telemetry: o Yes Date: ________
7) Test reports attached: o Yes Date: ________
8) Other applicable drawings or documents necessary for the proper design of the interconnection: Describe ____

Form I2

Small Generator Interconnection Information – Transmission Interconnection

This Form should be completed by those bidders proposing to interconnect to the Company's transmission system. This is not a formal request to interconnect.

Attachment 2

SMALL GENERATOR INTERCONNECTION REQUEST
(Application Form)

Transmission Provider: ____

Designated Contact Person: ____

Address: ____

Telephone Number: ____

Fax: ____

E-Mail Address: ____

An Interconnection Request is considered complete when it provides all applicable and correct information required below. Per SGIP section 1.5, documentation of site control must be submitted with the Interconnection Request.

Preamble and Instructions

An Interconnection Customer who requests a Federal Energy Regulatory Commission jurisdictional interconnection must submit this Interconnection Request by hand delivery, mail, e-mail, or fax to the Transmission Provider.

Processing Fee or Deposit:

If the Interconnection Request is submitted under the Fast Track Process, the non-refundable processing fee is $500.

If the Interconnection Request is submitted under the Study Process, whether a new submission or an Interconnection Request that did not pass the Fast Track Process, the Interconnection Customer shall submit to the Transmission Provider a deposit not to exceed $1,000 towards the cost of the feasibility study.

Interconnection Customer Information

Legal Name of the Interconnection Customer (or, if an individual, individual's name)

Name:
____

Contact Person: ____

Mailing Address:____

City: ______________________ State: ______________________ Zip: ____________________

Facility Location (if different from above): ____

Telephone (Day): ________________________Telephone (Evening): _____________________

Fax: ________________________ E-Mail Address: ____________________________________

Alternative Contact Information (if different from the Interconnection Customer)

Contact Name: ____

Title: ____

Address: ____

____

Telephone (Day): _______________________Telephone (Evening): _______________________

Fax: __________________________________E-Mail Address: ___________________________

Application is for: ____New Small Generating Facility

____Capacity addition to Existing Small Generating Facility

If capacity addition to existing facility, please describe:__________________________________

____

Will the Small Generating Facility be used for any of the following?

Net Metering? Yes ___ No ___

To Supply Power to the Interconnection Customer? Yes ___No ___

To Supply Power to Others? Yes ____ No ____

For installations at locations with existing electric service to which the proposed Small Generating Facility will interconnect, provide:

_______________________________________ _______________________________________
(Local Electric Service Provider*) (Existing Account Number*)

[*To be provided by the Interconnection Customer if the local electric service provider is different from the Transmission Provider]

Contact Name: ____

Title: ____

Address: ____

____

Telephone (Day): ____________________ Telephone (Evening): ________________________

Fax: ______________________________ E-Mail Address: ____________________________

Requested Point of Interconnection: ____

Interconnection Customer's Requested In-Service Date: _________________________________

Small Generating Facility Information

Data apply only to the Small Generating Facility, not the Interconnection Facilities.

Energy Source:____ Solar____ Wind____ Hydro____ Hydro Type (e.g. Run-of-River):_____
Diesel____ Natural Gas____ Fuel Oil____ Other (state type) ___________________

Prime Mover: ____Fuel Cell ____Recip Engine ____Gas Turb ____Steam Turb
____Microturbine ____PV ____Other

Type of Generator: _____Synchronous _____Induction _____Inverter

Generator Nameplate Rating: ____kW (Typical) Generator Nameplate kVAR: ___________

Interconnection Customer or Customer-Site Load: _________________kW (if none, so state)

Typical Reactive Load (if known): _________________

Maximum Physical Export Capability Requested: ______________ kW

List components of the Small Generating Facility equipment package that are currently certified:

Equipment Type	Certifying Entity
1. ______________________________	______________________________
2. ______________________________	______________________________
3. ______________________________	______________________________
4. ______________________________	______________________________
5. ______________________________	______________________________

Is the prime mover compatible with the certified protective relay package? ___Yes ___No

Generator (or solar collector)
Manufacturer, Model Name & Number: ____
Version Number: ____________________________

Nameplate Output Power Rating in kW: (Summer) ________ (Winter) ________

Nameplate Output Power Rating in kVA: (Summer) ________ (Winter) ________

Individual Generator Power Factor
Rated Power Factor: Leading: _____________ Lagging: _______________

Total Number of Generators in wind farm to be interconnected pursuant to this

Interconnection Request: _________ Elevation: _______ ___Single phase ___Three phase

Inverter Manufacturer, Model Name & Number (if used): ______________________________

List of adjustable set points for the protective equipment or software: _____________________

Note: A completed Power Systems Load Flow data sheet must be supplied with the Interconnection Request.

<u>Small Generating Facility Characteristic Data (for inverter-based machines)</u>

Max design fault contribution current: _______________ Instantaneous or RMS ____?

Harmonics Characteristics: __________________________

Start-up requirements: ______________________________

<u>Small Generating Facility Characteristic Data (for rotating machines)</u>

RPM Frequency: _____________
(*) Neutral Grounding Resistor (If Applicable): ____________

<u>Synchronous Generators:</u>

Direct Axis Synchronous Reactance, X_d: ________ P.U.
Direct Axis Transient Reactance, X'_d: ___________P.U.
Direct Axis Subtransient Reactance, X''_d: ______________P.U.
Negative Sequence Reactance, X_2: _________ P.U.
Zero Sequence Reactance, X_0: ____________ P.U.
KVA Base: __________________________
Field Volts: ______________
Field Amperes: ______________

Induction Generators:

Motoring Power (kW): _______________
I_2^2t or K (Heating Time Constant): _______________
Rotor Resistance, Rr: _______________
Stator Resistance, Rs: _______________
Stator Reactance, Xs: _______________
Rotor Reactance, Xr: _______________
Magnetizing Reactance, Xm: _______________
Short Circuit Reactance, Xd": _______________
Exciting Current: _______________
Temperature Rise: _______________
Frame Size: _______________
Design Letter: _______________
Reactive Power Required In Vars (No Load): _______________
Reactive Power Required In Vars (Full Load): _______________
Total Rotating Inertia, H: ______________ Per Unit on kVA Base

Note: Please contact the Transmission Provider prior to submitting the Interconnection Request to determine if the specified information above is required.

Excitation and Governor System Data for Synchronous Generators Only

Provide appropriate IEEE model block diagram of excitation system, governor system and power system stabilizer (PSS) in accordance with the regional reliability council criteria. A PSS may be determined to be required by applicable studies. A copy of the manufacturer's block diagram may not be substituted.

Primary frequency response operating range for electric storage resources:

Minimum State of Charge: __________
Maximum State of Charge: __________

Interconnection Facilities Information

Will a transformer be used between the generator and the point of common coupling? ____Yes ____No

Will the transformer be provided by the Interconnection Customer? ____Yes ____No

Transformer Data (If Applicable, for Interconnection Customer-Owned Transformer):

Is the transformer: _____single phase _____three phase? Size: ____________kVA
Transformer Impedance: _______% on __________kVA Base

If Three Phase:
Transformer Primary: _____ Volts _____ Delta _____Wye _____ Wye Grounded

Transformer Secondary: _____ Volts _____ Delta _____Wye _____ Wye Grounded
Transformer Tertiary: _____ Volts _____ Delta _____Wye _____ Wye Grounded

Transformer Fuse Data (If Applicable, for Interconnection Customer-Owned Fuse):

(Attach copy of fuse manufacturer's Minimum Melt and Total Clearing Time-Current Curves)

Manufacturer:______________ Type:_______________ Size:_________ Speed:___________

Interconnecting Circuit Breaker (if applicable):

Manufacturer: ____________________________ Type: __________

Load Rating (Amps):_______ Interrupting Rating (Amps):_______ Trip Speed (Cycles):______

Interconnection Protective Relays (If Applicable):

If Microprocessor-Controlled:

List of Functions and Adjustable Setpoints for the protective equipment or software:

Setpoint Function	Minimum	Maximum
1. ____________________	________	________
2. ____________________	________	________
3. ____________________	________	________
4. ____________________	________	________
5. ____________________	________	________
6. ____________________	________	________

If Discrete Components:

(Enclose Copy of any Proposed Time-Overcurrent Coordination Curves)

Manufacturer:	Type:	Style/Catalog No.:	Proposed Setting:
________________	________________	________________	________________
Manufacturer:	Type:	Style/Catalog No.:	Proposed Setting:
________________	________________	________________	________________
Manufacturer:	Type:	Style/Catalog No.:	Proposed Setting:

________________ ________________ ________________ ________________

Manufacturer: ________________ Type: ________________ Style/Catalog No.: ________________ Proposed Setting: ________________

Manufacturer: ________________ Type: ________________ Style/Catalog No.: ________________ Proposed Setting: ________________

Current Transformer Data (If Applicable):

(Enclose Copy of Manufacturer's Excitation and Ratio Correction Curves)

Manufacturer: ____

Type: ______________ Accuracy Class: ________ Proposed Ratio Connection: ________

Manufacturer: ____

Type: ______________ Accuracy Class: ________ Proposed Ratio Connection: ________

Potential Transformer Data (If Applicable):

Manufacturer: ____

Type: _____________ Accuracy Class: ________ Proposed Ratio Connection: ________

Manufacturer: ____

Type: _______________ Accuracy Class: ________ Proposed Ratio Connection: ________

General Information

Enclose copy of site electrical one-line diagram showing the configuration of all Small Generating Facility equipment, current and potential circuits, and protection and control schemes. This one-line diagram must be signed and stamped by a licensed Professional Engineer if the Small Generating Facility is larger than 50 kW. Is One-Line Diagram Enclosed? ____Yes ____No

Enclose copy of any site documentation that indicates the precise physical location of the proposed Small Generating Facility (e.g., USGS topographic map or other diagram or documentation).

Proposed location of protective interface equipment on property (include address if different from the Interconnection Customer's address) ______________________________________ ____

Enclose copy of any site documentation that describes and details the operation of the protection and control schemes. Is Available Documentation Enclosed? ____Yes ____No

Enclose copies of schematic drawings for all protection and control circuits, relay current circuits, relay potential circuits, and alarm/monitoring circuits (if applicable).
Are Schematic Drawings Enclosed? ___Yes ____No

Applicant Signature

I hereby certify that, to the best of my knowledge, all the information provided in this Interconnection Request is true and correct.

For Interconnection Customer:____________________________________ Date:___________

Form I3

Large Generator Interconnection Information – Transmission Interconnection

This Form should be completed by those bidders proposing to interconnect to the Company's transmission system. This is not a formal request to interconnect.

APPENDIX 1 to Revised LGIP
INTERCONNECTION REQUEST FOR A
LARGE GENERATING FACILITY

1. The undersigned Interconnection Customer submits this request to interconnect its Large Generating Facility with Transmission Provider's Transmission System pursuant to a Tariff.

2. This Interconnection Request is for (check one):
   _____A proposed new Large Generating Facility.
   _____An increase in the generating capacity or a Material Modification of an existing Generating Facility.
   _____A Generating Facility proposed for inclusion in a resource solicitation process.

3. The type of interconnection service requested (check one):
   _____Energy Resource Interconnection Service
   _____Network Resource Interconnection Service

4. Interconnection Customer provides the following information:

   a. Address or location or the proposed new Large Generating Facility site (to the extent known) or, in the case of an existing Generating Facility, the name and specific location of the existing Generating Facility;
   b. Maximum summer at ____ degrees C and winter at _____ degrees C megawatt electrical output of the proposed new Large Generating Facility or the amount of megawatt increase in the generating capacity of an existing Generating Facility;
   c. General description of the equipment configuration;
   d. Commercial Operation Date (Day, Month, and Year);
   e. Name, address, telephone number, and e-mail address of Interconnection Customer's contact person;
   f. Approximate location of the proposed Point of Interconnection (optional);
   g. Interconnection Customer Data (set forth in Attachment A)
   h. Primary frequency response operating range for electric storage resources.
   i. Requested capacity (in MW) of Interconnection Service (if lower than the Generating Facility Capacity).

5. Interconnection Customer provides applicable study deposit amount as specified in the Revised LGIP.

   $75,000 for requests of less than 50 MW; or
   $150,000 for requests of 50 MW and Greater, but less than 200 MW; or
   $250,000 for requests of 200 MW and greater

6. Interconnection Customer provides Readiness Milestone 1 (M1) as specified in the Revised LGIP.

M1 is satisfied by any one of the three options below (also described in 3.4.1.f of the Revised LGIP) at Interconnection Customer's option. M1 may also be satisfied by providing additional security described in Section 7.7.5 *in lieu* of providing one of the three options to demonstrate readiness.

i. Executed term sheet (or comparable evidence) related to a contract, binding upon the parties to the contract, for sale of (i) the constructed Generating Facility, (ii) the Generating Facility's energy, or (iii) the Generating Facility's ancillary services if the Generating Facility is an electric storage resource; where the term of sale is not less than five (5) years;

ii. Reasonable evidence the project has been selected in a Resource Plan or Resource Solicitation Process; or

iii. Provisional Large Generator Interconnection Agreement accepted for filing with FERC. Such an agreement shall not be suspended and shall include a commitment to construct the Generating Facility.

7. Interconnection Customer provides security equal to one times the study deposit described in Section 3.1 of the Revised LGIP in the form of an irrevocable letter of credit or cash.

8. If requesting NRIS: Interconnection Customer provides the expected point of delivery to deliver within the Transmission Provider's Control Area or to an adjoining Control Area if the Generating Facility is not designated a Network Resource pursuant to Section 30.2 of the Tariff.

9. Interconnection Customer provides Evidence of Site Control as specified in the Revised LGIP and Transmission Provider's business practices posted on OASIS.

10. This Interconnection Request shall be submitted to the representative indicated below:

    [To be completed by Transmission Provider]

11. Representative of Interconnection Customer to contact:

    [To be completed by Interconnection Customer]

12. This Interconnection Request is submitted by:

    Name of Interconnection Customer: ___________________________________

    By (signature): ____

    Name (type or print): ____

    Title: ____

Date: ___________________

Attachment A to Appendix 1
Interconnection Request

LARGE GENERATING FACILITY DATA

UNIT RATINGS

kVA _____________	°F _____________	Voltage _____________
Power Factor_____________		
Speed (RPM) _____________	Connection (e.g. Wye) ____________________________	
Short Circuit Ratio _________	Frequency, Hertz _________	
Stator Amperes at Rated kVA	________________________	Field Volts _______________
Max Turbine MW _________	°F _________	

Primary frequency response operating range for electric storage resources.

Minimum State of Charge:	____________
Maximum State of Charge:	____________

COMBINED TURBINE-GENERATOR-EXCITER INERTIA DATA

Inertia Constant, H =_____________kW sec/kVA
Moment-of-Inertia, WR^2 =_____________lb. $ft.^2$

REACTANCE DATA (PER UNIT-RATED KVA)

DIRECT AXIS QUADRATURE AXIS

Synchronous – saturated	X_{dv}________	X_{qv}________
Synchronous – unsaturated	X_{di}________	X_{qi}________
Transient – saturated	X'_{dv}________	X'_{qv}________
Transient – unsaturated	X'_{di}________	X'_{qi}________
Subtransient – saturated	X''_{dv}________	X''_{qv}________
Subtransient – unsaturated	X''_{di}________	X''_{qi}________
Negative Sequence – saturated	$X2_{v}$________	
Negative Sequence – unsaturated	$X2_{i}$________	
Zero Sequence – saturated	$X0_{v}$________	
Zero Sequence – unsaturated	$X0_{i}$________	

Leakage Reactance	Xl_m_______	
Open Circuit	T'_{do}________	T'_{qo}________
Three-Phase Short Circuit Transient	T'_{d3}________	T'_q________
Line to Line Short Circuit Transient	T'_{d1}________	
Short Circuit Subtransient	T''_d________	T''_q________
Open Circuit Subtransient	T'_{d2}________	
Line to Neutral Short Circuit Transient	T''_{do}________	T''_{qo}________

FIELD TIME CONSTANT DATA (SEC)
ARMATURE TIME CONSTANT DATA (SEC)

Three Phase Short Circuit	T_{a3}________
Line to Line Short Circuit	T_{a2}________
Line to Neutral Short Circuit	T_{a1}________

NOTE: If requested information is not applicable, indicate by marking "N/A."

MW CAPABILITY AND PLANT CONFIGURATION
LARGE GENERATING FACILITY DATA

ARMATURE WINDING RESISTANCE DATA (PER UNIT)

Positive	R_1________
Negative	R_2________
Zero	R_0________

Rotor Short Time Thermal Capacity I_2^2t = ________
Field Current at Rated kVA, Armature Voltage and PF =_______amps
Field Current at Rated kVA and Armature Voltage, 0 PF =_______amps
Three Phase Armature Winding Capacitance =_______microfarad
Field Winding Resistance = _______ ohms _______°C
Armature Winding Resistance (Per Phase) =_______ ohms _______°C

CURVES

Provide Saturation, Vee, Reactive Capability, Capacity Temperature Correction curves. Designate normal and emergency Hydrogen Pressure operating range for multiple curves.

GENERATOR STEP-UP TRANSFORMER DATA RATINGS

Capacity Self-cooled/

Maximum Nameplate
_______________/_______________kVA

Voltage Ratio(Generator Side/System side/Tertiary)
_______________/_______________/_______________kV

Winding Connections (Low V/High V/Tertiary V (Delta or Wye))
_______________/______________/_______________

Fixed Taps Available ____

Present Tap Setting ____

If more than one transformer stage is used to deliver the output from the proposed Generating Facility to the Transmission System, please provide the information above for each transformer or transformer type.

IMPEDANCE

Positive
Z_1 (on self-cooled kVA rating) _______________%_______________X/R

Zero
Z_0 (on self-cooled kVA rating) _______________%_______________X/R

EXCITATION SYSTEM DATA

Identify appropriate IEEE model block diagram of excitation system and power system stabilizer (PSS) for computer representation in power system stability simulations and the corresponding excitation system and PSS constants for use in the model.

GOVERNOR SYSTEM DATA

Identify appropriate IEEE model block diagram of governor system for computer representation in power system stability simulations and the corresponding governor system constants for use in the model.

WIND AND OTHER NON-SYNCHRONOUS GENERATORS

Number of generators to be interconnected pursuant to this Interconnection Request: ___________

Elevation: __________________ Single Phase ________Three Phase ________

Inverter manufacturer, model name, number, and version:
____

List of adjustable setpoints for the protective equipment or software:
____

Note: A completed General Electric Company Power Systems Load Flow (PSLF) data sheet or other compatible formats, such as IEEE and PTI power flow models, must be supplied with the Interconnection Request. If other data sheets are more appropriate to the proposed device, then they shall be provided and discussed at Scoping Meeting.

Project Information: Site Control and Adequacy

Total acres required to construct the Generating Facility: __________________________________

Total acres under site control for the Generating Facility at the time of application:
____

Is Site Control required for Interconnection Facilities, i.e. transmission gen-tie or substation, to interconnect the Generating Facility? ___ Y ___ N

> If yes, how many miles of gen-tie right-of-way are required? _______
> What is the total number of acres required to build the gen-tie? ________
> How many miles of gen-tie right-of-way are under Site Control at the time of this application?
> ________

List any local, state, or federal government permits required to construct the Generating Facility and any applicable Interconnection Facilities, i.e. transmission gen-tie:
____
____

INDUCTION GENERATORS

(*) Field Volts: ______________
(*) Field Amperes: ______________
(*) Motoring Power (kW): _________
(*) Neutral Grounding Resistor (If Applicable: ______________
(*) I_2^2t or K (Heating Time Constant): ______________
(*) Rotor Resistance: ______________
(*) Stator Resistance: ______________
(*) Stator Reactance: ______________
(*) Rotor Reactance: ______________
(*) Magnetizing Reactance: ______________
(*) Short Circuit Reactance: ______________
(*) Exciting Current: ________________
(*) Temperature Rise: ______________
(*) Frame Size: ______________
(*) Design Letter: ______________
(*) Reactive Power Required In Vars (No Load): ______________
(*) Reactive Power Required In Vars (Full Load): ______________
(*) Total Rotating Inertia, H: ______________Per Unit on KVA Base

Note: Please consult Transmission Provider prior to submitting the Interconnection Request to determine if the information designated by (*) is required.

- Draft for Discussion Purposes Only – Not an Offer -

TERM SHEET for the Purchase and Sale of a Natural Gas-Fired Energy Generation Project (the "Agreement")

Seller to provide the information Highlighted in yellow.

Buyer

Public Service Company of Colorado, a Colorado corporation ("Buyer").

Seller

[Developer/Seller Name] ("Seller"). Buyer will also require a financially capable counter-party guarantee, letter of credit, or other form of security acceptable to Buyer ("Seller Credit Support") covering all of Seller's obligations under the Agreement (defined below), including the Liquidated Damages provisions below.

Type of Transaction

The transaction will be structured as an entity acquisition. Buyer shall purchase and Seller shall sell 100% of the ownership interests of the project company ("Company"), which owns an operational natural gas-fired electricity generating plant with nameplate capacity of [XX] MW, and all facilities and all other assets and rights relating to the project (the "Project"), free and clear of all encumbrances and liabilities, except for permitted encumbrances and assumed liabilities as defined in the Agreement.

Purchase Price and Payment Terms

Buyer shall pay Seller the "Purchase Price," which is not to exceed [$XXX million] in total and is subject to certain adjustments including the capacity of the Project delivered at closing, working capital, liabilities, and, if applicable, fuel oil reserve and heat rate adjustments. Buyer shall pay the Purchase Price in a single lump sum payment at the closing. Buyer will consider making progress payments prior to Closing. Any progress payments will be tied to the achievement of specific milestones (or, if later, the occurrence of specified dates for each milestone) as outlined and agreed in the Agreement.

In no case will the amount of the Purchase Price paid prior to Closing exceed 80% of the total Purchase Price. All obligations of Seller under the Agreement will be secured via Seller Credit Support.

Buyer will be entitled to withhold from the Closing payment an amount equal to 150% of the amount sufficient to complete all punch list items, with Buyer's aggregate holdback amount not to exceed 20% of the Purchase Price.

Seller's Work and Other Responsibilities

Seller and/or Company is responsible for all work required to complete a commercially operational Project, including the integrated and operational infrastructure facilities, all radial transmission lines and other interconnection facilities (including network upgrades) required to deliver power from the Project to the point of interconnection (as described in the interconnection agreement) and the fully assembled, installed, tested and operational equipment, all in accordance with the applicable supply agreements, all manufacturer's warranties, Seller's engineering, procurement and construction subcontract, the interconnection agreement and the Agreement. All work shall be performed in accordance with prudent utility practices, prudent engineering practices, manufacturers' specifications and recommendations, Seller's quality management plan and Buyer's Technical Requirements (to be provided by Buyer as part

- Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Natural Gas-Fired Energy Generation Project (the "Agreement")

of the Agreement) that specify Buyer's standards and requirements for the design, construction, materials, equipment and supplies for certain aspects of the Project.

Seller's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Buyer to consummate the transactions contemplated are subject to the satisfaction by Seller of certain conditions as of the Closing date, including without limitation:

- Transfer of all of the ownership interests of the Company, which include all rights and title to assets necessary for the commercial operation of the Project, to Buyer or its designated affiliate.
- Evidence that any liens on the Company, Project, real property or any other assets or interests of the Company have been removed as of the Closing other than permitted liens which have been scheduled or liens which have been scheduled and bonded to Buyer's reasonable satisfaction.
- Seller has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Seller pertaining to the closing.
- Seller has delivered the title insurance commitment and title policy (premium to be paid by Seller).

Buyer's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Seller to consummate the transactions contemplated are subject to the satisfaction by Buyer of certain conditions as of the Closing date, including without limitation:

- Delivery of the Purchase Price or any remaining portion thereof, subject to certain adjustments.
- Buyer has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Buyer pertaining to the closing.

Required Approvals

The transaction is subject to obtaining specified approvals, authorizations, or orders, on or before the Closing date, including but not limited to the following (to the extent necessary):

- Approval of the board of directors of Buyer and the board of directors or similar governing body of Seller shall be obtained prior to execution of the definitive agreement.
- Third party consents.
- Applicable governmental and regulatory approvals prior to closing, including to the extent necessary, any applicable state agencies or commissions regulating utility activities and any government agencies having approval, consent or authority over the transactions contemplated by the Agreement, including, but not limited to, the Public Utilities Commission of the state of Colorado, the Colorado Department of Public Health and Environment, the IRS, the FERC, and the Department of Justice. All such approvals shall have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable.

- Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Natural Gas-Fired Energy Generation Project (the "Agreement")

Representations and Warranties

The transaction is subject to customary representations and warranties to be made by Buyer and Seller as of the execution date or the effective date of the definitive agreement and the Closing date thereunder, including the following:

- Corporate existence and powers – Seller is a [corporation] validly existing and in good standing and has the power and authority to conduct its business as now conducted.
- Company existence and powers – the Company is a limited liability company validly existing and in good standing and has the power and authority to develop, construct, operate and own the Project and has been engaged in no other business since its formation.
- Authority (execution and delivery)
- No conflicts - the transaction does not create any conflicts.
- Consents and approvals – no consent, approval or authorization is required in connection with the execution and performance of the Agreement.
- Legal proceedings of Buyer – there are no legal proceedings pending, or to Buyer's knowledge, threatened in writing, against Buyer, that affect the consummation of the transaction contemplated by the Agreement.
- Legal proceedings of Seller and Company – there are no legal proceedings pending, or to Seller's knowledge, threatened in writing, against the Seller or the Company relating to the Project or affecting Seller's ability to sell the Company or the Project and there are no material legal proceedings pending, or to Seller's knowledge, threatened in writing, against the Company relating to the Project.
- Compliance with Laws – Seller and the Company are in compliance with all laws applicable to the Seller, Company, Project and the transactions contemplated by the Agreement.
- Environmental – Seller, the Company and its affiliates have no environmental liabilities relating to the Project and are in compliance with environmental requirements relating to the Project. Seller and its affiliates have not received any notice of an alleged violation of environmental law pertaining to the Project from any governmental entity. There are no facts, circumstances, conditions or occurrences relating to the Project that could reasonably be expected to form the basis of a claim, requirement or obligation imposed by any governmental entity under any environmental law on Seller or its affiliates.
- Contracts – Schedule of material contracts binding on the Company or to which the Project is subject and Seller has furnished to Buyer true, correct and complete copies of all material contracts.
- Land Contracts – The land contracts and real property owned by the Company are in full force and effect, and shall comprise all of the real property interests necessary in connection with the acquisition, development, construction, installation, interconnection, completion and operation of the Project, all in accordance with all laws, and are sufficient to enable the Project to be commercially operable as contemplated in the Agreement, including legal and physical ingress and egress rights to and from public right-of-way for construction, operation, and maintenance of the Project.

- Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Natural Gas-Fired Energy Generation Project (the "Agreement")

- Permits - All permits required to develop, construct, own, and attain commercial operation of the Project are held by the Company, are final and non-appealable, are scheduled, and Seller has obtained and furnished to Buyer true, correct and complete copies of such permits. Such permits are in full force and effect and are legal, valid, binding and enforceable in accordance with their respective terms.
- Title – The Company is in possession of and has good and marketable title to the Project free and clear of all encumbrances, except for Permitted Encumbrances. Seller has good and marketable title to the Company's equity interests, free and clear of all encumbrances. Seller and its affiliates have no legal obligation to, or non-binding agreement in principle with any other person, to sell or affect a sale of all, or any portion of, the Project or the Company.
- Other representation and warranties customary in a transaction of this nature, including those pertaining to taxes, title, finders, intellectual property, brokers and insurance.

<u>Other Agreements</u>

- Interconnection. Seller shall be responsible for complying with all requirements necessary to attain the interconnection of the Project (including but not limited to construction or modification of any interconnection facilities, network upgrades or transmission lines required)
- Fuel Supply. If the Project is not located within Buyer's natural gas distribution service territory, the Company shall have entered into a fuel supply agreement acceptable to Buyer for the supply of natural gas.
- Technology. The major equipment components of the Project shall be manufactured by manufacturers reasonably acceptable to Buyer.
- Buyer's right to inspect. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. Such inspection of any part of the work shall in no way relieve Seller of its obligations under the agreement.
- Seller shall assume all risks arising from any change in its commodity prices and all changes associated with any change in law affecting Seller's Project costs including, but not limited to, changes in tariff rates.
- Seller shall be responsible for all taxes relating to the pre-closing period and all transfer taxes and any sales, use or other taxes related to the purchase and sale of the ownership interests of the Company and any purchase or conveyance of real or personal property to the Company to be used in the Project.
    - Liquidated Damages:
        - Delay Damages: Seller shall make a per diem liquidated damages payment, in an amount of $400/MW, for each day after a guaranteed substantial completion date that the Project has not achieved substantial completion, such delay damages not to exceed an agreed percentage of the Purchase Price in the aggregate.
        - SCADA Infrastructure Delay Damages: Seller agrees that if SCADA Infrastructure Completion (definition to be agreed in the Agreement) is not achieved by [date TBD] ("Guaranteed SCADA Infrastructure Completion Date"), then Seller shall pay as liquidated damages to Buyer an amount equal to $5,000.00 per day for each day after the Guaranteed SCADA Infrastructure Completion Date but prior to the date on which SCADA Infrastructure Completion is achieved.

- Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Natural Gas-Fired Energy Generation Project (the "Agreement")

- NERC Matters: Seller shall comply with the NERC Reliability Requirements applicable to generating projects during the period from the date of interconnection and up until the Closing Date and shall ensure the Project meets all NERC Reliability Requirements under the interconnection agreement. Seller shall maintain records required by NERC of such compliance actions and shall perform such other tasks and responsibilities as are set forth in Buyer's Technical Requirement. No later than fifteen (15) business days before Closing, Seller will provide Buyer current applicable compliance records related to the Project developed during testing or prior to Closing (such as test records, relay settings, energization and synchronization reporting activities, and voltage schedule). Seller will provide Buyer design documents required by NERC (such as the Reactive Power Report, Reactive Power Control design (for VAR-002 and to meet the Voltage Schedule), Facility Ratings, Coordination Studies, etc.) no later than 30 days before Closing.

<u>Termination Provisions</u>

The Agreement may be terminated prior to the Closing upon written notice by the terminating party (as described below) in the event of certain occurrences, including:

- By either party, in the event the closing has not occurred by the Outside Closing Date , regardless of the reason for such termination, provided that the terminating party is not in breach of the Agreement.
- By either party in the event regulatory approvals for the transaction are not obtained in form and substance acceptable to Buyer in its sole discretion.
- By Buyer in the event any authority has issued an order or taken any other action that restrains, enjoins, or otherwise prohibits the consummation of the transactions contemplated by the Agreement.
- By either party in the event of a material uncured breach or repudiation of the Agreement by the other party.
- By Buyer in the event of abandonment of the Project by the Company.
- By either party if the other party or, in the case of Seller, the provider of the Seller Credit Support, suffers insolvency or bankruptcy.
- By Buyer if there is a change of control of Seller.
- Termination Payment. Without limiting any other legal or contractual right or remedy available to Buyer (including Buyer's rights to liquidated damages under the Agreement that accrued prior to such termination), if the Agreement is terminated Seller will pay to Buyer a termination payment if the Closing has not occurred by the Outside Closing Date, an amount equal to $125.00 multiplied by the number of kW in the nameplate capacity;

  provided, that Seller shall have no obligation to make a termination payment if the termination is a result of (i) a material uncured breach or repudiation by Buyer; (ii) Buyer's failure to obtain the required regulatory approvals by [date TBD], or (iii) Buyer's insolvency or bankruptcy.
- Return of Progress Payments. In addition to any termination payment owing by Seller to Buyer, if the Agreement is terminated prior to Closing Seller will repay to Buyer the aggregate amount of any progress payments paid by Buyer as of such date.

- Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Natural Gas-Fired Energy Generation Project (the "Agreement")

Indemnification

Each party shall indemnify and hold harmless the other party and its respective employees, representatives, officers, directors and agents from and against any and all damages arising out of the result of any breach or violation of any representation, warranty, covenant, inaccuracy within the Agreement, or any liability not assumed as part of the Agreement, or any fraud, willful misconduct, or negligence in performance of this Agreement. Seller shall indemnify Buyer for any environmental (including hazardous material) claims arising prior to the closing date other than environmental claims resulting from Buyer's negligence. No claim for indemnification shall be brought against the indemnifying party until the total damages for which such party is liable exceeds in the aggregate a threshold amount of $100,000, at which point indemnification may be sought for the full aggregate amount of damages, including those amounts that do not exceed the threshold. The aggregate damages to which the indemnified parties are entitled shall not exceed the indemnity cap, which shall be at least 30% of the purchase price. Such threshold and indemnity cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or a breach of certain "fundamental" representations (as applicable to each party) such as corporate existence, power, authority, conflicts, title, land contracts, real property, environmental, intellectual property or tax matters or any liability not assumed as part of the Agreement. The aggregate damages to which the indemnified parties are entitled shall not exceed the Purchase Price. Such cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or any liability not assumed as part of the Agreement.

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TERM SHEET for the Purchase and Sale of a Solar Photovoltaic Electric Generation Project

Seller to provide the information Highlighted in yellow.

Buyer

Public Service Company, a Colorado corporation ("Buyer").

Seller

[Developer/Seller Name] ("Seller"). Buyer will also require a financially capable counter-party guarantee, letter of credit, or other form of security acceptable to Buyer ("Seller Credit Support") covering all of Seller's obligations under the Agreement (defined below), including the Liquidated Damages provisions below.

Type of Transaction

The transaction will be structured as an entity acquisition. Prior to the Project being placed in service for U.S. federal income tax purposes, and subject to the other terms and conditions contained in a definitive purchase and sale agreement pertaining to the transaction (the "Agreement"), Buyer shall purchase and Seller shall sell 100% of the ownership interests of the project company ("Company"), a special purpose vehicle which owns a mechanically complete, ready to be tested and placed in service, Investment Tax Credit ("ITC") qualified, integrated solar photovoltaic-powered electricity generating plant with a nameplate capacity of [XX] MW AC (the "Expected Nameplate Capacity"), with single-axis tracking design, and all facilities and all other assets and rights relating to the project (the "Project"), free and clear of all encumbrances and liabilities, except for permitted encumbrances and specific assumed liabilities as defined in the Agreement (the consummation of such purchase and sale transaction, the "Closing"). In any case, Seller would remain obligated after the Closing to perform the *Seller's Work and Other Responsibilities* (described below) and all of its other obligations described in the Agreement.

Purchase Price and Payment Terms

Unless the parties agree to progress payments, the "Purchase Price," which is not to exceed [$ per MW AC], will be paid by Buyer in two installments, one installment at Closing and one installment on the date (the "Substantial Completion Date") upon which Seller has achieved an agreed set of "Substantial Completion CPs" (which Substantial Completion CPs shall include without limitation that the Project has been placed in service for U.S. federal income tax purposes in order to qualify for the ITCs). Subject to Seller providing Seller Credit Support acceptable to Buyer, Buyer will consider making progress payments from and after the Firm Date (defined below) and prior to Closing. Any progress payments will be tied to the achievement of specific milestones (or, if later, the occurrence of specified dates for each milestone) as outlined and agreed in the Agreement.

In no case will the amount of the Purchase Price paid prior to the Substantial Completion Date exceed 80% of the total Purchase Price, and Buyer will be entitled to withhold from the Purchase Price installment paid in connection with the Substantial Completion Date an amount equal to 150% of the amount sufficient to complete all punch list items.

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Solar Photovoltaic Electric Generation Project

Conditions Precedent to the Firm Date

The Agreement shall provide for the satisfaction, on or prior to the Outside Firm Date (defined below) and in each case in form and substance acceptable to Buyer and at Seller's sole cost (except for costs of obtaining Buyer's regulatory approvals, which shall be at Buyer's sole cost) certain conditions precedent ("Firm Date CPs," and the date all such Firm Date CPs have been satisfied or waived in writing by Buyer, the "Firm Date"). The Firm Date CPs will include, without limitation, that: all regulatory approvals Buyer requires from the Public Utilities Commission of the state of Colorado (the "CPUC"), and all other required governmental approvals and permits (including without limitation the siting permit, environmental permits, and, if applicable, FERC approvals, and approvals under the Hart-Scott-Rodino Antitrust Improvements Act of 1976) have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable; Seller has obtained all land contracts (including that Seller shall obtain (x) amendments to the existing leases as needed to ensure that the lease payment provisions and other applicable terms provide for utility ownership, that the term of the leases is no shorter than the 35 years following construction of the Project and/or to address other matters reasonably required by Buyer, and (y) new lease agreements required for site setbacks or other requirements or otherwise reasonably required by Buyer) and otherwise secured full site control, including real estate rights required to interconnect the Project; Seller has obtained and delivered to Buyer title reports and title insurance commitments, and completed any curative work required by Buyer, solar equipment and other required equipment procurement agreements, O&M agreement (if applicable), construction contracts, letters of credit and guarantees, all third-party reports and studies (including without limitation those relating to wildlife, environmental, geotechnical, archaeological, noise impact, solar resources, engineering and cost segregation) and related reliance letters, and all required third-party estoppels (including with respect to each lease and other land contracts) and third-party consents; the design documents have been finalized; Buyer has received a bring down of the Signing Opinion (defined below) confirming the Signing Opinion as of the Firm Date and otherwise in form and substance acceptable to Buyer; Buyer has secured interconnection rights for the Project and obtained an effective interconnection agreement for the Project acceptable to Buyer. Seller will provide Buyer with evidence that the Firm Date CPs have been satisfied in accordance with the terms of the Agreement, and Buyer will have a stated period to object to whether the Firm Date CPs have in fact been so satisfied. The "Outside Firm Date" will be [date TBD].

Seller's Work and Other Responsibilities

Seller will be responsible, at its sole cost and expense, under the Agreement for all work required to achieve Project final completion, including with respect to the Project substation, O&M building, and all other integrated and operational infrastructure facilities, all radial transmission lines and other interconnection facilities required to deliver power from the electric grid to the Project and from the Project to [insert] substation/point of interconnection, and including without limitation the fully assembled, installed, tested and commercially operational solar photovoltaic panels and inverter and related equipment, all in compliance with prudent utility practices, prudent engineering practices, applicable law, applicable permits, an agreed site plan, the applicable supply agreements, all manufacturer's warranties, specifications and recommendations, the operations and maintenance agreement (if applicable), the applicable construction agreements, the interconnection agreement, Seller's quality management plan, Buyer's Technical Requirements (to be provided by Buyer as part of the Agreement) that specify Buyer's standards and requirements for the design, construction, materials, equipment and supplies for certain aspects of the Project, and the Agreement (the foregoing, collectively,

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Solar Photovoltaic Electric Generation Project

the "Performance Standard"). Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. For the avoidance of doubt, the foregoing obligations of Seller will continue after the Closing and Seller will remain responsible for all costs and expenses of completing the work, including those arising under the applicable supply agreements and construction agreements.

Seller's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Buyer to consummate the transactions contemplated are subject to the satisfaction by Seller of certain conditions as of the Closing date, including without limitation:

- Achievement of the Firm Date.
- Transfer of all of the ownership interests of the Company, which include all rights and title to assets relating to the Project, to Buyer or its designated affiliate.
- Certification that the Project has achieved project mechanical, electrical and structural completion in compliance with the Performance Standard.
- Buyer has received, at Seller's sole cost, a bring down of the Signing Opinion confirming the Signing Opinion as of the Closing date and otherwise in form and substance acceptable to Buyer.
- Evidence that any liens on the Company, Project, real property or any other assets or interests of the Company have been removed as of the Closing other than permitted liens which have been scheduled or liens which have been scheduled and bonded to Buyer's satisfaction.
- Seller has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Seller pertaining to the closing.
- Seller has delivered the title insurance commitment and title policy (premium to be paid by Seller).

Buyer's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Seller to consummate the transactions contemplated are subject to the satisfaction by Buyer of certain conditions as of the Closing date, including without limitation:

- Payment of the Purchase Price installment due on the Closing date, subject to certain adjustments.
- Buyer has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Buyer pertaining to the closing.

Required Approvals

The transaction is subject to obtaining specified approvals, authorizations, or orders, on or before the Closing date, including without limitation (to the extent necessary):

- Approval of the board of directors of Buyer and the board of directors or similar governing body of Seller shall be obtained prior to execution of the definitive agreement.
- Third party consents.

- Applicable governmental and regulatory approvals prior to Closing, including to the extent necessary, any applicable state agencies or commissions regulating utility activities and any government agencies having approval, consent or authority over the transactions contemplated by the Agreement, including without limitation the CPUC, the IRS, the FERC, the Department of Justice, the US Fish and Wildlife Service and the FAA. All such approvals shall have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable.

Representations and Warranties

The transaction is subject to customary representations and warranties to be made by Buyer and Seller as of the execution date or the effective date of the definitive agreement, the Firm Date, and the Closing date thereunder, including without limitation:

- Corporate existence and powers – Seller is a [corporation] validly existing and in good standing and has the power and authority to conduct its business as now conducted.
- Company existence and powers – the Company is a limited liability company validly existing and in good standing and has the power and authority to develop, construct, operate and own the Project and has been engaged in no other business since its formation.
- Authority (execution and delivery)
- No conflicts - the transaction does not create any conflicts.
- Consents and approvals – no consent, approval or authorization is required in connection with the execution and performance of the Agreement.
- Legal proceedings of Buyer – there are no legal proceedings pending, or to Buyer's knowledge, threatened, against Buyer, that affect the consummation of the transaction contemplated by the Agreement.
- Legal proceedings of Seller and Company – there are no legal proceedings pending, or to Seller's knowledge, threatened, against (i) Seller relating to the Project or affecting Seller's ability to sell the Company or (ii) the Company or the Project, and there are no material legal proceedings pending, or to Seller's knowledge, threatened, against (x) the Company relating to the Project or (y) the Company or the Project.
- Compliance with Laws – Seller and the Company are in compliance with all laws applicable to Seller, Company, Project and the transactions contemplated by the Agreement.
- Environmental – Seller, the Company and its affiliates have no environmental liabilities relating to the Project and are in compliance with environmental requirements relating to the Project. Seller and its affiliates have not received any notice of an alleged violation of environmental law pertaining to the Project from any governmental entity. There are no facts, circumstances, conditions or occurrences relating to the Project that could reasonably be expected to form the basis of a claim, requirement or obligation imposed by any governmental entity under any environmental law on Seller or its affiliates.
- Contracts – Schedule of contracts (i) binding on the Company, (ii) binding on Seller that relate to the Project, or (iii) to which the Project is subject or bound, and Seller has furnished to Buyer true, correct and complete copies of all such contracts.
- Land Contracts – The land contracts and real property owned by the Company are in full force and effect, and shall comprise all of the real property interests necessary in connection with the

acquisition, development, construction, installation, interconnection, completion and operation of the Project, all in accordance with all laws, and are sufficient to enable the Project to be commercially operable as contemplated in the Agreement, including legal and physical ingress and egress rights to and from public right-of-way for construction, operation, and maintenance of the Project.

- Permits - All permits required to develop, construct, own, and attain commercial operation of the Project are held by the Company, are final and non-appealable, are scheduled, and Seller has obtained and furnished to Buyer true, correct and complete copies of such permits. Such permits are in full force and effect and are legal, valid, binding and enforceable in accordance with their respective terms.
- Solar Data – Seller has delivered to buyer true, correct and complete copies of all insolation and related meteorological data, and energy production estimates if any, related to the Project.
- Title – The Company is in possession of and has good and marketable title to the Project free and clear of all encumbrances, except for Permitted Encumbrances. Seller has good and marketable title to the Company's equity interests, free and clear of all encumbrances. Seller and its affiliates have no legal obligation to, or non-binding agreement in principle with any other person, to sell or affect a sale of all, or any portion of, the Project or the Company.
- Other representation and warranties customary in a transaction of this nature, including those pertaining to ITCs, taxes, title, finders, intellectual property, brokers and insurance or that are required following Buyer's due diligence review.

Other Agreements

- Interconnection. Seller shall be responsible for complying with all costs and requirements necessary to attain the final interconnection of the Project, including, but not limited to, all costs for the construction of any gen tie transmission line to [insert] substation/point of interconnection and any necessary network upgrade costs.
- Technology. The major equipment components of the Project shall be manufactured by top tier manufacturers acceptable to Buyer as specified in Buyer's Technical Requirements.
- Buyer's right to inspect. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. Such inspection of any part of the work shall in no way relieve Seller of its obligations under the agreement.
- Seller will cause the Project to satisfy (in accordance with the Internal Revenue Code and associated guidance) requirements that qualify the project for the ITC at the [XX%] level. Seller has qualified the project for the ITC using the following process: [Seller to provide detailed description of qualification method]
- At Seller's cost, a legal opinion (the "Signing Opinion") from tax counsel selected by Buyer and in form and substance acceptable to Buyer shall be delivered to Buyer prior to the effective date of the Agreement, which Signing Opinion shall speak to the tax benefits associated with the transactions contemplated by the Agreement accruing to Buyer upon or after the Closing, and must include, without limitation, an opinion that, under the rules, regulations, and other laws in effect as of the date of the Signing Opinion, the Project will, based on among other things, the representations made by Seller on the date the Signing Opinion is delivered, generate a [XX%] ITC (including by having begun construction, within the meaning of applicable IRS guidance, on or prior to December 31, 20[XX]) and, assuming the Closing occurs, that the exclusive rights

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Solar Photovoltaic Electric Generation Project

to such investment tax credits will accrue to Buyer upon the placed in service date of the Project in accordance with applicable law and tax rules.

- In addition to, and independent of any pass-through warranties from the panel, inverter, racking and monitoring equipment manufacturers, balance of plant contractor and other suppliers and subcontractors, Seller shall provide a full wrap project warranty of no less than two years in duration as to defects in materials, workmanship and title, quality of work and performance as intended as a solar photovoltaic energy generation system.
- Seller shall assume all risks arising from any change in its commodity prices and all changes associated with any change in law affecting Seller's Project costs including, but not limited to, changes in tariff rates.
- Seller shall be responsible for all taxes relating to the pre-closing period and all transfer taxes and any sales, use or other taxes related to the purchase and sale of the ownership interests of the Company and any purchase or conveyance of real or personal property to the Company to be used in the Project.
- Buyer will not be required to close if the aggregate nameplate capacity of the Project is less than 95% of the Expected Nameplate Capacity (the "Minimum Capacity").
- Liquidated Damages:
  - Delay Damages: Seller shall make a per diem liquidated damages payment, in an amount of $400/MW, for each day after a guaranteed substantial completion date that the Project has not achieved the Substantial Completion Date, such delay damages not to exceed an agreed percentage of the Purchase Price in the aggregate.
  - SCADA Infrastructure Delay Damages: Seller agrees that if SCADA Infrastructure Completion (definition to be agreed in the Agreement) is not achieved by [date TBD] ("Guaranteed SCADA Infrastructure Completion Date"), then Seller shall pay as liquidated damages to Buyer an amount equal to $5,000.00 per day for each day after the Guaranteed SCADA Infrastructure Completion Date but prior to the date on which SCADA Infrastructure Completion is achieved.
  - Buy-Down Damages: If the Closing occurs and the aggregate nameplate capacity of the Project as of the Substantial Completion Date is equal to or greater than the Minimum Capacity but less than the Expected Nameplate Capacity, Seller will be required to pay liquidated damages in an amount to be agreed in the Agreement.
  - Outside SC Date Damages: If the Closing occurs and the Project fails to achieve the Substantial Completion Date on or before [date TBD], Seller shall pay Buyer an amount equal to the net present value (using a discount rate corresponding to Buyer's then-current average weighted cost of capital) of the grossed-up pre-tax value of any resulting lost ITCs.
- NERC Matters: Seller shall comply with the NERC Reliability Requirements applicable to generating projects during the period from the date of Closing and the Substantial Completion Date and shall ensure the Project meets all NERC Reliability Requirements under the interconnection agreement. Seller shall maintain records required by NERC of such compliance actions and shall perform such other tasks and responsibilities as are set forth in Buyer's Technical Requirements. No later than fifteen (15) business days before Closing, Seller will provide Buyer current applicable compliance records related to the Project developed during testing or prior to Closing (such as test records, relay settings, energization and synchronization reporting activities, and voltage schedule). Seller will provide Buyer design documents required by NERC (such as

the Reactive Power Report, Reactive Power Control design (for VAR-002 and to meet the Voltage Schedule), Facility Ratings, Coordination Studies, etc.) no later than 30 days before Closing.

Termination Provisions

The Agreement may be terminated upon written notice by the terminating party (as described below) in the event of certain occurrences, including without limitation:

- If applicable, by Buyer if the Firm Date has not occurred by the Outside Firm Date, regardless of the reason for such failure, provided that the terminating party is not in breach of the Agreement.
- By either party if the Closing has not occurred by the Outside Closing Date [date TBD], regardless of the reason for such termination, provided that the terminating party is not in breach of the Agreement.
- By either party if regulatory approvals for the transaction are not obtained by the Outside Firm Date on terms acceptable to Buyer in its sole discretion.
- By Buyer if applicable law or any order issued by, or any other action taken by, an authority restrains, enjoins, or otherwise prohibits the consummation of the transactions contemplated by the Agreement.
- By either party in the event of a material uncured breach or repudiation of the Agreement by the other party.
- By Buyer in the event of abandonment of the Project by Seller or the Company.
- By either party if the other party or, in the case of Seller, the provider of the Seller Credit Support, suffers insolvency or bankruptcy.
- By Buyer if there is a change of control of Seller.
- By Buyer if Closing has occurred but the Substantial Completion Date has not occurred by [date TBD].
- Termination Payment. Without limiting any other legal or contractual right or remedy available to Buyer (including Buyer's rights to liquidated damages under the Agreement that accrued prior to such termination), if the Agreement is terminated Seller will pay to Buyer a termination payment in the indicated amount:
    - if the Firm Date has not occurred and the termination occurs on or prior to Outside Firm Date, an amount equal to $75.00 multiplied by the number of kW AC in the Expected Nameplate Capacity;
    - if the Closing has not occurred by the Outside Closing Date, an amount equal to $125.00 multiplied by the number of kW AC in the Expected Nameplate Capacity;
    - if the Closing has occurred but the Substantial Completion Date has not occurred by on or before [date TBD], and without duplication of Outside SC Date Damages described above that accrued prior to the termination, an amount equal to:
        - the net present value (using a discount rate corresponding to Buyer's then-current average weighted cost of capital) of the grossed-up pre-tax value of any resulting lost ITCs; *plus*

- an amount, which may be positive or negative, equal to Buyer's costs to achieve final completion of the Project *less* the remaining unpaid Purchase Price;

provided, that Seller shall have no obligation to make a termination payment if the termination is a result of (i) a material uncured breach or repudiation by Buyer; (ii) Buyer's failure to obtain the required regulatory approvals by [date TBD], or (iii) Buyer's insolvency or bankruptcy.

- Return of Progress Payments. In addition to any termination payment owing by Seller to Buyer, if the Agreement is terminated prior to Closing Seller will repay to Buyer the aggregate amount of progress payments paid by Buyer as of such date.

Indemnification

Each party shall indemnify and hold harmless the other party and its respective employees, representatives, officers, directors and agents from and against any and all damages arising out of any breach or violation of any representation, warranty, covenant, inaccuracy within the Agreement, or any liability not assumed as part of the Agreement, or negligence in performance of the Agreement. Seller shall indemnify Buyer for any environmental (including hazardous material) claims arising prior to the Closing date. No claim for indemnification shall be brought against the indemnifying party until the total damages for which such party is liable exceeds in the aggregate a threshold amount of $100,000, at which point indemnification may be sought for the full aggregate amount of damages, including those amounts that do not exceed the threshold. The aggregate damages to which the indemnified parties are entitled in respect of breaches or representations and warranties shall not exceed the indemnity cap, which shall be 30% of the purchase price.[1] Such threshold and indemnity cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or a breach of certain "fundamental" representations (as applicable to each party) such as corporate existence, power, authority, conflicts, title, land contracts, real property, environmental, intellectual property or tax matters or any liability not assumed as part of the Agreement. The aggregate damages to which the indemnified parties are entitled shall not exceed the Purchase Price. Such cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or any liability not assumed as part of the Agreement.

Changes to Transaction Structure

The parties recognize that changes to the ITC may be made, or other incentives for solar energy generation may become available for U.S. federal income tax purposes, and that the parties may need to restructure the transaction in order for Buyer to be able to utilize such revised ITC or other incentives. The parties agree that they will negotiate in good faith to restructure the transaction in a manner that will maximize the ability of the parties to utilize any such revised ITC or other incentives.

[1] If deemed appropriate by Buyer based on the size and/or technology of the Project, the indemnity threshold and cap may be determined on a $/kW or $/MW basis.

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -

TERM SHEET for the Purchase and Sale of a Solar Photovoltaic Electric Generation Project and Battery Energy Storage System

Seller to provide the information Highlighted in yellow.

Buyer

Public Service Company of Colorado, a Colorado corporation ("Buyer").

Seller

[Developer/Seller Name] ("Seller"). Buyer will also require a financially capable counter-party guarantee, letter of credit, or other form of security acceptable to Buyer ("Seller Credit Support") covering all of Seller's obligations under the Agreement (defined below), including the Liquidated Damages provisions below.

Type of Transaction

The transaction will be structured as an entity acquisition. Prior to the Project being placed in service for U.S. federal income tax purposes, and subject to the other terms and conditions contained in a definitive purchase and sale agreement pertaining to the transaction (the "Agreement"), Buyer shall purchase and Seller shall sell 100% of the ownership interests of the project company ("Company"), a special purpose vehicle which owns a mechanically complete, ready to be tested and placed in service, Investment Tax Credit ("ITC") qualified, integrated solar photovoltaic-powered electricity generating plant and a substantially complete, ready for commercial operation, battery energy storage system (as described in greater detail below, the "Project"), free and clear of all encumbrances and liabilities, except for permitted encumbrances and specific assumed liabilities as defined in the Agreement (the consummation of such purchase and sale transaction, the "Closing"). In any case, Seller would remain obligated after the Closing to perform the *Seller's Work and Other Responsibilities* (described below) and all of its other obligations described in the Agreement.

Project and Project Site

The Project will consist of a solar generating facility with single-axis tracking design (the "Solar Facility") with a nameplate capacity of [XX] MW AC (the "Expected Solar Nameplate Capacity"), a battery energy storage system (the "Storage Facility") with a nameplate capacity of [XX] MW AC and [XX] MWh (the "Expected Storage Nameplate Capacity"), and all facilities and all other assets and rights relating to the Project, located at [describe site] (the "Project Site"). Electric energy used to charge, and that will be discharged by, the Project's battery energy storage system will be transmitted via an interconnection to the Buyer's [transmission/distribution] system.

Purchase Price and Payment Terms

Unless the parties agree to progress payments, the "Purchase Price," which is not to exceed [$ per MW AC], will be paid by Buyer in two installments, one installment at Closing and one installment on the date (the "Substantial Completion Date") upon which Seller has achieved an agreed set of "Substantial Completion CPs" (which Substantial Completion CPs shall include without limitation that the Project has been placed in service for U.S. federal income tax purposes in order to qualify for the ITCs). Subject to Seller providing Seller Credit Support acceptable to Buyer, Buyer will consider making progress payments from and after the Firm Date (defined below) and prior to Closing. Any progress payments will be tied to the achievement of specific milestones (or, if later, the occurrence of specified dates for each milestone) as outlined and agreed in the Agreement.

In no case will the amount of the Purchase Price paid prior to the Substantial Completion Date exceed 80% of the total Purchase Price, and Buyer will be entitled to withhold from the Purchase Price installment paid in connection with the Substantial Completion Date an amount equal to 150% of the amount sufficient to complete all punch list items.

Conditions Precedent to the Firm Date

The Agreement shall provide for the satisfaction, on or prior to the Outside Firm Date (defined below) and in each case in form and substance acceptable to Buyer and at Seller's sole cost (except for costs of obtaining Buyer's regulatory approvals, which shall be at Buyer's sole cost) certain conditions precedent ("Firm Date CPs," and the date all such Firm Date CPs have been satisfied or waived in writing by Buyer, the "Firm Date"). The Firm Date CPs will include, without limitation, that: all regulatory approvals Buyer requires from the Public Utilities Commission of the State of Colorado ("CPUC"), as applicable, and all other required governmental approvals and permits (including, without limitation, the siting permit, environmental permits, and, if applicable, Federal Energy Regulatory Commission ("FERC") approvals, and approvals under the Hart-Scott-Rodino Antitrust Improvements Act of 1976) have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable; Seller has obtained all land contracts (including that Seller shall obtain (x) amendments to the existing leases as needed to ensure that the lease payment provisions and other applicable terms provide for utility ownership, that the term of the leases is no shorter than the 35 years following construction of the Project and/or to address other matters reasonably required by Buyer, and (y) new lease agreements required for site setbacks or other requirements or otherwise reasonably required by Buyer) and otherwise secured full site control, including real estate rights required to interconnect the Project; Seller has obtained and delivered to Buyer title reports and title insurance commitments, and completed any curative work required by Buyer, solar equipment, panels, batteries, power electronic systems, enclosures and other equipment necessary for the Project to generate and store electricity, and transmit such electricity upon command, procurement agreements, O&M agreement (if applicable), construction contracts, letters of credit and guarantees, all third-party reports and studies (including without limitation those relating to wildlife, environmental, geotechnical, archaeological, noise impact, solar resources, engineering and cost segregation) and related reliance letters, and all required third-party estoppels (including with respect to each lease and other land contracts) and third-party consents; the design documents have been finalized; Buyer has received a bring down of the Signing Opinion (defined below) confirming the Signing Opinion as of the Firm Date and otherwise in form and substance acceptable to Buyer; Buyer has secured interconnection rights for the Project and obtained an effective interconnection agreement for the Project acceptable to Buyer. Seller will provide Buyer with evidence that the Firm Date CPs have been satisfied in accordance with the terms of the Agreement, and Buyer will have a stated period to object to whether the Firm Date CPs have in fact been so satisfied. The "Outside Firm Date" will be [date TBD].

Seller's Work and Other Responsibilities

Seller will be responsible, at its sole cost and expense, under the Agreement for all work required to achieve Project final completion, including any O&M building and other integrated and operational infrastructure facilities, all radial transmission lines and other interconnection facilities required to deliver power from the electric grid to the Project and from the Project to the electric grid, and including without limitation the fully assembled, installed, tested and commercially operational solar photovoltaic panels and inverter, battery storage system and related equipment, all in compliance with prudent utility practices, prudent engineering practices, applicable law, applicable safety requirements, applicable permits, an agreed site plan, the applicable supply agreements, all manufacturer's warranties, specifications and recommendations, the Long-Term Services Agreement (if applicable), the applicable construction agreements, the interconnection agreement, Seller's quality management plan, Buyer's policies and procedures governing electronic and physical access controls required by the North American Electric Reliability Corporation ("NERC") Critical Infrastructure Protection ("CIP") standards (if applicable), Buyer's Technical Requirements (to be provided by Buyer as part of the Agreement) that specify Buyer's standards and requirements for the design, construction, materials, equipment and supplies for certain aspects of the Project, Seller's operating procedures for the operation of the Project (to be agreed upon by Buyer and Seller as part of the Agreement), and the Agreement. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. Seller shall also be responsible for the decommissioning of the battery energy storage system under the Decommissioning Plan (as defined below). For the avoidance of doubt, the foregoing obligations of Seller will continue after the Closing and Seller will remain responsible for all costs and expenses of completing the work, including those arising under any applicable supply, construction, and decommissioning agreements.

Seller's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Buyer to consummate the transactions contemplated are subject to the satisfaction by Seller of certain conditions on or before the Closing date, including without limitation:

- Achievement of the Firm Date.
- Transfer of all of the ownership interests of the Company, which include all rights and title to assets relating to the Project, to Buyer or its designated affiliate.
- Certification that the Project has achieved project mechanical, electrical and structural completion in compliance with the Performance Standard.
- Buyer has received, at Seller's sole cost, a bring down of the Signing Opinion confirming the Signing Opinion as of the Closing date and otherwise in form and substance acceptable to Buyer.
- Evidence that any liens on the Company, Project, real property or any other assets or interests of the Company have been removed as of the Closing, other than permitted liens which have been scheduled or liens which have been scheduled and bonded to Buyer's satisfaction.
- Seller has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Seller pertaining to the Closing.
- Seller has delivered the title insurance commitment and title policy (premium to be paid by Seller).

Buyer's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Seller to consummate the transactions contemplated are subject to the satisfaction by Buyer of certain conditions on or before the Closing date, including without limitation:

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -

TERM SHEET for the Purchase and Sale
of a
Solar Photovoltaic Electric Generation Project and Battery Energy Storage System

- Payment of the Purchase Price installment due on the Closing date, subject to certain adjustments.
- Buyer has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Buyer pertaining to the Closing.

Pre-COD Test

The "Pre-COD Test" shall measure at the point of delivery, among other things, the Project's grid charging capability, maximum charging rates, maximum discharging rates, minimum charging time, minimum discharging time, storage capacity, round-trip efficiency, ability to communicate with Buyer using Buyer's Supervisory Control and Data Acquisition ("SCADA") System, and other testing to be agreed by the Parties (including factory testing). Any failure to pass the Pre-COD Test will trigger Seller's obligation to complete the repairs needed to bring the Project into compliance with the pre-determined performance levels required to pass such test. Prior to performing any repair obligations, Seller may conduct a limited number of discretionary tests that Seller deems necessary for purposes of re-performing a required test.

Required Approvals

The transaction is subject to obtaining specified approvals, authorizations, or orders, on or before the Closing date, including without limitation (to the extent necessary):

- Approval of the board of directors of Buyer and the board of directors or similar governing body of Seller shall be obtained prior to execution of the definitive agreement.
- Third party consents.
- Applicable governmental and regulatory approvals prior to Closing, including to the extent necessary, any applicable state agencies or commissions regulating utility activities and any government agencies having approval, consent or authority over the transactions contemplated by the Agreement or the operation of the Project, including without limitation, the CPUC, the FERC, the Department of Justice, the Federal Trade Commission, the US Fish and Wildlife Service and the FAA. All such approvals shall have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable.

Long-Term Services Agreement

Buyer may elect to enter into a long-term services agreement for the Project with Seller upon the terms set forth below (the "Long-Term Services Agreement"). In the event that Buyer elects to enter into a Long-Term Services Agreement, Seller [or an agreed affiliate of Seller], shall provide the applicable operations and maintenance services (the "Services") for an initial term of up to ten (10) years following the Substantial Completion Date. Thereafter, the Long-Term Services Agreement shall automatically renew in increments of five (5) years at the election of Buyer, up to three (3) times after the expiration of the initial term. Seller shall provide the Services based upon (i) a fixed fee for certain work to be defined as in-scope; (ii) pre-agreed pricing for certain additional work that is outside of the scope but which Buyer may elect to purchase in its sole and absolute discretion; and (iii) cost-plus pricing for work not included in the preceding clauses (i) and (ii), which shall be subject to a mark-up of no more than 10% exclusive of equipment costs and focused on labor to cover, among other things, general and administrative and other overhead costs.

The Long-Term Services Agreement will (i) contain performance guarantees for the Project, as described further below, (ii) identify any Operating Limitations, as defined below, and (iii) address compliance with the NERC CIP standards (if applicable). The Long-Term Services Agreement will also contain terms and conditions related to the Services provided thereunder that are customary for the operation and maintenance of a solar generating plus battery energy storage system, subject to any necessary conforming changes to adjust for the applicable technology, the size, or the scope of the Project. The form of the Long-Term Services Agreement would be attached as an exhibit to the Agreement.

If Buyer elects not to provide for a Long-Term Services Agreement, Seller agrees to specify the base level of storage capacity the battery storage system will sustain over its useful life.

Performance Guaranties

The Long-Term Services Agreement shall specify the terms under which the parties will measure the performance of Project's battery energy storage system over the duration of the Agreement, which shall be dependent in part on the maturity of the battery storage technology used for the Project. Satisfactory performance will require the battery energy storage system to meet certain guaranteed performance criteria (the "Guaranteed Performance Levels"), which measurements shall be obtained through periodic testing, on an annual basis, or more frequently if requested by Buyer, of the following:

- Guaranteed Round Trip Efficiency;
- Guaranteed Storage Capacity;
- Self-Discharge Rate;
- Guaranteed Minimum Charging Time;
- Guaranteed Maximum Charging Rate;
- Guaranteed Minimum Discharging Time;
- Guaranteed Maximum Discharging Rate;
- Maximum Ramp Rate;
- Guaranteed Response Time; and
- [Others TBD].

Seller agrees to maintain the Storage Facility such that it is capable of maintaining a base level of storage capacity of no less than [__] MWh during the term of the Long-Term Services Agreement[, and to augment the battery energy storage system prior to the time the level of storage capacity falls below [__] MWh].

The parties agree that the Performance Guaranties will be contingent upon the Project being operated, scheduled, and dispatched in accordance with the "Operating Limitations, which shall specify the Project's operating requirements and limitations.

The Operating Limitations shall, at a minimum, address the following regarding the operation of the Storage Facility: [maximum annual state of charge (averaged);] maximum number of annual equivalent cycles, which shall not be below [___] equivalent cycles per year; [others TBD]; and the potential cost impact if Buyer were to exceed any of these limitations.

With respect to the Storage Facility's maximum number of annual equivalent cycles, the Operating Limitations shall allow Buyer the flexibility to defer or extend a portion of the cycles allocated to a given operating year, such that (i) if Buyer does not use all of its cycles at the end of an operating year, Buyer may transfer up to [__] cycles to the subsequent operating year, or (ii) if Buyer uses all of its cycles prior to the end of an operating year, Buyer may add up to [__] cycles that are allocated to the subsequent operating year.

In addition, by no later than 90 days prior to the Closing date, the parties shall develop "Operating Guidelines" to specify the parameters for the operation of the Project, such as operation modes for specific functionality (e.g., frequency response); set-points and limitations for each operating mode; scheduling parameters; the parties' communication protocols; and the data points to be transmitted to Buyer's SCADA. The parties agree that the Operating Guidelines can be reviewed annually to optimize operations for Buyer.

Solar, Battery, and Related Equipment Warranties

Seller shall not purchase or otherwise acquire any of the major equipment components or related materials or services from an entity that is not approved by Buyer as specified in the Buyer's Technical Requirements without Buyer's prior written consent (not to be unreasonably withheld or delayed).

Seller shall provide to Buyer a description of the terms and conditions of the equipment warranties that Seller shall obtain from the solar equipment, panels, battery, power conversion system, thermal management system, enclosure and monitoring equipment manufacturers, balance of plant contractor and other suppliers, contractors, and subcontractors, which shall include (i) a serial defect warranty with respect to the solar equipment, panels, batteries, battery enclosures, power conversion system, thermal management system, fire suppression and safety systems, and switchgear, medium voltage generator step-up transformers, and protection devices, and (ii) a lifetime warranty with respect to the Project control system. In addition, Seller shall provide a full wrap project warranty of no less than two (2) years in duration as to defects in materials, workmanship and title, quality of work and performance as intended as a solar generating plus battery energy storage system.

To the extent a change in applicable law prohibits Seller's acquisition, importation, or installation of major equipment or associated software, firmware, and digital components that control the operation of such major equipment ("Prohibited Equipment"), Seller agrees to procure an equivalent or superior alternative to the Prohibited Equipment, subject to Buyer's approval.

Safety

Seller shall design and construct the Project in compliance with all applicable laws, codes, and standards that are applicable to the design of the Project and ensure that upon the Closing date the Project meets all such applicable laws, codes, and standards. Prior to the Closing date, Seller will provide Buyer with an independent registered professional engineer's certification stating that the Project has been completed in all material respects (including compliance with all applicable laws, codes, and standards). Only non-occupiable battery energy storage system enclosures shall be considered. Seller shall have the battery energy storage system enclosures certified to UL 9540. Seller shall design, construct, and install the Project under the guidance of NFPA 855 and shall comply with all applicable portions of that standard. Seller shall also complete first responder training for its and Buyer's operating personnel as well as any local first responders, which training shall be reconducted on a periodic basis.

Prior to the Closing date, Seller will also provide the following additional documents: all schematics, drawings, and other documentation needed for developing lock out-tag out procedures and performing hazard assessments of the facility, site level emergency response plans, and system operations training manual.

Representations and Warranties

The transaction is subject to customary representations and warranties to be made by Buyer and Seller as of the execution date or the effective date of the definitive agreement, the Firm Date, and the Closing date thereunder, including without limitation:

- Corporate existence and powers – Seller is a [corporation] validly existing and in good standing and has the power and authority to conduct its business as now conducted.
- Company existence and powers – the Company is a limited liability company validly existing and in good standing and has the power and authority to develop, construct, operate and own the Project and has been engaged in no other business since its formation.
- Authority (execution and delivery)
- No conflicts - the transaction does not create any conflicts.
- Consents and approvals – no consent, approval or authorization is required in connection with the execution and performance of the Agreement.
- Legal proceedings of Buyer – there are no legal proceedings pending, or to Buyer's knowledge, threatened, against Buyer, that affect the consummation of the transaction contemplated by the Agreement.
- Legal proceedings of Seller and Company – there are no legal proceedings pending, or to Seller's knowledge, threatened, against (i) Seller relating to the Project or affecting Seller's ability to sell the Company or (ii) the Company or the Project, and there are no material legal proceedings pending, or to Seller's knowledge, threatened, against (x) the Company relating to the Project or (y) the Company or the Project.
- Compliance with Laws – Seller and the Company are in compliance with all laws applicable to Seller, Company, Project and the transactions contemplated by the Agreement.
- Environmental – Seller, the Company and its affiliates have no environmental liabilities relating to the Project and are in compliance with environmental requirements relating to the Project. Seller and its affiliates have not received any notice of an alleged violation of environmental law pertaining to the Project from any governmental entity. There are no facts, circumstances, conditions or occurrences relating to the Project that could reasonably be expected to form the basis of a claim, requirement or obligation imposed by any governmental entity under any environmental law on Seller or its affiliates.
- Contracts – Schedule of contracts (i) binding on the Company, (ii) binding on Seller that relate to the Project, or (iii) to which the Project is subject or bound, and Seller has furnished to Buyer true, correct and complete copies of all such contracts.
- Land Contracts – The land contracts and real property owned by the Company are in full force and effect, and shall comprise all of the real property interests necessary in connection with the acquisition, development, construction, installation, interconnection, completion and operation of the Project, all in accordance with all laws, and are sufficient to enable the Project to be

commercially operable as contemplated in the Agreement, including legal and physical ingress and egress rights to and from public right-of-way for construction, operation, and maintenance of the Project.

- Permits - All permits required to develop, construct, own, and attain commercial operation of the Project are held by the Company, are final and non-appealable, are scheduled, and Seller has obtained and furnished to Buyer true, correct and complete copies of such permits. Such permits are in full force and effect and are legal, valid, binding and enforceable in accordance with their respective terms.
- Solar Data – Seller has delivered to buyer true, correct and complete copies of all insolation and related meteorological data, and energy production estimates, if any, related to the Project.
- Title – The Company is in possession of and has good and marketable title to the Project free and clear of all encumbrances, except for Permitted Encumbrances. Seller has good and marketable title to the Company's equity interests, free and clear of all encumbrances. Seller and its affiliates have no legal obligation to, or non-binding agreement in principle with any other person, to sell or affect a sale of all, or any portion of, the Project or the Company.
- Other representation and warranties customary in a transaction of this nature, including those pertaining to ITCs, taxes, title, finders, intellectual property, brokers and insurance or that are required following Buyer's due diligence review.

Other Agreements

- Interconnection. Seller shall be responsible for complying with all costs and requirements necessary to attain the final interconnection of the Project, including, but not limited to, all costs for the construction of any radial transmission line to [insert] substation/point of interconnection and any necessary network upgrade costs.
- Technology. The major equipment components of the Project shall be manufactured by top tier manufacturers acceptable to Buyer or specified in the Buyer's Technical Requirements.
- Buyer's right to inspect. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. Such inspection of any part of the work shall in no way relieve Seller of its obligations under the agreement.
- Seller will cause the Project to satisfy (in accordance with the Internal Revenue Code and associated guidance) requirements that qualify the project for the ITC at the [XX%] level. Seller has qualified the project for the ITC using the following process: [Seller to provide detailed description of qualification method]
- At Seller's cost, a legal opinion (the "Signing Opinion") from tax counsel selected by Buyer and in form and substance acceptable to Buyer shall be delivered to Buyer prior to the effective date of the Agreement, which Signing Opinion shall speak to the tax benefits associated with the transactions contemplated by the Agreement accruing to Buyer upon or after the Closing, and must include, without limitation, an opinion that, under the rules, regulations, and other laws in effect as of the date of the Signing Opinion, the Project will, based on among other things, the representations made by Seller on the date the Signing Opinion is delivered, generate a [XX%] ITC (including by having begun construction, within the meaning of applicable IRS guidance, on or prior to December 31, 20[XX]) and, assuming the Closing occurs, that the exclusive rights

to such investment tax credits will accrue to Buyer upon the placed in service date of the Project in accordance with applicable law and tax rules.

- In addition to, and independent of any pass-through warranties from the panel, battery, inverter, racking and monitoring equipment manufacturers, balance of plant contractor and other suppliers and subcontractors, Seller shall provide a full wrap project warranty of no less than two years in duration as to defects in materials, workmanship and title, quality of work and performance as intended as a solar photovoltaic energy generation system and battery energy storage system.
- Decommissioning. Seller shall be responsible for developing and implementing a plan for the decommissioning of the battery energy storage system and any related balance of plant (e.g. battery enclosures, power conversion system) in accordance with applicable law (the "Decommissioning Plan"). The Decommissioning Plan will address the end-of-life management of the battery energy storage system, including the dismantling, removal, transportation, and disposal of the batteries and any associated solid and hazardous waste in accordance with applicable law, and any restoration of the Project Site, if required. The battery manufacturer (or an entity designated by the battery manufacturer) will accept the battery packs at the end of their useful life for disposal and/or recycling.
- Seller shall assume all risks arising from any change in its commodity prices and all changes associated with any change in law affecting Seller's Project costs including, but not limited to, changes in tariff rates.
- Seller shall be responsible for all taxes relating to the pre-closing period and all transfer taxes and any sales, use or other taxes related to the purchase and sale of the ownership interests of the Company and any purchase or conveyance of real or personal property to the Company to be used in the Project.
- Buyer will not be required to close if (i) the nameplate capacity of the Solar Facility is less than 95% of the Expected Solar Nameplate Capacity, or (ii) the nameplate capacity of the Storage Facility is less than 100% of the Expected Storage Nameplate Capacity (the "Minimum Capacity").
- Liquidated Damages:
  - Delay Damages: Seller shall make a per diem liquidated damages payment, in an amount of $[__]/MW, for each day after the guaranteed substantial completion date that the Project has not achieved the Substantial Completion Date, such delay damages not to exceed an agreed percentage of the Purchase Price in the aggregate.
  - SCADA Infrastructure Delay Damages: Seller agrees that if SCADA Infrastructure Completion (definition to be agreed in the Agreement) is not achieved by [date TBD] ("Guaranteed SCADA Infrastructure Completion Date"), then Seller shall pay as liquidated damages to Buyer an amount equal to $5,000.00 per day for each day after the Guaranteed SCADA Infrastructure Completion Date but prior to the date on which SCADA Infrastructure Completion is achieved.
  - Buy-Down Damages: If the Closing occurs and the aggregate nameplate capacity of the Solar Facility, as of the Substantial Completion Date is equal to or greater than the Minimum Capacity but less than the Expected Solar Nameplate Capacity, Seller will be required to pay liquidated damages in an amount to be agreed in the Agreement.

- Outside SC Date Damages. If the Closing occurs and the Project fails to achieve the Substantial Completion Date on or before [date TBD], Seller shall pay Buyer an amount equal to the net present value (using a discount rate corresponding to Buyer's then-current average weighted cost of capital) of the grossed-up pre-tax value of any resulting lost ITCs.

- NERC Matters: Seller shall comply with the NERC Reliability Requirements during commissioning and up until the Substantial Completion Date and shall ensure the Project meets all NERC Reliability Requirements under the interconnection agreement. Seller shall maintain records required by NERC of such compliance actions and shall perform such other tasks and responsibilities as are set forth in Buyer's Technical Requirements. No later than fifteen (15) business days before the Closing, Seller will provide Buyer current applicable compliance records related to the Project developed during commissioning or prior to the Closing (such as test records, relay settings, energization and synchronization reporting activities, and voltage schedule). Seller will provide Buyer design documents required by NERC (such as the Reactive Power Report, Reactive Power Control Design for VAR-002 and to meet the Voltage Schedule) no later than 30 days before the Closing.

Termination Provisions

The Agreement may be terminated upon written notice by the terminating party (as described below) in the event of certain occurrences, including without limitation:

- If applicable, by Buyer if the Firm Date has not occurred by the Outside Firm Date, regardless of the reason for such failure, provided that the terminating party is not in breach of the Agreement.
- By either party if the Closing date has not occurred by [date TBD] (the "Outside Closing Date"), regardless of the reason for such termination, provided that the terminating party is not in breach of the Agreement.
- By either party if regulatory approvals for the transaction are not obtained by the Outside Firm Date on terms acceptable to Buyer in its sole discretion.
- By Buyer if applicable law or any order issued by, or any other action taken by, an authority restrains, enjoins, or otherwise prohibits the consummation of the transactions contemplated by the Agreement.
- By either party in the event of a material uncured breach or repudiation of the Agreement by the other party.
- By Buyer in the event of abandonment of the Project by Seller or the Company.
- By either party if the other party or, in the case of Seller, the provider of the Seller Credit Support, suffers insolvency or bankruptcy.
- By Buyer if there is a change of control of Seller.
- By Buyer if Closing has occurred but the Substantial Completion Date has not occurred by [date TBD].
- Termination Payment. Without limiting any other legal or contractual right or remedy available to Buyer (including Buyer's rights to liquidated damages under the Agreement that accrued prior to such termination), if the Agreement is terminated Seller will pay to Buyer a termination payment in the indicated amount:

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Solar Photovoltaic Electric Generation Project and Battery Energy Storage System

- o if termination occurs prior to the Firm Date, an amount equal to $[__] multiplied by the sum of the number of kW AC in the Expected Solar Nameplate Capacity and the number of kW AC in the Expected Storage Nameplate Capacity;
- o if termination occurs after the Firm Date and prior to the Closing date, an amount equal to $[__] multiplied by the sum of the number of kW AC in the Expected Solar Nameplate Capacity and the number of kW AC in the Expected Storage Nameplate Capacity; or
- o if termination occurs after the Closing date and prior to the Substantial Completion Date, and without duplication of Outside SC Date Damages described above that accrued prior to the termination, an amount equal to:
  - the net present value (using a discount rate corresponding to Buyer's then-current average weighted cost of capital) of the grossed-up pre-tax value of any resulting lost ITCs; *plus*
  - an amount, which may be positive or negative, equal to Buyer's costs to achieve final completion of the Project less the remaining unpaid Purchase Price.

provided, that Seller shall have no obligation to make a termination payment if the termination is a result of (i) a material uncured breach or repudiation by Buyer; (ii) Buyer's failure to obtain the required regulatory approvals by [date TBD], or (iii) Buyer's insolvency or bankruptcy.

- Return of Progress Payments. In addition to any termination payment owing by Seller to Buyer, if the Agreement is terminated prior to Closing, Seller will repay to Buyer the aggregate amount of progress payments paid by Buyer as of such date.

Indemnification

Each party shall indemnify and hold harmless the other party and its respective employees, representatives, officers, directors and agents from and against any and all damages arising out of any breach or violation of any representation, warranty, covenant, inaccuracy within the Agreement, or any liability not assumed as part of the Agreement, or negligence in performance of the Agreement. Seller shall indemnify Buyer for any environmental (including hazardous material) claims arising prior to the Closing date. No claim for indemnification shall be brought against the indemnifying party until the total damages for which such party is liable exceeds in the aggregate a threshold amount of $100,000, at which point indemnification may be sought for the full aggregate amount of damages, including those amounts that do not exceed the threshold. The aggregate damages to which the indemnified parties are entitled in respect of breaches or representations and warranties shall not exceed the indemnity cap, which shall be 30% of the purchase price.[1] Such threshold and indemnity cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or a breach of certain "fundamental" representations (as applicable to each party) such as corporate existence, power, authority, conflicts, title, land contracts, real property, environmental, intellectual property or tax matters or any liability not assumed as part of the Agreement. The aggregate damages to which the indemnified parties are entitled shall not exceed the

[1] If deemed appropriate by Buyer based on the size and/or technology of the Project, the indemnity threshold and cap may be determined on a $/kW or $/MW basis.

Purchase Price. Such cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or any liability not assumed as part of the Agreement.

Changes to Transaction Structure

The parties recognize that changes to the ITC may be made, or other incentives for solar energy generation may become available for U.S. federal income tax purposes, and that the parties may need to restructure the transaction in order for Buyer to be able to utilize such revised ITC or other incentives. The parties agree that they will negotiate in good faith to restructure the transaction in a manner that will maximize the ability of the parties to utilize any such revised ITC or other incentives.

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TERM SHEET for the Purchase and Sale
of a
Battery Energy Storage System

Seller to provide the information Highlighted in yellow.

Buyer

Public Service Company of Colorado, a Colorado corporation ("Buyer").

Seller

[Developer/Seller Name] ("Seller"). Buyer will also require a financially capable counter-party guarantee, letter of credit, or other form of security acceptable to Buyer ("Seller Credit Support") covering all of Seller's obligations under the Agreement (defined below), including the Liquidated Damages provisions below.

Type of Transaction

The transaction will be structured as an entity acquisition. After the Closing CPs (defined below) have been satisfied, and subject to the other terms and conditions contained in a definitive purchase and sale agreement pertaining to the transaction (the "Agreement"), Buyer shall purchase and Seller shall sell 100% of the ownership interests of the project company ("Company"), a special purpose vehicle which owns a substantially complete, ready for commercial operation, battery energy storage system (as described in greater detail below, the "Project"), free and clear of all encumbrances and liabilities, except for permitted encumbrances and specific assumed liabilities as defined in the Agreement (the consummation of such purchase and sale transaction, the "Closing"). In any case, Seller would remain obligated after the Closing to perform the *Seller's Work and Other Responsibilities* (described below) and all of its other obligations described in the Agreement.

Project and Project Site

The Project will consist of a battery energy storage system with a nameplate capacity of [XX] MW and [XX] MWh AC (the "Expected Nameplate Capacity"), and all facilities and all other assets and rights relating to the Project, located at [describe site] (the "Project Site"). Electric energy used to charge, and that will be discharged by, the Project's battery energy storage system will be transmitted via an interconnection to Buyer's [transmission/distribution] system.

Purchase Price and Payment Terms

Unless the parties agree to progress payments, the "Purchase Price," which is not to exceed [$ per MW/MWh AC], will be paid by Buyer in one installment at Closing, which shall occur on a date (the "Closing Date") after which Seller has satisfied the Closing CPs. Subject to Seller providing Seller Credit Support acceptable to Buyer, Buyer will consider making progress payments from and after the Firm Date (defined below) and prior to Closing. Any progress payments will be tied to the achievement of specific milestones (or, if later, the occurrence of specified dates for each milestone) as outlined and agreed in the Agreement.

In no case will the amount of the Purchase Price paid prior to the Substantial Completion Date exceed 80% of the total Purchase Price, and Buyer will be entitled to withhold from the Purchase Price installment paid in connection with the Closing Date an amount equal to 150% of the amount sufficient to complete all punch list items.

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TERM SHEET for the Purchase and Sale of a Battery Energy Storage System

Conditions Precedent to the Firm Date

The Agreement shall provide for the satisfaction, on or prior to the Outside Firm Date (defined below) and in each case in form and substance acceptable to Buyer and at Seller's sole cost (except for costs of obtaining Buyer's regulatory approvals, which shall be at Buyer's sole cost) certain conditions precedent ("Firm Date CPs," and the date all such Firm Date CPs have been satisfied or waived in writing by Buyer, the "Firm Date"). The Firm Date CPs will include, without limitation, that: all regulatory approvals Buyer requires from the Public Utilities Commission of the State of Colorado ("CPUC"), as applicable, and all other required governmental approvals and permits (including, without limitation, environmental permits, and, if applicable, Federal Energy Regulatory Commission ("FERC") approvals, and approvals under the Hart-Scott-Rodino Antitrust Improvements Act of 1976) have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable; Seller has obtained all land contracts (including that Seller shall obtain (x) amendments to the existing leases as needed to ensure that the lease payment provisions and other applicable terms provide for utility ownership, that the term of the leases is no shorter than the 35 years following construction of the Project and/or to address other matters reasonably required by Buyer, and (y) new lease agreements required for site setbacks or other requirements or otherwise reasonably required by Buyer) and otherwise secured full site control, including real estate rights required to interconnect the Project; Seller has obtained and delivered to Buyer title reports and title insurance commitments, and completed any curative work required by Buyer, batteries, power electronic systems, enclosures and other equipment necessary for the Project to store electricity and transmit such electricity upon command, procurement agreements, O&M agreement (if applicable), construction contracts, letters of credit and guarantees, all third-party reports and studies (including without limitation those relating to wildlife, environmental, geotechnical, archaeological, noise impact, engineering and cost segregation) and related reliance letters, and all required third-party estoppels (including with respect to each lease and other land contracts) and third-party consents; the design documents have been finalized; Buyer has secured interconnection rights for the Project and obtained an effective interconnection agreement for the Project acceptable to Buyer. Seller will provide Buyer with evidence that the Firm Date CPs have been satisfied in accordance with the terms of the Agreement, and Buyer will have a stated period to object to whether the Firm Date CPs have in fact been so satisfied. The "Outside Firm Date" will be [date TBD].

Seller's Work and Other Responsibilities

Seller will be responsible, at its sole cost and expense, under the Agreement for all work required to achieve Project final completion, including any O&M building and other integrated and operational infrastructure facilities, all interconnection facilities required to deliver power from the electric grid to the Project and from the Project to the electric grid, and including without limitation the fully assembled, installed, tested and commercially operational battery storage system and related equipment, all in compliance with prudent utility practices, prudent engineering practices, applicable law, applicable safety requirements, applicable permits, an agreed site plan, the applicable supply agreements, all manufacturer's warranties, specifications and recommendations, the Long-Term Services Agreement (if applicable), the applicable construction agreements, the interconnection agreement, Seller's quality management plan, Buyer's policies and procedures governing electronic and physical access controls required by the North American Electric Reliability Corporation ("NERC") Critical Infrastructure Protection ("CIP") standards (if applicable), Buyer's Technical Requirements (to be provided by Buyer as part of the Agreement) that specify Buyer's standards and requirements for the design, construction, materials, equipment and supplies for certain aspects of the Project, Seller's operating procedures for the operation of the Project (to be agreed upon by Buyer and Seller as part of the Agreement) (as defined below, the "Operating Guidelines"), and the Agreement. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. Seller shall also be responsible for the decommissioning of the battery energy storage system under the Decommissioning Plan (as defined below). For the avoidance of doubt, the foregoing obligations of Seller will continue after the Closing and Seller will remain responsible for all costs and expenses of completing the work, including those arising under any applicable supply, construction, and decommissioning agreements.

Closing Conditions Precedent

The Agreement shall provide for the satisfaction, on or prior to the Closing, and in each case in form and substance acceptable to Buyer and at Seller's sole cost (except for costs of obtaining Buyer's regulatory approvals, which shall be at Buyer's sole cost) certain conditions precedent ("Closing CPs"). The Closing CPs will include, without limitation, that: Substantial Completion has occurred; the Firm Date has been achieved; any applicable third-party and governmental approvals have been obtained as set forth below under *Required Approvals*; Seller has delivered to Buyer all final as-built drawings and related documentation, including all manufacturers' recommended operating and maintenance procedures required for maintenance of manufacturers' warranties; Seller has delivered to Buyer evidence that it has obtained and assigned to Buyer all manufacturers' warranties; Seller has delivered new or updated environmental reports, and no such reports identified any issues that are material and adverse to Buyer that were not identified in prior environmental reports delivered to Buyer; Seller has delivered to Buyer a complete and accurate list of all equipment, plant, machinery, installations, special tools, spare parts, supplies and other personal property owned by Seller included in the Project, excluding only those items which are immaterial and can be replaced in the ordinary course of business, and such list shall specifically indicate any such item of the Project which is not located on or at the Project Site and identify the location thereof; Seller has delivered to Buyer a Decommission Plan (as defined below) that will govern the end-of-life management of the battery energy storage system and all related balance of plant, in accordance with applicable law; all representations and warranties of Seller shall be true and correct in all respects; at the election of the Buyer, the Parties have entered into a Long-Term Services Agreement (as defined below); no event has occurred that has had or could reasonably be expected to have a material adverse effect, including any suit, action, dispute or other similar proceeding filed by any contractor, subcontractor, or other person against Seller, enjoining or limiting the transaction contemplated by the Agreement or the use or operation of the Project, or seeking to obtain damages or other relief in connection with the Agreement or any contracts to be transferred to Buyer under the Agreement; Seller has delivered to Buyer a claims statement identifying every dispute, suit, action or other proceeding that is pending, or threatened in writing, between Seller and any contractor or subcontractor connected with, or arising out of, the development and/or construction of the Project; and, if applicable, Seller or its operating personnel have completed all training requirements pertaining to the start-up, shut-down and operation of, and safety, general process understanding and emergency procedures for, the Project and all of its sub-systems, in accordance with the requirements of a training program to be prepared by Seller and approved by Buyer.

Seller's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Buyer to consummate the transactions contemplated are subject to the satisfaction by Seller of certain conditions on or before the Closing Date, including without limitation:

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Battery Energy Storage System

- Transfer of all of the ownership interests of the Company, which include all rights and title to assets relating to the Project, to Buyer or its designated affiliate.
- Certifications that Seller has satisfied the Closing Date CPs, including a certification from an independent engineer that the Project has achieved Substantial Completion.
- Evidence that any liens on the Company, Project, real property or any other assets or interests of the Company have been removed or waived as of the Closing, including any mechanics' or workmans' liens with respect to work required to achieve Substantial Completion, other than permitted liens which have been scheduled or liens which have been scheduled and bonded to Buyer's satisfaction.
- All certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Seller pertaining to the Closing.

Buyer's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Seller to consummate the transactions contemplated are subject to the satisfaction by Buyer of certain conditions on or before the Closing Date, including without limitation:

- Payment of the Purchase Price installment due on the Closing Date, subject to certain adjustments.
- All certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Buyer pertaining to the Closing.

Required Approvals

The transaction is subject to obtaining specified approvals, authorizations, or orders, on or before the Closing date, including, without limitation (to the extent necessary):

- Approval of the board of directors of Buyer and the board of directors or similar governing body of Seller shall be obtained prior to execution of the definitive agreement.
- Third party consents prior to Closing.
- Applicable governmental and regulatory approvals prior to Closing, including to the extent necessary, any applicable state agencies or commissions regulating utility activities and any government agencies having approval, consent or authority over the transaction contemplated by the Agreement or the operation of the Project, including, without limitation, the CPUC, the FERC, the Department of Justice, the Federal Trade Commission, the US Fish and Wildlife Service and the FAA.

Substantial Completion

"Substantial Completion" shall occur after the Seller has successfully completed a performance test (the "Pre-COD Test").

The Pre-COD Test shall measure at the point of delivery, among other things, the Project's grid charging capability, maximum charging rates, maximum discharging rates, minimum charging time, minimum discharging time, storage capacity, round-trip efficiency, ability to communicate with Buyer using Buyer's Supervisory Control and Data Acquisition ("SCADA") System, and other testing to be agreed by the Parties (including factory testing). Any failure to pass the Pre-COD Test will trigger Seller's obligation to complete the repairs needed to bring the Project into compliance with the pre-determined performance levels required to pass such test. Prior to performing any repair obligations, Seller may conduct a limited number of discretionary tests that Seller deems necessary for purposes of re-performing a required test.

Long-Term Services Agreement

Buyer may elect to enter into a long-term services agreement for the Project with Seller upon the terms set forth below (the "Long-Term Services Agreement"). In the event that Buyer elects to enter into a Long-Term Services Agreement, Seller [or an agreed affiliate of Seller], shall provide the applicable operations and maintenance services (the "Services") for an initial term of up to [__] ten (10) years following the Closing. Thereafter, the Long-Term Services Agreement shall automatically renew in increments of five (5) years at the election of Buyer, up to three (3) times after the expiration of the initial term. Seller shall provide the Services based upon (i) a fixed fee for certain work to be defined as in-scope; (ii) pre-agreed pricing for certain additional work that is outside of the scope but which Buyer may elect to purchase in its sole and absolute discretion; and (iii) cost-plus pricing for work not included in the preceding clauses (i) and (ii), which shall be subject to a mark-up of no more than 10% exclusive of equipment costs and focused on labor to cover, among other things, general and administrative and other overhead costs.

The Long-Term Services Agreement will (i) contain performance guarantees for the Project, as described further below, (ii) identify any Operating Limitations, as defined below, (iii) address the supply for any needed auxiliary or house power, if the Project is located outside of Buyer's franchised retail electric service territory; and (iv) address compliance with the NERC CIP standards (if applicable). The Long-Term Services Agreement will also contain terms and conditions related to the Services provided thereunder that are customary for the operation and maintenance of a battery energy storage system, subject to any necessary conforming changes to adjust for the applicable technology, the size, or the scope of the Project. The form of the Long-Term Services Agreement would be attached as an exhibit to the Agreement.

If Buyer elects not to provide for a Long-Term Services Agreement, Seller agrees to specify the base level of storage capacity the battery storage system will sustain over its useful life.

Performance Guaranties

The Long-Term Services Agreement shall specify the terms under which the parties will measure the performance of Project's battery energy storage system over the duration of the Agreement, which shall be dependent in part on the maturity of the battery storage technology used for the Project. Satisfactory performance will require the battery energy storage system to meet certain guaranteed performance criteria (the "Guaranteed Performance Levels"), which measurements shall be obtained through periodic testing, on an annual basis, or more frequently if requested by Buyer, of the following:

- Guaranteed Round Trip Efficiency;
- Guaranteed Storage Capacity;
- Self-Discharge Rate;
- Guaranteed Minimum Charging Time;
- Guaranteed Maximum Charging Rate;
- Guaranteed Minimum Discharging Time;
- Guaranteed Maximum Discharging Rate;

- Maximum Ramp Rate;
- Guaranteed Response Time; and
- [Others TBD].

Seller agrees to maintain the battery energy storage system such that it is capable of maintaining a base level of storage capacity of no less than [__] MWh during the term of the Long-Term Services Agreement, [and to augment the battery energy storage system prior to the time the level of storage capacity falls below [__] MWh.

The parties agree that the Performance Guaranties will be contingent upon the Project being operated, scheduled, and dispatched in accordance with the "Operating Limitations, which shall specify the Project's operating requirements and limitations.

The Operating Limitations shall, at a minimum, address the following: [maximum annual state of charge (averaged);] maximum number of annual equivalent cycles, which shall not be below [___] equivalent cycles per year; [others TBD]; and the potential cost impact if Buyer were to exceed any of these limitations.

With respect to the maximum number of annual equivalent cycles, the Operating Limitations shall allow Buyer the flexibility to defer or extend a portion of the cycles allocated to a given operating year, such that (i) if Buyer does not use all of its cycles at the end of an operating year, Buyer may transfer up to [__] cycles to the subsequent operating year, or (ii) if Buyer uses all of its cycles prior to the end of an operating year, Buyer may add up to [__] cycles that are allocated to the subsequent operating year.

In addition, by no later than 90 days prior to the Closing Date, the parties shall develop "Operating Guidelines" to specify the parameters for the operation of the Project, such as operation modes for specific functionality (e.g., frequency response); set-points and limitations for each operating mode; scheduling parameters; the parties' communication protocols; and the data points to be transmitted to Buyer's SCADA. The parties agree that the Operating Guidelines can be reviewed annually to optimize operations for Buyer.

Battery and Related Equipment Warranties

Seller shall not purchase or otherwise acquire any of the major equipment components or related materials or services from an entity that is not approved by Buyer as specified in the Buyer's Technical Requirements without Buyer's prior written consent (not to be unreasonably withheld or delayed).

Seller shall provide to Buyer a description of the terms and conditions of the equipment warranties that Seller shall obtain from the battery, power conversion system, thermal management system, enclosure and monitoring equipment manufacturers, balance of plant contractor and other suppliers, contractors, and subcontractors, which shall include (i) a serial defect warranty with respect to the batteries, battery enclosures, power conversion system, thermal management system, fire suppression and safety systems, and switchgear, medium voltage generator step-up transformers, and protection devices, and (ii) a lifetime warranty with respect to the battery control system. In addition, Seller shall provide a full wrap project warranty of no less than two (2) years in duration as to defects in materials, workmanship and title, quality of work and performance as intended as a battery energy storage system.

To the extent a change in applicable law prohibits Seller's acquisition, importation, or installation of major equipment or associated software, firmware, and digital components that control the operation of such major equipment ("Prohibited Equipment"), Seller agrees to procure an equivalent or superior alternative to the Prohibited Equipment, subject to Buyer's approval.

Safety

Seller shall design and construct the Project in compliance with all applicable laws, codes, and standards that are applicable to the design of the Project and ensure that upon the Closing Date the Project meets all such applicable laws, codes, and standards. Prior to the Closing Date, Seller will provide Buyer with an independent registered professional engineer's certification stating that the Project has been completed in all material respects (including compliance with all applicable laws, codes, and standards). Only non-occupiable battery energy storage system enclosures shall be considered. Seller shall have the battery energy storage system enclosures certified to UL 9540. Seller shall design, construct, and install the Project under the guidance of NFPA 855 and shall comply with all applicable portions of that standard. Seller shall also complete first responder training for its and Buyer's operating personnel as well as any local first responders, which training shall be reconducted on a periodic basis.

Prior to the Closing Date, Seller will also provide the following additional documents: All schematics, drawings, and other documentation needed for developing lock out-tag out procedures and performing hazard assessments of the facility, site level emergency response plans, and system operations training manual.

Representations and Warranties

The transaction is subject to customary representations and warranties to be made by Buyer and Seller as of the execution date or the effective date of the definitive agreement, the Firm Date, and the Closing date thereunder, including without limitation:

- Corporate existence and powers – Seller is a [corporation] validly existing and in good standing and has the power and authority to conduct its business as now conducted.
- Company existence and powers – the Company is a limited liability company validly existing and in good standing and has the power and authority to develop, construct, operate and own the Project and has been engaged in no other business since its formation.
- Authority (execution and delivery)
- No conflicts - the transaction does not create any conflicts.
- Consents and approvals – no consent, approval or authorization is required in connection with the execution and performance of the Agreement.
- Legal proceedings of Buyer – there are no legal proceedings pending, or to Buyer's knowledge, threatened, against Buyer, that affect the consummation of the transaction contemplated by the Agreement.
- Legal proceedings of Seller and Company – there are no legal proceedings pending, or to Seller's knowledge, threatened, against (i) Seller relating to the Project or affecting Seller's ability to sell the Company or (ii) the Company or the Project, and there are no material legal proceedings pending, or to Seller's knowledge, threatened, against (x) the Company relating to the Project or (y) the Company or the Project.

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Battery Energy Storage System

- Compliance with Laws – Seller and the Company are in compliance with all laws applicable to Seller, Company, Project and the transactions contemplated by the Agreement.
- Environmental – Seller, the Company and its affiliates have no environmental liabilities relating to the Project and are in compliance with environmental requirements relating to the Project. Seller and its affiliates have not received any notice of an alleged violation of environmental law pertaining to the Project from any governmental entity. There are no facts, circumstances, conditions or occurrences relating to the Project that could reasonably be expected to form the basis of a claim, requirement or obligation imposed by any governmental entity under any environmental law on Seller or its affiliates.
- Contracts – Schedule of contracts (i) binding on the Company, (ii) binding on Seller that relate to the Project, or (iii) to which the Project is subject or bound, and Seller has furnished to Buyer true, correct and complete copies of all such contracts.
- Land Contracts – The land contracts and real property owned by the Company are in full force and effect, and shall comprise all of the real property interests necessary in connection with the acquisition, development, construction, installation, interconnection, completion and operation of the Project, all in accordance with all laws, and are sufficient to enable the Project to be commercially operable as contemplated in the Agreement, including legal and physical ingress and egress rights to and from public right-of-way for construction, operation, and maintenance of the Project.
- Permits - All permits required to develop, construct, own, and attain commercial operation of the Project are held by the Company, are final and non-appealable, are scheduled, and Seller has obtained and furnished to Buyer true, correct and complete copies of such permits. Such permits are in full force and effect and are legal, valid, binding and enforceable in accordance with their respective terms.
- Title – The Company is in possession of and has good and marketable title to the Project free and clear of all encumbrances, except for Permitted Encumbrances. Seller has good and marketable title to the Company's equity interests, free and clear of all encumbrances. Seller and its affiliates have no legal obligation to, or non-binding agreement in principle with any other person, to sell or affect a sale of all, or any portion of, the Project or the Company.
- Other representation and warranties customary in a transaction of this nature, including those pertaining to taxes, title, finders, intellectual property, brokers and insurance or that are required following Buyer's due diligence review.

Other Agreements

- Interconnection. Seller shall be responsible for all new facility costs necessary to enable Buyer to attain the final interconnection of the Project.
- Technology. The major equipment components of the Project shall be manufactured by top tier manufacturers acceptable to Buyer or specified in the Buyer's Technical Requirements.
- Buyer's right to inspect. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. Such inspection of any part of the work shall in no way relieve Seller of its obligations under the agreement.
- Decommissioning. Seller shall be responsible for developing and implementing a plan for the decommissioning of the battery energy storage system and any related balance of plant (e.g. battery enclosures, power conversion system) in accordance with applicable law (the

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -
TERM SHEET for the Purchase and Sale
of a
Battery Energy Storage System

"Decommissioning Plan"). The Decommissioning Plan will address the end-of-life management of the battery energy storage system, including the dismantling, removal, transportation, and disposal of the batteries and any associated solid and hazardous waste in accordance with applicable law, and any restoration of the Project Site, if required. The battery manufacturer (or an entity designated by the battery manufacturer) will accept the battery packs at the end of their useful life for disposal and/or recycling.

- Seller shall assume all risks arising from any change in its commodity prices and all changes associated with any change in law affecting Seller's Project costs including, but not limited to, changes in tariff rates.
- Seller shall be responsible for all taxes relating to the pre-closing period and all transfer taxes and any sales, use or other taxes related to the purchase and sale of the ownership interests of the Company and any purchase or conveyance of real or personal property to the Company to be used in the Project.
- Buyer will not be required to close if the aggregate nameplate capacity of the Project is less than 100% of the Expected Nameplate Capacity (the "Minimum Capacity") or if the Project fails to pass the Pre-COD Test.
- Liquidated Damages:
  - Delay Damages: Seller shall make a per diem liquidated damages payment, in an amount of $[__]/MW, for each day after the guaranteed closing date that the Closing has not occurred, such delay damages not to exceed an agreed percentage of the Purchase Price in the aggregate.
  - SCADA Infrastructure Delay Damages: Seller agrees that if SCADA Infrastructure Completion (definition to be agreed in the Agreement) is not achieved by [date TBD] ("Guaranteed SCADA Infrastructure Completion Date"), then Seller shall pay as liquidated damages to Buyer an amount equal to $5,000.00 per day for each day after the Guaranteed SCADA Infrastructure Completion Date but prior to the date on which SCADA Infrastructure Completion is achieved.
  - Buy-Down Damages: If the Closing occurs and, as of the Closing Date, the round-trip efficiency measured by the Pre-COD Test is less than [__]%, Seller will be required to pay liquidated damages in an amount to be agreed in the Agreement.
- NERC Matters: Seller shall comply with the NERC Reliability Requirements during commissioning and up until the Closing Date and shall ensure the Project meets all NERC Reliability Requirements under the interconnection agreement. Seller shall maintain records required by NERC of such compliance actions and shall perform such other tasks and responsibilities as are set forth in Buyer's Technical Requirements. No later than fifteen (15) business days before the Closing Date, Seller will provide Buyer current applicable compliance records related to the Project developed during commissioning or prior to the Closing Date (such as test records, relay settings, energization and synchronization reporting activities, and voltage schedule). Seller will provide Buyer design documents required by NERC (such as the Reactive Power Report, Reactive Power Control Design for VAR-002 and to meet the Voltage Schedule) no later than 30 days before the Closing.

- Non-Binding Draft for Discussion Purposes Only – Not an Offer -

TERM SHEET for the Purchase and Sale
of a
Battery Energy Storage System

Termination Provisions

The Agreement may be terminated prior to the Closing Date upon written notice by the terminating party (as described below) in the event of certain occurrences, including without limitation:

- If applicable, by Buyer if the Firm Date has not occurred by the Outside Firm Date, regardless of the reason for such failure, provided that the terminating party is not in breach of the Agreement.
- By either party if the Closing Date has not occurred by [date TBD] (the "Outside Closing Date"), regardless of the reason for such termination, provided that the terminating party is not in breach of the Agreement.
- By either party if regulatory approvals for the transaction are not obtained by the Outside Firm Date on terms acceptable to Buyer in its sole discretion.
- By Buyer if applicable law or any order issued by, or any other action taken by, an authority restrains, enjoins, or otherwise prohibits the consummation of the transactions contemplated by the Agreement.
- By either party in the event of a material uncured breach or repudiation of the Agreement by the other party.
- By Buyer in the event of abandonment of the Project by Seller or the Company.
- By either party if the other party or, in the case of Seller, the provider of the Seller Credit Support, suffers insolvency or bankruptcy.
- By Buyer if there is a change of control of Seller.
- Termination Payment. Without limiting any other legal or contractual right or remedy available to Buyer (including Buyer's rights to liquidated damages under the Agreement that accrued prior to such termination), if the Agreement is terminated Seller will pay to Buyer a termination payment in the indicated amount:
  - if termination occurs prior to the Firm Date, an amount equal to $[__].00 multiplied by the number of kW AC in the Expected Nameplate Capacity; or
  - if termination occurs after the Firm Date and prior to the Closing Date, an amount equal to $[__].00 multiplied by the number of kW AC in the Expected Nameplate Capacity;

  provided, that Seller shall have no obligation to make a termination payment if the termination is a result of (i) a material uncured breach or repudiation by Buyer; (ii) Buyer's failure to obtain the required regulatory approvals by [date TBD], or (iii) Buyer's insolvency or bankruptcy.
- Return of Progress Payments. In addition to any termination payment owing by Seller to Buyer, if the Agreement is terminated prior to Closing, Seller will repay to Buyer the aggregate amount of progress payments paid by Buyer as of such date.

Indemnification

Each party shall indemnify and hold harmless the other party and its respective employees, representatives, officers, directors and agents from and against any and all damages arising out of any breach or violation of any representation, warranty, covenant, inaccuracy within the Agreement, or any liability not assumed as part of the Agreement, or negligence in performance of the Agreement. Seller shall indemnify Buyer for any environmental (including hazardous material) claims arising prior to the Closing date. No claim for indemnification shall be brought against the indemnifying party until the total damages for which such party is liable exceeds in the aggregate a threshold amount of 1% of the purchase price, at which point indemnification may be sought for the full aggregate amount of damages, including those amounts that do not exceed the threshold. The aggregate damages to which the indemnified parties are entitled in respect of breaches or representations and warranties shall not exceed the indemnity cap, which shall be 30% of the purchase price.[1] Such threshold and indemnity cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or a breach of certain "fundamental" representations (as applicable to each party) such as corporate existence, power, authority, conflicts, title, land contracts, real property, environmental, intellectual property or tax matters. The aggregate damages to which the indemnified parties are entitled shall not exceed the Purchase Price. Such cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence.

Changes to Transaction Structure

The parties recognize that an Investment Tax Credit ("ITC") or other incentives for stand-alone energy storage may become available and that the parties may need to restructure the transaction in order for Buyer to be able to utilize such investment tax credit or other incentives, including, in the case of an ITC, by requiring that Buyer acquire the Project prior to the Project being placed in service for U.S. federal income tax purposes. The parties agree that they will negotiate in good faith to restructure the transaction in a manner that will maximize the ability of the parties to utilize any such investment tax credit or other incentives.

In the event the transaction is restructured to accommodate the ITC or other incentives for stand-alone storage, to the extent necessary to accommodate the ITC or other incentives for stand-alone storage, the parties will agree, among other things, to the following: (i) the Closing shall occur after mechanical completion and prior to the Project being placed in service for U.S. federal income tax purposes in order to qualify for the ITC; (ii) at Seller's cost, a legal opinion (the "Signing Opinion") from tax counsel selected by Buyer and in form and substance acceptable to Buyer shall be delivered to Buyer prior to the effective date of the Agreement, which Signing Opinion shall speak to the tax benefits associated with the transactions contemplated by the Agreement accruing to Buyer upon or after the Closing, and must include, without limitation, an opinion that, under the rules, regulations, and other laws in effect as of the date of the Signing Opinion, the Project will, based on among other things, the representations made by Seller on the date the Signing Opinion is delivered, generate a [XX%] ITC (including by having begun construction, within the meaning of applicable IRS guidance, on or prior to December 31, 20[XX]) and, assuming the Closing occurs, that the exclusive rights to such investment tax credits will accrue to Buyer upon the placed in service date of the Project in accordance with applicable law and tax rules; (iii) Buyer will receive, at Seller's sole cost, a bring down of the Signing Opinion confirming the Signing Opinion as of the Closing date and otherwise in form and substance acceptable to Buyer; (iv) Firm Date CPs will include that Buyer has received a bring down of the Signing Opinion confirming the Signing Opinion as of the Firm Date and otherwise in form and substance acceptable to Buyer; (v) the transaction will be subject to customary representations and warranties pertaining to ITCs; (vi) Seller will cause the Project to satisfy (in accordance with the Internal Revenue Code and associated guidance) requirements that qualify the project for the ITC at the [XX%] level; (vii) Seller will qualify the project for the ITC using an agreed upon method; and (viii) if the Project fails to achieve the Substantial Completion by [TBD], the

[1] If deemed appropriate by Buyer based on the size and/or technology of the Project, the indemnity threshold and cap may be determined on a $/kW or $/MW basis.

liquidated damages payable to Buyer shall include an amount equal to the net present value (using a discount rate corresponding to Buyer's then-current average weighted cost of capital) of the grossed-up pre-tax value of any resulting lost ITCs.

- Draft for Discussion Purposes Only – Not an Offer -
NON-BINDING TERM SHEET for the Purchase and Sale of an Wind Electric Generation Project

Seller to provide the information Highlighted in yellow.

Buyer

Public Service Company, a Colorado corporation ("Buyer").

Seller

[Developer/Seller Name] ("Seller"). Buyer will also require a financially capable counter-party guarantee, letter of credit, or other form of security acceptable to Buyer ("Seller Credit Support") covering all of Seller's obligations under the Agreement (defined below), including the Liquidated Damages provisions below.

Type of Transaction

The transaction will be structured as an entity acquisition. Buyer shall purchase and Seller shall sell 100% of the ownership interests of the project company ("Company"), which owns a completed, commercially operational, Federal Production Tax Credit ("PTC") qualified, integrated wind-powered electricity generating project and all facilities and all other assets and rights relating to the project (the "Project"), free and clear of all encumbrances and liabilities, except for permitted encumbrances and assumed liabilities as defined in the Purchase and Sale Agreement of an Operational Wind Project (the "Agreement") (the consummation of such purchase and sale transaction, the "Closing").

Purchase Price and Payment Terms

Unless the parties agree to progress payments, the "Purchase Price," which is not to exceed [$ per MW], will be paid by Buyer at Closing. Subject to Seller providing Seller Credit Support acceptable to Buyer, Buyer will consider making progress payments from and after the Firm Date (defined below) and prior to Closing. Any progress payments will be tied to the achievement of specific milestones (or, if later, the occurrence of specified dates for each milestone) as outlined and agreed in the Agreement.

In no case will the amount of the Purchase Price paid prior to Closing exceed 80% of the total Purchase Price, and Buyer will be entitled to withhold from the Closing payment an amount equal to 150% of the amount sufficient to complete all punch list items.

Conditions Precedent to the Firm Date

The Agreement shall provide for the satisfaction, on or prior to the Outside Firm Date (defined below) and in each case in form and substance acceptable to Buyer and at Seller's sole cost (except for costs of obtaining Buyer's regulatory approvals, which shall be at Buyer's sole cost) certain conditions precedent ("Firm Date CPs," and the date all such Firm Date CPs have been satisfied or waived in writing by Buyer, the "Firm Date"). The Firm Date CPs will include, without limitation, that: all regulatory approvals Buyer requires from the Public Utilities Commission of the state of Colorado (the "CPUC"), and all other required governmental approvals and permits (including without limitation the siting permit, environmental permits, and, if applicable, FERC approvals, and approvals under the Hart-Scott-Rodino Antitrust Improvements Act of 1976) have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable; Seller has obtained all land contracts (including that Seller shall obtain (x) amendments to the existing leases as needed to ensure that the lease payment provisions and other applicable terms provide for utility ownership, that the term of the leases is no shorter than the 25 years following construction of the Project and/or to address other matters reasonably required by Buyer, and (y) new lease agreements required for site setbacks or other requirements or otherwise reasonably required by Buyer) and otherwise secured full site control, including real estate rights required to interconnect the Project; Seller has obtained and delivered to Buyer title reports and title insurance commitments, and completed any curative work required by Buyer, wind turbine generators ("WTGs") and other required equipment procurement agreements, O&M agreement (if applicable), construction contracts, letters of credit and guarantees, all third-party reports and studies (including without limitation those relating to wildlife, environmental, geotechnical, archaeological, noise impact, solar resources, engineering and cost segregation) and related reliance letters, and all required third-party estoppels (including with respect to each lease and other land contracts) and third-party consents; the design documents have been finalized; Buyer has received a bring down of the Signing Opinion (defined below) confirming the Signing Opinion as of the Firm Date and otherwise in form and substance acceptable to Buyer; Buyer has secured interconnection rights for the Project and obtained an effective interconnection agreement for the Project acceptable to Buyer. Seller will provide Buyer with evidence that the Firm Date CPs have been satisfied in accordance with the terms of the Agreement, and Buyer will have a stated period to object to whether the Firm Date CPs have in fact been so satisfied. The "<u>Outside Firm Date</u>" will be [date TBD].

<u>Seller's Work and Other Responsibilities</u>

Seller will be responsible, at its sole cost and expense, under the Agreement for all work required to achieve Project final completion, including with respect to the Project substation, O&M building, and all other integrated and operational infrastructure facilities, all radial transmission lines and other interconnection facilities required to deliver power from the electric grid to the Project and from the Project to [insert] substation/point of interconnection, and including without limitation the fully assembled, installed, tested and commercially operational WTGs, all in accordance with the turbine supply agreement, the turbine warranty and O&M agreement (if applicable), Seller's EPC subcontract, the interconnection agreement and the Agreement. All work shall be performed in accordance with prudent utility practices, prudent engineering practices, applicable law, applicable permits, an agreed site plan, Seller's quality management plan, manufacturers' specifications and recommendations, and Buyer's Technical Requirements (to be provided by Buyer as part of the Agreement) as to standards and requirements for the design, construction, materials, equipment and supplies for certain aspects of the Project. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site, including the entire project footprint and point of interconnection, for such purpose. At Closing, Seller shall sell 100% of the ownership interests of the Company to Buyer, free and clear of all encumbrances and liabilities, except for permitted encumbrances and assumed liabilities as defined in the Agreement.

<u>Seller's Closing Deliverables:</u>

Upon the terms and conditions to be defined within the Agreement, the obligations of Buyer to consummate the transactions contemplated are subject to the satisfaction by Seller of certain conditions as of the Closing date, including, but not limited to:

- Achievement of the Firm Date.
- Transfer of all of the ownership interests of the Company, which include all rights and title to assets necessary for the commercial operation of the Project, to Buyer or its designated affiliate.

- Certification that the Project has achieved Project Substantial Completion in accordance with the terms of the Agreement.
- Buyer has received, at Seller's sole cost, a bring down of the Signing Opinion confirming the Signing Opinion as of the Closing date and otherwise in form and substance acceptable to Buyer.
- Evidence that any liens on the Company, Project real property or any other assets or interests of the Company have been removed as of the Closing other than permitted liens which have been scheduled or liens which have been scheduled and bonded to Buyer's reasonable satisfaction.
- Seller has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Seller pertaining to the closing.
- Seller has delivered the title insurance commitment and title policy (premium to be paid by Seller).

Buyer's Closing Deliverables:

Upon the terms and conditions to be defined within the Agreement, the obligations of Seller to consummate the transactions contemplated are subject to the satisfaction by Buyer of certain conditions as of the Closing date, including:

- Delivery of the Purchase Price or any remaining portion thereof, subject to certain adjustments.
- Buyer has obtained all certifications, affidavits, approvals and permits required to demonstrate satisfaction of all representations, warranties, and covenants made by Buyer pertaining to the closing.

Required Approvals

The transaction is subject to obtaining specified approvals, authorizations, or orders, on or before the Closing date, including but not limited to the following (to the extent necessary):

- Approval of the board of directors of Buyer and the board of directors or similar governing body of Seller shall be obtained prior to execution of the definitive agreement.
- Third party consents.
- Applicable governmental and regulatory approvals, including to the extent necessary, any applicable state agencies or commissions regulating utility activities and any government agencies having approval, consent or authority over the transactions contemplated by the Agreement, including without limitation the CPUC, the IRS, the FERC, the Department of Justice, the FAA, the DOD, and the US Fish and Wildlife Service. All such approvals shall have been obtained in form and substance acceptable to Buyer in its sole discretion and are final and non-appealable.

Representations and Warranties

The transaction is subject to customary representations and warranties to be made by Buyer and Seller as of the execution date or the effective date of the definitive agreement, the Firm Date, and the Closing date thereunder, including without limitation:

- Corporate existence and powers – Seller is a [corporation] validly existing and in good standing and has the power and authority to conduct its business as now conducted.

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NON-BINDING TERM SHEET for the Purchase and Sale of an Wind Electric Generation Project

- Company existence and powers – the Company is a limited liability company validly existing and in good standing and has the power and authority to develop, construct, operate and own the Project and has been engaged in no other business since its formation.
- Authority (execution and delivery)
- No conflicts - the transaction does not create any conflicts.
- Consents and approvals – no consent, approval or authorization is required in connection with the execution and performance of the Agreement.
- Legal proceedings of Buyer – there are no legal proceedings pending, or to Buyer's knowledge, threatened, against Buyer, that affect the consummation of the transaction contemplated by the Agreement.
- Legal proceedings of Seller and Company – there are no legal proceedings pending, or to Seller's knowledge, threatened, against (i) Seller relating to the Project or affecting Seller's ability to sell the Company or (ii) the Company or the Project, and there are no material legal proceedings pending, or to Seller's knowledge, threatened, against (x) the Company relating to the Project or (y) the Company or the Project.
- Compliance with Laws – Seller and the Company are in compliance with all laws applicable to Seller, Company, Project and the transactions contemplated by the Agreement.
- Environmental – Seller, the Company and its affiliates have no environmental liabilities relating to the Project and are in compliance with environmental requirements relating to the Project. Seller and its affiliates have not received any notice of an alleged violation of environmental law pertaining to the Project from any governmental entity. There are no facts, circumstances, conditions or occurrences relating to the Project that could reasonably be expected to form the basis of a claim, requirement or obligation imposed by any governmental entity under any environmental law on Seller or its affiliates.
- Contracts – Schedule of contracts (i) binding on the Company, (ii) binding on Seller that relate to the Project, or (iii) to which the Project is subject or bound, and Seller has furnished to Buyer true, correct and complete copies of all such contracts.
- Land Contracts – The land contracts and real property owned by the Company are in full force and effect, and shall comprise all of the real property interests necessary in connection with the acquisition, development, construction, installation, interconnection, completion and operation of the Project, all in accordance with all laws, and are sufficient to enable the Project to be commercially operable as contemplated in the Agreement, including legal and physical ingress and egress rights to and from public right-of-way for construction, operation, and maintenance of the Project.
- Permits - All permits required to develop, construct, own, and attain commercial operation of the Project are held by the Company, are final and non-appealable, are scheduled, and Seller has obtained and furnished to Buyer true, correct and complete copies of such permits. Such permits are in full force and effect and are legal, valid, binding and enforceable in accordance with their respective terms.
- Wind Data – Seller has delivered to Buyer true, correct and complete copies of all wind data, and energy production estimates if any, related to the Project.
- Title – The Company is in possession of and has good and marketable title to the Project free and clear of all encumbrances, except for Permitted Encumbrances. Seller has good and

marketable title to the Company's equity interests, free and clear of all encumbrances. Seller and its affiliates have no legal obligation to, or non-binding agreement in principle with any other person, to sell or affect a sale of all, or any portion of, the Project or the Company.

- Other representation and warranties customary in a transaction of this nature, including those pertaining to PTCs, taxes, title, finders, intellectual property, brokers and insurance or that are required following Buyer's due diligence review.

Other Agreements

- Interconnection. Seller shall be responsible for complying with all costs and requirements necessary to attain the final interconnection of the Project, including, but not limited to, all costs for the construction of any gen tie transmission line to [insert] substation/point of interconnection and any necessary network upgrade costs.
- Technology. The major equipment components of the Project shall be manufactured by top tier manufacturers acceptable to Buyer as specified in Buyer's Technical Requirements.
- Buyer's right to inspect. Buyer and Buyer's authorized representatives shall have the right to inspect the work and to maintain personnel at the Project site for such purpose. Such inspection of any part of the work shall in no way relieve Seller of its obligations under the Agreement.
- Seller will cause the Project to satisfy (in accordance with the Internal Revenue Code and associated guidance) requirements that qualify the project for the PTC at the [XX%] level. Seller has qualified the project for the PTC using the following process: [Seller to provide detailed description of qualification method]
- Build Out Restrictions. Seller agrees not to permit or construct a wind project within 5 miles of the Project.
- At Seller's cost, a legal opinion (the "Signing Opinion") from tax counsel selected by Buyer and in form and substance acceptable to Buyer shall be delivered to Buyer prior to the effective date of the Agreement, which Signing Opinion shall speak to the tax benefits associated with the transactions contemplated by the Agreement accruing to Buyer upon or after the Closing, and must include, without limitation, an opinion that, under the rules, regulations, and other laws in effect as of the date of the Signing Opinion, the Project will, based on among other things, the representations made by Seller on the date the Signing Opinion is delivered, generate a [XX%] PTC and, assuming the Closing occurs, that the exclusive rights to such PTCs will accrue to Buyer upon the placed in service date of the Project in accordance with applicable law and tax rules.
- In addition, and independent of to any pass-through warranties from the equipment manufacturers, balance of plant contractor and other suppliers and subcontractors, Seller shall provide a full wrap project warranty of no less than two years in duration as to defects in materials, workmanship and title, quality of work and performance as intended as a wind energy generation system.
- Seller shall assume all risks arising from any change in its commodity prices and all changes associated with any change in law affecting Seller's Project costs including, but not limited to, changes in tariff rates.
- Seller shall be responsible for all taxes relating to the pre-closing period and all transfer taxes and any sales, use or other taxes related to the purchase and sale of the ownership interests of the Company and any purchase or conveyance of real or personal property to the Company to be used in the Project.

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NON-BINDING TERM SHEET for the Purchase and Sale of an Wind Electric Generation Project

- Buyer will not be required to close if the aggregate nameplate capacity of the Project is less than 95% of the Expected Nameplate Capacity (the "Minimum Capacity").
- Liquidated Damages:
  - Delay Damages: Seller shall make a per diem liquidated damages payment, in an amount of $400/MW, for each day after a guaranteed substantial completion date that the Project has not achieved the Substantial Completion Date, such delay damages not to exceed an agreed percentage of the Purchase Price in the aggregate.
  - SCADA Infrastructure Delay Damages: Seller agrees that if SCADA Infrastructure Completion (definition to be agreed in the Agreement) is not achieved by [date TBD] ("Guaranteed SCADA Infrastructure Completion Date"), then Seller shall pay as liquidated damages to Buyer an amount equal to $5,000.00 per day for each day after the Guaranteed SCADA Infrastructure Completion Date but prior to the date on which SCADA Infrastructure Completion is achieved.
  - Buy-Down Damages: If the Closing occurs and the aggregate nameplate capacity of the Project as of the Substantial Completion Date is equal to or greater than the Minimum Capacity but less than the Expected Nameplate Capacity, Seller will be required to pay liquidated damages in an amount to be agreed in the Agreement.
- PTC Ineligible Damages: Seller to make payment of a PTC ineligibility fee in an amount equal to the net present value (using a discount rate corresponding to Buyer's then-current average weighted cost of capital) of the grossed-up pre-tax value of any lost PTCs resulting from one or more WTGs not being placed in service for U.S. federal income tax purposes in order to qualify for the PTCs
- NERC Matters: Seller shall comply with the NERC Reliability Requirements applicable to generating projects during commissioning and up until the Closing date and shall ensure the Project meets all NERC Reliability Requirements under the interconnection agreement. Seller shall maintain records required by NERC of such compliance actions and shall perform such other tasks and responsibilities as are set forth in Buyer's Technical Requirements. No later than fifteen (15) business days before Closing, Seller will provide Buyer current applicable compliance records related to the Project developed during commissioning or prior to Closing (such as commissioning test records, relay settings, energization and synchronization reporting activities, and voltage schedule). Seller will provide Buyer design documents required by NERC (such as the Reactive Power Report, Reactive Power Control design (for VAR-002 and to meet the Voltage Schedule), Facility Ratings, Coordination Studies, etc.) no later than 30 days before Closing.

Termination Provisions

The Agreement may be terminated upon written notice by the terminating party (as described below) in the event of certain occurrences, including without limitation:

- If applicable, by Buyer if the Firm Date has not occurred by the Outside Firm Date, regardless of the reason for such failure, provided that the terminating party is not in breach of the Agreement.

- By either party if the Closing has not occurred by the Outside Closing Date [date TBD], regardless of the reason for such termination, provided that the terminating party is not in breach of the Agreement.
- By either party if regulatory approvals for the transaction are not obtained by the Outside Firm Date on terms acceptable to Buyer in its sole discretion.
- By Buyer if applicable law or any order issued by, or any other action taken by, an authority restrains, enjoins, or otherwise prohibits the consummation of the transactions contemplated by the Agreement.
- By either party in the event of a material uncured breach or repudiation of the Agreement by the other party.
- By Buyer in the event of abandonment of the Project by Seller or the Company.
- By either party if the other party or, in the case of Seller, the provider of the Seller Credit Support, suffers insolvency or bankruptcy.
- By Buyer if there is a change of control of Seller.
- Termination Payment. Without limiting any other legal or contractual right or remedy available to Buyer (including Buyer's rights to liquidated damages under the Agreement that accrued prior to such termination), if the Agreement is terminated Seller will pay to Buyer a termination payment in the indicated amount:
    - if the Firm Date has not occurred and the termination occurs on or prior to Outside Firm Date, an amount equal to $75.00 multiplied by the number of kW in the Expected Nameplate Capacity;
    - if the the Closing has not occurred by the Outside Closing Date, an amount equal to $125.00 multiplied by the number of kW in the Expected Nameplate Capacity;

  provided, that Seller shall have no obligation to make a termination payment if the termination is a result of (i) a material uncured breach or repudiation by Buyer; (ii) Buyer's failure to obtain the required regulatory approvals by [date TBD], or (iii) Buyer's insolvency or bankruptcy.
- Return of Progress Payments. In addition to any termination payment owing by Seller to Buyer, if the Agreement is terminated prior to Closing Seller will repay to Buyer the aggregate amount of any progress payments paid by Buyer as of such date.

Indemnification

Each party shall indemnify and hold harmless the other party and its respective employees, representatives, officers, directors and agents from and against any and all damages arising out of any breach or violation of any representation, warranty, covenant, inaccuracy within the Agreement, or any liability not assumed as part of the Agreement, or negligence in performance of the Agreement. Seller shall indemnify Buyer for any environmental (including hazardous material) claims arising prior to the Closing date. No claim for indemnification shall be brought against the indemnifying party until the total damages for which such party is liable exceeds in the aggregate a threshold amount of $100,000, at which point indemnification may be sought for the full aggregate amount of damages, including those amounts that do not exceed the threshold. The aggregate damages to which the indemnified parties are entitled in respect of breaches or representations and warranties shall not exceed the indemnity cap,

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which shall be 30% of the purchase price.[1] Such threshold and indemnity cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or a breach of certain "fundamental" representations (as applicable to each party) such as corporate existence, power, authority, conflicts, title, land contracts, real property, environmental, intellectual property or tax matters or any liability not assumed as part of the Agreement. The aggregate damages to which the indemnified parties are entitled shall not exceed the Purchase Price. Such cap shall not apply to damages to the extent they arise from a party's fraud, willful misconduct or gross negligence or any liability not assumed as part of the Agreement.

Changes to Transaction Structure

The parties recognize that changes to the PTC may be made, or other incentives for wind energy generation may become available for U.S. federal income tax purposes, and that the parties may need to restructure the transaction in order for Buyer to be able to utilize such revised PTC or other incentives. The parties agree that they will negotiate in good faith to restructure the transaction in a manner that will maximize the ability of the parties to utilize any such revised PTC or other incentives.

[1] If deemed appropriate by Buyer based on the size and/or technology of the Project, the indemnity threshold and cap may be determined on a $/kW or $/MW basis.

MINIMUM REQUIRMENTS FOR COMBUSTION TURBINE PROJECTS BUILD-OWN TRANSFER

TECHNICAL SPECIFICATIONS FOR COMBUSTION TURBINE GENERATOR

94.03.36.100

XCEL ENERGY

KIEWIT PROJECT NO. 20038657

ISSUED: DECEMBER 11, 2020

REVISION A – ISSUED FOR REVIEW

KIEWIT
8900 Renner Blvd., Lenexa, KS 66219
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TECHNICAL SPECIFICATIONS
TABLE OF CONTENTS

TITLE **Pages** **Revision**

TECHNICAL REQUIREMENTS

APPENDIX A

SECTION TS1

COMBUSTION TURBINE

1. SCOPE

1.1 This specification covers the design, fabrication, testing, delivery, and technical direction of the installation and initial operation of combustion turbine generator (CTG) unit(s). The scope of supply is shown in the *CTG Engineering Design Requirements (EDR)*. This specification covers the combustion turbine and all auxiliaries required for operation, starting, control, and protection. It shall be the responsibility of the Supplier to furnish equipment that has been designed and fabricated for the specified service. Where Supplier's standard specifications differ, Supplier must request Owner's approval for deviation.

1.2 The Supplier shall provide guarantees as indicated in the EDR.

1.3 The combustion turbine shall be designed to operate continuously and reliably while firing the fuels within the ranges specified in the EDR.

2. EQUIPMENT TO BE FURNISHED BY SUPPLIER

2.1 The CTG units shall be assembled pre-engineered modules including, but not limited to, the following equipment and auxiliaries:

2.1.1 Combustion turbine units including:

a. Multistage, axial flow compressor with corrosion protected blades

b. Combustion systems

c. Low NOx emission control systems

d. Multistage turbines

e. Single fuel operation on natural gas as stated in EDR

f. XX% H_2 blend retrofit option

g. Ignition systems

h. Inlet air system with inlet air filtration

i. Inlet air evaporative cooling system

j. Lubricating and hydraulic oil systems

k. Excitation system

l. DC power supply system

m. Microprocessor combustion turbine control system with DCS interface capability

n. Gas chromatograph (if required)

o. Borescope openings for compressor and turbine maintenance and inspection

p. Velocity type vibration sensors

q. Proximity type axial shaft position sensors

r. Proximity type vibration sensors

s. Thermocouples for measurement of exhaust temperature and bearing metal temperatures

t. Compressor inlet air plenum with drain valves

u. Turbine exhaust plenums / diffusers with outlet expansion joints

v. Air processing units

w. Rigid type load couplings

x. Exhaust frame blowers or cooling fans

y. Enclosure air blowers

z. Fire protection system in conformance with all applicable codes and regulations

aa. Fire detection system in conformance with all applicable codes and regulations

bb. Off-line and on-line water wash manifolds with piping to enclosure edge

cc. Base mounted terminal boxes and on-base interconnecting wiring in rigid metal conduits per NEC dd. All necessary specialty maintenance/erection tools

ee. Portable Compressor Water Wash Skid common for both units

ff. All necessary startup spares for each CTG

gg. Supplier shall provide a complete list of 2 year operating spare parts.

2.1.2 Accessory systems modules including:

a. Lubrication and hydraulic oil systems

b. Fuel gas control systems

c. Starting system for each CTG

d. Metering and Relaying class current transformers and potential transformers, appropriate for equipment served

e. Shaft turning systems

f. Base mounted terminal boxes and interconnecting wiring in rigid metal conduits per NEC.

2.2 Balance of Plant equipment will be controlled through the existing Ovation system on site. TheCTG shall be controlled through the CTG supplier's control system. Supplier shall allow for datalink connection to the Ovation system.

2.3 Relaying and metering in accordance with Supplier's standards. Relay protection shall be sufficient to protect equipment and shall have the allowance for a typical substation.

2.4 Factory Assembly

2.4.1 All separately packaged accessory items shall be shop assembled to the maximum extent possible. The only exception shall be to meet shipping restrictions.

3. DESIGN REQUIREMENTS

3.1 General

3.1.1 All CTG units provided for a multiple unit installation shall be of identical design, layout, and componentry.

3.1.2 All CTG piping provided by the Supplier shall be in accordance with ASME B31.1.

3.2 The combustion turbine generators shall be designed for safe and reliable operation at all load conditions and with the range of environmental conditions and fuels specified. The various operations include:

3.2.1 Cold or warm start-up or immediate restart after coast-down including synchronization and loading to full capacity.

3.2.2 Continuous operation at 100% base load firing.

3.2.3 Emission requirements shall be met at all specified loads and operating conditions.

3.3 Structural Requirements

3.3.1 Seismic design as specified in the EDR.

3.3.2 Design Loads

a. The structural design of the equipment and support shall be based as a minimum, on the requirements of the 2018 International Building Code (IBC)

b. The CTG and accessory equipment shall be designed by the Supplier for the following loads:

1. Dead loads

2. Normal torque loads (turbine)

3. Live loads

4. Temperature and pressure loads

5. Emergency loads, such as turbine accident loads, generator short circuit loads and any temperature and pressure loads present during the emergency.

6. Wind Load

7. Seismic Load

8. Transportation Loads

9. Piping Loads

10. Impact Loads

3.3.3 Load Combinations

The following load combinations shall be considered, as a minimum, in the design of the turbine generator and accessory equipment:

a. Dead Load

b. Dead load plus live load plus all loads associated with normal operation of the equipment, e.g., temperature and pressure loads, piping loads, normal torque loads, impact loads, etc.

c. Dead load plus all loads associated with normal operation plus wind or seismic loads.

d. Dead load plus emergency loads plus wind loads plus seismic loads.

3.3.4 The turbine generator and accessories shall be functional after combined application of all the loads in their various load combinations. Load factors for the loads shall be determined by the Supplier using industry standards and the 2018 International Building Code (IBC) .

3.3.5 The loading combination producing the maximum stress shall be considered. The maximum stress shall not exceed the allowable stress permitted by the appropriate code for that combination.

3.3.6 The Supplier shall provide all foundation embedment drawings necessary for the installation of the CTG and the CTG system skids. Foundation bolts shall be provided by the Contractor. Any required fabricated embedments shall be provided by the Supplier.

3.4 Inlet Air System

The inlet air system shall consist of the following components:

3.4.1 Self-Cleaning Pulse Filter

3.4.2 Silencer – galvanized steel perforated liner (85 dBA @ 3 feet).

3.4.3 Ductwork.

3.4.4 Flexible connections.

3.4.5 Support structure, walkways, platforms, and ladders.

3.4.6 Control system.

3.4.7 The aerodynamic design shall be such that air intake velocities shall be uniform across the entire filter area.

3.5 Exhaust Gas System

3.5.1 The exhaust stack and silencer shall be furnished by others.

3.5.2 All control elements and bleed air connections required by the Supplier are to be included in the Supplier's scope.

3.6 Control System and Instrumentation

3.6.1 The CTG control system and instrumentation shall be provided in accordance with Supplier's standard specifications.

3.6.2 All hydrodynamic radial and thrust bearings in the combustion turbine generator shall be fitted with thermocouples for measuring the bearing metal temperatures. The bearing metal temperature monitoring shall be provided by the Supplier.

3.6.3 Vibration and Position Detectors: Non-contacting vibration, phase angle (keyphasor), and axial position transducers shall be provided for the combustion turbine generator. Two axial position proximity probes shall be supplied.

3.6.4 The vibration and axial position monitors shall be provided by the Supplier. The axial position monitor shall be of the dual voting type. If the Supplier's standard vibration system will function as the primary protection, then readings for each probe may be supplied in place of the monitors through the Supplier's control panel data highway.

3.7 Lubrication and Hydraulic Oil System

The lube and control oil systems shall include the following components and features as a minimum:

3.7.1 One (1) main lube oil reservoir mounted on skid including access opening for draining, cleaning and fitting, instrumentation, oil level indicator and alarm contacts, switches for sequential starting of pumps. The lube oil reservoir shall have built-in secondary containment or provisions to be set in a secondary containment structure.

3.7.2 One (1) Main AC motor driven lube oil pump and one (1) full capacity AC motor driven auxiliary lube oil pump

3.7.3 Partial capacity DC motor drive emergency lube oil pump

3.7.4 Main hydraulic oil pump

3.7.5 Full capacity AC motor driven auxiliary hydraulic oil pump

3.7.6 Dual oil filters with continuous flow transfer valve

3.7.7 Dual oil coolers with continuous flow transfer valve and removable bundles.

3.7.8 All piping from the oil filter to the lube oil feed points shall be stainless steel, butt-welded on all supply piping. The use of slip-on flanges is not acceptable.

3.7.9 All hydraulic oil piping or tubing for control and trip oil systems shall be stainless steel.

3.7.10 Oil system reservoir vent demister.

3.7.11 All oil piping shall be fabricated using butt welded fittings and flanges for disassembly. No socket welds are permitted in the bearing supply lines or hydraulic system downstream of the filters. All first pass welds shall be welded using a gas tungsten arc welding (GTAW) process. All first pass welds shall be inspected using liquid penetrant or magnetic particle examinations. All welding shall be in accordance with ASME requirements.

3.8 Vibration

3.8.1 During shop and field testing, the unfiltered vibration of the CTG unit measured by the Supplier installed probes shall not exceed the more restrictive of 0.25 inches per second housing vibration velocity or 3.0 mils relative shaft displacement. Verified runout may be vectorially deducted from the measured displacement.

3.8.2 Axial vibration shall not exceed 1 mil.

3.9 Materials

3.9.1 The Supplier's standard materials of construction are acceptable provided they are suitable for the service and conditions stated herein, and are in full compliance with the codes, standards, and conditions listed in this specification.

3.10 Fire Protection

3.10.1 A fire detection and automatic extinguishing system shall be provided for the turbine and accessory compartments. Detectors are required in all compartments to initiate a zoned release of extinguishing media in concentrations that meet the requirements of NFPA 12A.

3.11 Electrical

3.11.1 The electrical systems and components shall be provided in accordance with these specifications.

3.12 Generator

3.12.1 The generator shall be supplied in accordance with the EDR.

3.12.2 All generator cooler components in contact with cooling water shall be constructed of 304SS.

4. SPECIAL REQUIREMENTS

4.1 Emissions – Per the EDR

4.2 Hydrogen Retrofit Package Requirements

4.2.1 Hydrogen Fuel Blending Skid

a. Skid to blend 100% H2 and natural gas
   1. H2 and natural gas stop/control valves
   2. H2 and natural gas flow meters
   3. Instrument and controls

4.2.2 Hydrogen Package Additions and Modifications

a. Inert purge system hardware and instrumentation
b. Optical fire detection inside the enclosure
c. H2-capable gas speciation sensor
d. Ventilation system upgrade
e. Software modifications
f. Catalytic-bead LEL hazardous gas detection
g. Fuel system pipe material upgrade to address H2 embrittlement
h. SIL compliance (if required)
i. Analysis to ensure system is properly sized for higher volumetric h2-fuel and higher diluent flow demand to maintain emissions

4.3 Preparation for Shipment

4.3.1 The combustion turbine unit shall be suitably prepared for rail, truck, or sea shipment as applicable, including blocking of the rotor when necessary. The preparation shall be suitable for a minimum period of 6 months of outdoor storage from the time of shipment, such that disassembly is not required, except for bearing and seal inspections, before operation. Any combustion turbine component, accessory, or instrument not suitable for the extremes of temperatures that can be expected during shipment or storage shall be identified by the Supplier prior to shipment.

4.3.2 Preparation for shipment shall be made after all testing and inspection of the equipment has been accomplished and the equipment has been authorized to ship by the Owner. The preparation shall include as a minimum the steps described in the following paragraphs:

a. All exterior surfaces, with the exception of machined surfaces, shall be given a minimum of one priming coat of paint by the Supplier. This primer must be compatible with the finish paint specified and applied by the Owner.

b. All exterior machined surfaces shall be coated with a suitable rust preventive.

c. The interior of the equipment shall be sprayed, flushed, or fogged with a suitable rust preventive that is removable by solvent. This shall be done through available openings, preferably while the machine is slow rolled.

d. All parts that will be in contact with system oils shall be prepared for shipment in accordance with the following:

1. All internal steel surfaces of components fabricated of carbon steel, such as oil reservoir pumps, bearing housings, and piping, shall be coated with a suitable oil-soluble rust preventive that can be completely removed by flushing with the normal charge oil.

2. Each filter shall be shipped with clean elements installed and shall carry outside a securely affixed all-weather tag stating, "SHIPPED WITH CLEAN ELEMENTS INSTALLED."

e. All flanged openings, except air inlet and exhaust, shall be provided with metal closures, of 3/16 inch minimum thickness with rubber or plastic gaskets and at least four full-diameter bolts. Inlet and exhaust openings shall be provided with substantial gasketed watertight closures.

f. All threaded openings shall be fitted with steel caps or solid-shank steel plugs of metallurgy equal to or better than that of the pressure casing.

g. All openings that have been beveled for field welding shall be provided with closures designed to prevent the entrance of moisture or foreign materials and damage to the bevel.

h. Lifting points and lifting lugs shall be clearly identified along with lifting weight limits if applicable.

i. All combustion turbine units shall be identified with item and serial numbers. All material shipped separately shall be identified with securely affixed, corrosion resistant metal tags indicating the items and serial number for which it is intended.

5. DOCUMENTATION

5.1 Supplier shall supply the type and quantity of drawings and documentation for Owner's authorization or information in accordance with the Seller's Deliverable Schedule (SDS).

6. TESTS AND INSPECTIONS

6.1 Upon receipt of a purchase order, the Supplier will provide the Owner with a detailed inspection and test program (ITP) with an accompanying schedule of activities. The Supplier shall provide the Owner with advance notification of shop inspections and tests so that the Owner can observe testing, dismantling, inspection and reassembly of the equipment.

6.2 Acceptance of shop tests does not constitute a waiver of requirements to meet performance under specified operating conditions, nor does inspection relieve the Supplier of his responsibilities.

END OF SECTION

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Scope of Supply - If applicable based on Manufacturer's available offerings

Item		Description	By Mfg.	By Purch.	Option	N / A
1.0		**General Description**				
1.1		Size Designation				
		Capacity at summer max ambient				
	X	50 MW				
		Shaft Arrangement (if both checked, Mfg's choice)				
	X	Single Shaft				
	X	Multi-Shaft				
1.2		Quantity of Combustion Turbine Generator Sets				
	4	CTG's				
1.3		Frequency				
		50 Hz				
	X	60 Hz				
1.4		Inlet Filtration System				
	X	Self-cleaning				
		Multi-stage				
1.5		Inlet Cooling			X	
	X	Evaporative				
		Chiller coil				
1.6		Fuel Type				
	X	Natural Gas				
		Fuel Oil				
		Dual Fuel				
1.7		Exhaust Arrangement				
	X	Simple Cycle				
		Combined Cycle (with SC Bypass)				
		Combined Cycle (No Bypass)				
		Twin Pac				
1.8		Exhaust Connection				
		Flanged (incl. Expansion Joint only)				
		Flanged - with Expansion Joint and Transition				
	X	Vendor Defined				
		NOTE:				
1.9		Location				
		Indoors				
	X	Outdoors				
1.10		Combustion Turbine Performance Information Request				
	X	Guarantee point indicated with *. Provide performance at MECL, 75% load, and 100% load				

					*			
Ambient DBT	, F	-40	0	30	60	90	105	
Relative Humidity	, %	60	60	60	60	25	20	
Site Elevation	, ft	981	981	981	981	981	981	
NOX Limit	, tons/year	25	25	25	25	25	25	
CO Limit	, ppmvd	L.A.	L.A.	L.A.	L.A.	L.A.	L.A.	L.A.: Lowest Achievable
SCR Pressure Drop Max	, dp							

Item		Description
1.11		Fluid Supply Conditions
	X	See attached data sheet(s)

1	**Natural Gas**	**TBD**	psia	**TBD**	F	OEM to advise on temperature, pressure, cleanliness, and superheat requirements at scope interface. Fuel analysis in Appendix A.
2	**Steam / Water**	**N/A**	psia	**N/A**	F	
3	**Fuel Oil**	**N/A**	psia	**N/A**	F	

Item		Description	By Mfg.	By Purch.	Option	N / A
1.12		Coupling				
		Direct Coupled				
		Synchronized Clutch				
	X	Manufacturer Standard				
1.13		Codes and Standards				
	X	Local Applicable Laws and Ordinances				
	X	Applicable ASME Power Piping and Pressure Vessel Codes				
	X	Applicable ANSI Codes and Standards				
	X	Applicable PE Stamp				
	X	See Attached for List of Codes				
1.14		CTG/Contractor Interface				
	X	per ANSI Standards				
	X	per IEEE Standards				
		NERC CIP Compliance Requirements				
		Other _____				
1.15		Expected CTG Load Demand				
	X	Min Emissions% - 100% With Rapid Daily Cycle				
		100% Base Loaded				
		See Attachment				

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Item	Scope of Supply - If applicable based on Manufacturer's available offerings Description	By Mfg.	By Purch.	Option	N / A
1.16	Cooling Water System				
	Open				
	X Closed				
	X Propylene Glycol %				
	Supply Temperature: **32 - 106** degrees F				
	Supply Pressure: **87 - 150** psig				
1.17	Seismic Data per ASCE 7-16				
	Site Class: D				
	Mapped Spectral Response Accelleration Parameters S_s= 0.045g				
	S_1= 0.032g				
	Site Coefficients F_a= 1.6				
	F_v= 2.4				
	Occupancy Category: III				
	Seismic Importance Factor for Occupancy Category III I= 1.25				
	Seismic Design Category: A				
2.0	**Electrical Voltage Levels**				
	345 kV High Voltage				
	Medium Voltage				
	480 V Low Voltage				
3.0	**Configuration**				
3.1	Supports	X			
	X Skid Base				
	Sole Plate				
3.2	Erection / Commissioning Hardware				
	Anchor Bolts and Nuts		X		
	Anchor Bolt Templates	X			
	Foundation Leveling Wedges / Adjustable Support Devices	X			
3.3	Embedments (incl. any specialty anchor bolts like foundation "thru" bolts or support steel unique to the CTG)	X			
3.4	Starting Device	X			
	DC Motor Driven w/Starter				
	Static				
	X Manufacturer Standard				
	Qty: 1 per CTG; **X** 1 per Power Block				
3.5	Inlet Air Structure				
	Arrangement: Side Inlet or Over-the-Top Inlet	X			
	Inlet Filter House	X			
	Rain Hood	X			
	Bird Screen	X			
	Self-Cleaning with Air Processing Unit/Air Compressor Assembly	X			
	Multi-stage				X
	Evaporative Cooler	X			
	Chiller Heat Exchanger Grid/Coils				X
	Mist Eliminator	X			
	Inlet Duct and Expansion Joint	X			
	Inlet Duct Silencer (as required)	X			
	Inlet Duct Acoustical Lagging (as required)	X			
	Inlet Air Heating System (as required)	X			
	Inlet Filterhouse and Duct Support Steel/Structure	X			
	Inlet Plenum (with viewing window)	X			
	Inlet Compartment Differential Pressure Alarm	X			
	Thermocouples for Inlet Air Temperature Measurement	X			
	Ladder Access	X			
	Access panels at all filtration maintenance levels	X			
	Manual hoist rated 1/2 ton	X			
	Inlet filter compartment interior lighting	X			
	Inlet air filter support steel drawings	X			
3.6	Compressor				
	Compressor inlet humidity sensor	X			
	Inlet bleed heat manifold for anti-icing	X			
	Inlet bleed heat control valve(s)	X			
	Inlet Guide Vanes and Actuators	X			
	Variable Guide Vanes and Actuators	X			
	Blade and Vane Thermal Coatings	X			
3.7	Combustor				
	Distillate Oil w/ Water Injection				X
	Distillate Oil w/o Water Injection				X
	Dual Fuel w/ Water Injection				X
	Dual Fuel w/ DLN or ULN				X
	Natural Gas w/Water Injection				X
	Natural Gas - DLN with Steam Injection for Power Augmentation				X
	Crossfire flame tubes	X			
	Natural Gas w/ DLN or ULN	X			
	Thermal barrier coatings	X			
	Transition Pieces to Turbine 1st Stage	X			
	SiC flame detectors	X			

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Item	Description			By Mfg.	By Purch.	Option	N / A
	Scope of Supply - If applicable based on Manufacturer's available offerings						
3.8	Fuel System						
	Fuel Gas System - as requried			X			
		X	Unit Fuel Gas Flow Meter				
		X	Fuel Strainer				
		X	Main Fuel Final Filter System				
		X	Pilot Fuel Final Filter System				
		X	Fuel Gas Supply Piping (stainless from final filters)				
		X	Control Valves, Throttle Valves & Instrumentation (Main & Pilot)				
		X	Overspeed Trip Valve (Main & Pilot)				
		X	Vent and State Isolation Valves (as required by NFPA 85 to maintain purge credit)				
		X	Ring Manifolds				
		X	Acoustic Lagging (for piping and valves outside turbine enclosure, as needed)				
	Fuel Oil System						X
			Transfer from Fuel Gas Operation to Fuel Oil Operation during reduced engine load				
			Unit Fuel Oil Flow Meter				
			Fuel Oil Pump Skid (incl. suction filters, pump(s) and on-skid power wiring)				
			Fuel Oil Heater				
			Fuel Oil / Water Injection Skid				
			Water Injection Skid (incl. suction strainer, pump, flow meters, control valves, etc.)				
			Control Valves, Throttle Valves & Instrumentation (Main & Pilot)				
			Overspeed Trip Valve (Main & Pilot)				
			Vent and State Isolation Valves (as required by NFPA 85 to maintain purge credit)				
			Ring Manifolds				
			Acoustic Lagging (for piping and valves outside turbine enclosure, as needed)				
3.9	Turbine						
	Bleed air Cooled Blades and Nozzles			X			
	Nozzle and Blade Thermal Coatings			X			
	Position Switches, Position Transmitters for above			X			
	Turbine Gas and Metal Temperature Monitoring System			X			
	Interconnecting Piping between for Bleed Air Cooling, Lube Oil, etc.			X			
	Journal Bearings with Thermocouples			X			
	Thrust Bearing with Thermocouples			X			
	Rotor Vibration Monitoring			X			
	Turbine Drain System			X			
	Turbine / Generator Coupling Cover			X			
	Blade Cooling Air System & Support Structure (Rotor Air Cooler) (if applicable)			X			
		X	Air-to-Air Forced Draft Type				
			Kettle Boiler Type				
	Purge Air System (for fuel oil operation)						X
	Steam Power Augmentation Nozzles (incl. control valves, instrumentation, flow meter, and pipe)						X
3.10	Exhaust						
	Exhaust Diffuser / Transition Piece			X			
	Exhaust Diffuser Enclosure			X			
	Expansion Joint			X			
	Exhaust Thermocouple Rakes			X			
	Internal Lagging			X			
	Exhaust Frame Blowers			X			
	Galvanized Bolts, Nuts, and Washers			X			
3.11	Cleaning Systems			X			
		X	Portable Compressor Water Wash Skid: Common for both CTG's				
		X	Stainless Steel Tank and Fittings				
		X	Immersion Heater				
		X	On base piping				
		X	Manual ON and OFF line wash capabilities				
		X	Water Wash System Orifice Plates				
3.12	Instrument Air System						X
			Instrument Air Compressor				
			Instrument Air Receiver Tank				
			Instrument Air Tubing				
			Pressure Switch and Gauge Panel				
3.13	Local Gauges			X			
		X	Rack mounted				
			Local				
3.14	Thermal Insulation Material			X			
		X	Including thermal insulation blankets for Combustion Turbine				
3.15	Interconnecting Piping between OEM Supplied Skids			X			
3.16	Insulation and Lagging for OEM Supplied Piping Scope			X			
3.17	Heat Tracing				X		

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Item		Description	By Mfg.	By Purch.	Option	N / A
		Scope of Supply - If applicable based on Manufacturer's available offerings				
3.18		Combustion Turbine Enclosure(s)	X			
	X	Lagging or Enclosure				
		Outdoor Type Sound Proof Cover (85 dBA at 3 ft)				
	X	Sound Proof Cover (85 dBA at 3 ft)				
	X	Enclosure Lighting, Heating and Ventilation				
	X	Modular Construction				
	X	Designed to meet heat tracing requirements				
3.19		Name Plate	X			
3.20		Special Tools	X			
	X	Installation Tools				
	X	Maintenance Tools				
	X	Lifting Beam for Crossover Piping to be Lifted Without Disassembly				
4.0		**Noise Guarantees**				
4.1		Near Field	X			
	X	85 dBA at 3 Ft. Distance and 5 Ft. Above Grade or Platform referred to 20 micropascals				
		Other				
4.2		Far Field (Sound Pressure Levels, A-Weighted)	X			
	TBD	dBA at 400 feet from the equipment/enclosure				
		Other:				
5.0		**Turbine Control Protective Devices**				
5.1		Fuel Control System	X			
	X	Fuel Supply Header to Combustors				
	X	Master Fuel Control Valve				
	X	Fuel Strainers and Filters				
	X	Fuel Gas Separator				
5.2		Speed Control	X			
5.3		Power Control	X			
5.4		Vibration Monitoring	X			
	X	Bentley Nevada				
		Manufacturer Standard				
6.0		**Protective Devices**				
6.1		Overspeed Protection	X			
		Mechanical Overspeed Trip Device (emergency governor)				
	X	Electrical Overspeed Trip Device (2 out of 3)				
6.2		Thrust Protection	X			
		Mechanical Thrust Bearing Wear Trip Device				
	X	Electrical Shaft Position Abnormal Trip System				
6.3		Emergency Manual Trip Device	X			
6.4		Lube Oil Pressure Excessive Low Trip System	X			
6.5		Shaft Vibration Excessive High Trip System (Compatible with Bently Nevada SystemOne)	X			
6.6		Differential Expansion High Trip System	X			
6.7		Shaft Eccentricity Trip System	X			
6.8		Turbine Inlet Temperature High Trip	X			
6.9		Turbine Inlet Differential Temperature High Trip	X			
7.0		**Fire Protection System**				
7.1		Locations				
		Turbine Enclosure(s)	X			
	X	Thermal Detectors				
	X	Combustible Gas Sensors				
	X	Manual Pull Stations at Exits				
	X	Alarm Horns				
	X	Alarm Strobes				
	X	Compartment Warning Signage				
	X	Agent Discharge Nozzles				
	X	Piping (including valves, hangers, insulation and instrumentation)				
	X	Fire Protection Agent				
		CO_2				
		Water Mist				
	X	Inert Gas				

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Item	Description			By Mfg.	By Purch.	Option	N / A
	Scope of Supply - If applicable based on Manufacturer's available offerings						
	Electrical Package(s)			X			
	X	Control Panel					
	X	Thermal Detectors					
	X	Smoke Detectors					
	X	Manual Pull Stations at Exits					
	X	Alarm Horns					
	X	Alarm Strobes					
	X	Compartment Warning Signage					
	X	Agent Discharge Nozzles					
	X	Piping (including valves, hangers, insulation and instrumentation)					
	X	Fire Protection Agent					
			CO_2				
		X	Inert Gas (FM200)				
	Lube Oil Package Enclosure(s)			X			
	X	Thermal Detectors					
	X	Smoke Detectors					
	X	Manual Pull Stations at Exits					
	X	Alarm Horns					
	X	Alarm Strobes					
	X	Compartment Warning Signage					
	X	Agent Discharge Nozzles					
	X	Piping (including valves, hangers, insulation and instrumentation)					
	X	Fire Protection Agent					
			CO_2				
			Water Mist				
		X	Inert Gas (FM200)				
8.0	**Lubricating and Hydraulic Oil System**			X			
8.1	General System Design Requirements			X			
		Carbon Steel Tank (sufficient size to include flowback during trips)					
	X	Carbon Steel Double Wall Tank					
	X	AC Motor Driven Main Dual Lube Oil Pumps					
	X	AC Motor Driven Main Dual Hydraulic Oil Pumps: Used for jacking (lift) oil, also					
	X	AC Motor Driven Oil Vapor Fan (2 x 100%) with Mist Eliminators					
	X	DC Motor Driven Emergency Lube Oil Pump					
	X	Duplex Oil Filter (10 microns, parallel)					
	X	Accumulator					
	X	Temperature and Pressure Control Valves					
		Electric Heater with Control System					
	X	Air Cooled or Water Cooled Lube Oil Cooler (2 x 100%) with temp control system					
			90/10 CU-NI				
		X	304 SS				
			Other				
	X	Skid Mounted Piping					
	X	Handrails and Ladder					
8.2	Interconnecting Piping			X			
	X	Manual Valves					
	X	CS Piping return from CTG (Pickled and Passivated)					
	X	SS Oil Pressure Piping (supply to CTG)					
	X	Supply Pipe in High Temp Areas to be Contained Inside Return Oil Pipe					
	X	SS Piping after Oil Filter					
	X	All lube oil piping shall be butt welded, including small bore					
8.3	Oil Conditioner			X			
		Coalescer Type					
		Centrifugal Type					
		Vacuum Type					
	X	Other: Bypass type lube oil purifier sized to process entire contents of the lube oil system in 4 hours					
	X	Interconnecting Piping					
8.4	Lube Oil/Hydraulic Oil Skid Enclosure			X			
	X	Indoor with Soundproof Cover (85 dBA at 3 ft.)					
		Outdoor with Soundproof Cover (85 dBA at 3 ft.)					
		Outdoor					
8.5	Skid Mounted			X			
	X	Combined Lube Oil & Control Oil Systems					
		Separate Lube Oil & Control Oil Systems					
9.0	**Synchronous Generator and Accessories**			X			
9.1	Type						
	X	Totally Enclosed					
		Open					
		Skid Mounted					
		Non-Skid Mounted					

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Scope of Supply - If applicable based on Manufacturer's available offerings

Item	Description		By Mfg.	By Purch.	Option	N / A
9.2	Cooling System					
		Water-to-Air Cooled				
		Hydrogen Cooled				
		Air-to-Air Cooled				
	X	Vendor Defined				
9.3	Rotor					
	X	Cylindrical Rotor				
		Salient Pole Rotor				
9.4	Excitation (If both checked, Manufacturer's choice)					
	X	Brushless				
	X	Static				
9.5	Number of Poles					
	X	Two (2) Pole				
		Four (4) Pole				
9.6	Terminal Entry Location					
		Bottom				
		Top				
	X	Side				
9.7	Location					
	X	Indoor				
		Outdoor				
9.8	Generator Frequency					
		50 Hertz				
	X	60 Hertz				
10.0	**Generator Scope**					
10.1	Generator Proper Including Bearing Pedestals & Journal Bearings		X			
10.2	Anchor Bolts and Nuts		X			
10.3	Supports		X			
	X	Skid Base				
		Sole Plates				
10.4	Fixators		X			
10.5	Embeds		X			
10.6	Fin-Tube Hydrogen to Water Coolers (if applicable)		X			
10.7	Number of Coolers (vendor to define capacity of each)		X			
		2				
		4				
	X	Vendor Defined Standard				
10.8	Cooler Tube Materials					
		90/10 CU-NI				
		304 SS				
		Carbon Steel				
	X	Vendor Defined Standard				
10.9	Generator Voltage					
	X	13.8 kV				
		18 kV				
		Other: kV				
10.10	Power Factor					
	0.95	Leading				
	0.85	Lagging				
10.11	Seal Oil System (if applicable)		X			
	X	Redundant Seal Oil Pumps				
	X	AC/DC Motor Driven Seal Oil Pumps				
	X	SS Feed Pipe and CS Drain Pipe				
	X	Degassing System				
10.11	Insulation for Prevention Against Shaft Current		X			
10.12	Shaft Guarding Brush		X			
10.13	Shaft Current Monitor		X			
10.14	Air-Gap Flux Probe		X			
10.15	Stator Liquid Cooling System		X			
10.16	Stator Core Condition Monitor		X			
10.17	Space Heater		X			
10.18	Cooling Water Leakage Alarm System		X			
10.19	Main Terminals		X			
10.20	Earth Terminals		X			
10.21	Class F Insulation & Class B Temperature Rise		X			
10.22	Generator Enclosure		X			
		Generator Cover				
	X	Sound-Proof Cover (85 dBA at 3 feet)				
		Outdoor-Type Cover (85 dBA at 3 feet)				
		Enclosure Heating and Ventilation				
		Modular Construction				
10.23	Generator Terminal Enclosure		X			

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Scope of Supply - If applicable based on Manufacturer's available offerings

Item		Description	By Mfg.	By Purch.	Option	N / A
10.24		Contractor Interface				
		At Generator Enclosure Wall				
	X	At Mfg Supplied Equipment				
10.25		Nameplate	X			
10.26		Special Tools	X			
	X	Start-up Tools				
	X	Maintenance Tools				
11.0		**Excitation System**				
11.1		Type (If both checked, Manufacturer's choice)	X			
	X	Permanent Magnet Generator (PMG)				
	X	Bus Fed Static Exciter				
11.2		Rotor Excitation	X			
	X	Slip Ring				
	X	Brushless				
11.3		Automatic Voltage Regulator (AVR)	X			
		Analog Type				
	X	Digital Type				
11.4		Excitation Transformer(s)	X			
11.5		Excitation Cross-Tie Switch (if Applicable)				X
11.6		De-Excitation System with DC Breaker	X			
11.7		Diode Failure Protection System with Cooling Fan and Space Heater	X			
11.8		APR (Automatic Power Factor Regulator)	X			
11.9		Power System Stabilizer	X			
11.10		Excitation Enclosure	X			
12.0		**Electrical Equipment**				
12.1		Generator Main Circuit Breaker	X			
12.2		Generator PT/SA System Class 800, Billing Meter Quality	X			
12.3		Generator Neutral System	X			
		Resistor Type				
	X	Grounding Transformer with Secondary Resistor and Terminals				
12.4		Current Transformer (bushing type, total 7, line side) Class 800	X			
12.5		Current Transformer (bushing type, total 9, neutral side) Class 800	X			
12.6		CT Boxes for the Above (Located in CTG Supplier Housing)	X			
12.7		Low Voltage AC & DC Switchgear	X			
12.8		AC/DC Distribution Panel	X			
12.9		DC Motor Starting Device (only for EOP and Turning Motor)	X			
12.10		Synchronizing Device	X			
		Manual				
	X	Automatic				
12.11		Generator Step-up Transformer		X		
12.12		House Transformer, Starting Transformer		X		
12.13		Non-Segregated Bus Duct (up to Gen. Step-up Transformer)		X		
12.14		Segregated Bus Duct		X		
12.15		Iso Phase Bus Duct		X		
12.16		Motor Type	X			
		TEFC or TENV				
		WPII				
	X	CTG Supplier Define				
12.17		Terminal Boxes or Panels				
		Electric Cubicles	X			
		Auxiliary Motors and Motor Starters	X			
		Local Lube Oil and Hydraulic Fluid Panels	X			
		Control Panel and Junction Boxes	X			
	X	Ring Tongue Terminals				
		Spade Tongue Terminals				
12.18		Wiring Between Instruments or Switches on CTG or manufacturer supplied skids and Junction Boxes	X			
12.19		Wiring from Switchgear to CTG		X		
12.20		Low Voltage Station Service Transformers		X		
12.21		Power Cable for CTG (External Wiring)		X		
12.22		Control Cable for CTG (External Wiring)		X		
12.23		DC Facilities (Batteries, Rack, Battery Charger, etc.)	X			
12.24		UPS		X		
12.25		Electrical Equipment Enclosure	X			
	X	Enclosure Lighting, Heating and Ventilation				
	X	Modular Construction				
	X	Power & Control Wiring				

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Item			Description	By Mfg.	By Purch.	Option	N / A
			Scope of Supply - If applicable based on Manufacturer's available offerings				
13.0			**Control and Monitoring Equipment**				
13.1			Turbine Control and Supervisory	X			
			Interface with Plant BOP	X			
			Ability to Control Remotely	X			
13.2			Digital Turbine/Generator Regulator	X			
			Single MPU				
	X		Double MPU				
			Triple MPU				
13.3			Interlock and Protection System	X			
	X		Auxiliary Control				
	X		Turbine Trip (hard wired)				
	X		Generator Protective Relays				
13.4			ATS Logic with Turbine Stress Evaluator			X	
13.5			Annunciation Device with Annunciation Window			X	
13.6			Monitoring System Cubicle (transducer, conditioner/monitor, etc.)	X			
13.7			Transmitters and Sensors				
			Pressure Inst./Gauge/Switch on Equipment provided by CTG vendor	X			
			Temperature Inst./Gauge/Switch on Equipment provided by CTG vendor	X			
			Level Inst./Gauge/Switch on Equipment provided by CTG vendor	X			
			Speed Measuring Instruments	X			
			Vibration and Monitoring System (Bentley Nevada equivalent)	X			
			Shaft Position Sensor and Monitor			X	
			Flow Measuring Devices on Equipment Provided by CTG vendor	X			
			Key Phaser			X	
			Eccentricity Sensor and Monitor			X	
			Differential Expansion Sensor and Monitor			X	
			Overall Casing Expansion Sensor and Monitor			X	
			Pre-wired from Sensor/Actuators to Junction Boxes	X			
14.0			**Miscellaneous**				
14.1			Performance Testing				
	X		Pressure Taps and Duplicate Temperature Wells Required to Perform Performance Test According to ASME PTC-22	X			
	X		Performance Test Written Procedures	X			
	X		Standard Test Instrumentation	X			
	X		Special Test Instrumentation	X			
	X		Calibration of Test Instrumentation / Equipment	X			
	X		Installation of Test Instrumentation / Equipment	X			
	X		Preliminary Fuel Samples		X		
	X		Testing Fuel Samples		X		
	X		Execution of Performance Tests	X			
	X		Performance Test Reports	X			
14.2			Performance Guarantees with Liquidated Damages, Test Tolerance: 0% Uncertainty: Test quality is to achieve <= 1.0%, however uncertainty is not applied to reults for pass/fail assessment.	X			
	X		Output				
	X		Heat Rate - LHV w/ conversion factor to HHV				
			Exhaust Temperature				
	X		Exhaust Flow				
			Exhaust Energy				
	NOTE:		1. ALL PERFORMANCE DESIGN BASIS CONDITIONS SHALL BE LOCATED AT THE PHYSICAL HARDWARE SCOPE OF SUPPLY. 2. EXHAUST FLOW GUARANTEE IS A NOT-TO-EXCEED FOR THE PURPOSE OF SIZING THE SCR.				
14.2			Performance Guarantees - Make Right	X			
	X		Emission Guarantees (from Minimum Emissions Compliance Load to Full/Base Load)				
		X	NO_x (ppmvd @ 15% O_2, lb/hr as NO_2, lb/MMBtu as NO_2)				
		X	CO (ppmvd @ 15% O2, lb/hr , lb/MMBtu)				
		X	VOC/POC (ppmvd @ 15% O2, lb/hr as CH_4, lb/MMBtu as CH_4)				
		X	PM/PM 10/PM 2.5 (lb/hr, lb/MMBtu)				
			SO_2 (lb/hr, lb/MMBtu)				
			H_2SO_4 (lb/hr, lb/MMBtu)				
			Other				
			Rate of Load Change Emissions Guarantees				
	X		Starting Reliability Guarantee				
	X		Running Reliability Guarantee				
			Ramp Rate Guarantee (while meeting emissions requirements)				
			Increasing (MW/min)				
			Decreasing (MW/min)				
			Ramp Time Guarantee				
	X		Evaporative Cooler Effectiveness (≥ 85%)				
			Heat Input (for Performance Cases)				
	X		Startup Emissions				
	X		Shutdown Emissions				

XCEL ENERGY - WHEATON, WISCONSIN
EDR - COMBUSTION TURBINE GENERATOR

Scope of Supply - If applicable based on Manufacturer's available offerings					
Item	**Description**	**By Mfg.**	**By Purch.**	**Option**	**N / A**
14.3	Shop Inspection and Tests - Combustion Turbine				
	Mechanical Balance	X			
	Governor and Control Function Operation	X			
	All Standard Factory Tests	X			
	Shop Inspection and Tests - Generator				
	Mechanical inspection	X			
	Rotor Balance with Rotor at Normal Maximum Operating Temperature	X			
	Rotor Overspeed at 120% Rated	X			
	Measurement of Cold Resistance of Stator and Rotor Windings	X			
	Winding Insulation Resistance Measurement	X			
	Standard IEEE 4 Dielectric Tests on Stator and Rotor	X			
	Resistance Temperature Detector Test	X			
	Lubricating Systems Including Hot Oil Flushing and Bearing Inspection	X			
	Comprehensive tests of all systems and controls to assure proper assembly and connection, including simulation tests of all safety devices	X			
	Test in Workshops for Generator and Excitation	X			
14.4	Dynamic Analysis				
	Foundation		X		
	CTG	X			
	CTG and Foundation Combined	X			
14.5	Sole Plates, Sub Sole Plate, Leveling Plates, Seating Plates, Shims and Liners	X			
14.6	Freeze Protection				
	X Inside Enclosure	X			
	X Outside Enclosure	X			
14.7	Lighting				
	X Inside Enclosures and Panels	X			
	X Outside Enclosures		X		
14.8	Access Platforms, Stairs and Support Structures	X			
14.9	Applicable Insurance Required Under Combustion Turbine Contract	X			
14.10	Crating for Export (if required) and Suitable Packing for Shipment	X			
	Exhaust Flow Profile Data (raw files) (incl. velocity and temperature)	X			
14.11	As-built design drawings	X			
14.12	O&M Manuals (10 hard copies and 1 electronic copy)	X			
14.13	Controls Instruction Manuals (10 hard copies and 1 electronic copy)	X			
14.14	Software Licenses	X			
14.15	Cleaning and Painting of CTG and Auxiliaries	X			
14.16	Quality Assurance Procedures	X			
14.17	NERC / CIP Requirements	X	X		
14.19	2-Year Operating Spare Parts - Priced			X	
14.20	Start-up and Commissioning Spare Parts	X			

SELLER'S DELIVERABLE SCHEDULE (SDS)

Combustion Turbine Generator		For specific dates associated with the durations specified herein, see the Material Contract section.			
		Kiewit Spec:	94.03.36.100		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
BM-01	Preliminary Compiled Bill of Materials (in Excel format) including all subvendor equipment, appurtenances, etc. per Section GR-B	4			
BM-02	Compiled Bill of Materials (in Excel format) including all subvendor equipment, appurtenances, etc. per Section GR-B	8 weeks prior to Delivery			
CA-01	Calculation proving structural design and derivation of loads for Buyer's support structure design. Must be sealed/stamped by a P.E. registered in the jurisdiction of the project.	12			***
CA-02	Calculation proving structural design for all steel components. Must be sealed/stamped by a P.E. registered in the jurisdiction of the project.	12			***
CA-03	ASME Code Calculations. Must be sealed/stamped by a P.E. registered in the jurisdiction of the project.	6	*		***
CN-01	System Control Philosophy Narratives (including Startup and Normal Operating Conditions) with detailed description of all permissives, alarms and trip set points for all devices. Deliverables shall not have network architecture drawings attached	16	*		
DA-01	Data Sheets - Piping Specialties and Inline Components	2			
DA-02	Data Sheets - Safety/Relief Valves including valve type, design code, sizing criteria, set point pressures, and connection sizes	10			
DA-03	Data Sheets - Actuated/Control Valves	10			
DA-04	Data Sheets including: -Solenoid(s) -Positioner -Limit Switch(es)	10			
DA-05	Motor Nameplate Data per Section E1	8			
DA-06	Nameplate drawings including a nameplate voltage connection diagram for all electrical equipment	6			
DA-07	Fill out Cyber Assets Log per Section I3 NERC CIP / Cybersecurity Sensitive	2 weeks prior to FAT		**	

SELLER'S DELIVERABLE SCHEDULE (SDS)

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
DA-08	Motor thermal damage curve including each of the curves listed below and plotted on one graph: 1. Thermal limit curve at cold (ambient temperature) condition for locked rotor 2. Thermal limit curve at hot (operating temperature) condition for locked rotor 3. Thermal limit curve at cold (ambient temperature) condition for running overload 4. Thermal limit curve at hot (operating temperature) condition for running overload 5. Time-current motor acceleration curve at 110% of rated voltage 6. Time-current motor acceleration curve at rated voltage 7. Time-current motor acceleration curve at 90% of rated voltage 8. Time-current motor acceleration curve at 80% of rated voltage	6	*		
DA-09	Motor speed versus torque and current curves indicated at rated voltage, 90% of rated voltage, and 80% of rated voltage	6	*		
DA-10	Consecutive number of starts with the motor at ambient temperature and at operating temperature. Cool down time between starts with the motor at ambient temperature and at operating temperature.	6	*		
DA-11	Superimposed speed-torque curves for each motor driven equipment match. Speed-torque curves shall include the motor speed-torque curves at 80% of rated voltage and at 110% of rated voltage, superimposed on the driven equipment speed-torque curve during acceleration.	6	*		
DA-12	Motor Data - Parameters for relay settings including voltage imbalance limits and current imbalance limits	6	*		
DA-13	Motor Data - Winding and bearing temperature alarm and trip setpoints	6	*		
DA-14	Preliminary Motor Data Sheets per Section GR-B, including data sheets for any motor space heaters.	8	*		
DA-15	Final Motor Data Sheets per Section GR-B, including data sheets for any motor space heaters.	16	*		
DA-16	Start Up Curves and Associated Curve Development Assumptions	10	*		
DA-17	Performance Curves - Generator	6			
DA-18	Performance Correction Curves	8	*		

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
DA-19	Detailed termination connection details for all Buyer wiring terminations (e.g. terminal blocks, breakers, bolted connections, grounding lugs, bus bar, etc.) including, but not limited to: a. Minimum wire size b. Maximum wire size c. Maximum number of wires d. Termination type (e.g. screw clamp, ring lug, spring-cage, push-in, NEMA hole pattern, etc.)	10			
DA-20	Complete and submit the attached White Listed Ports and Services Template per the I3. NERC CIP / Cybersecurity Sensitive	2 weeks prior to FAT		**	
DK-01	Deliver Backup and Recovery capability along with baseline configuration files and software installs per Section I3 NERC CIP / Cybersecurity Sensitive	2 weeks after Delivery	*	**	
EO-01	Electrical one line diagrams including, but not limited to the following: a. Power distribution scheme for all electrical equipment b. Applicable ratings for all electrical equipment c. Applicable notes and standards d. Legend and reference	6	*		
EO-02	Electrical three line diagrams including, but not limited to the following: a. Power distribution scheme for all electrical equipment b. Applicable ratings for all electrical equipment including all CTs and VTs c. Applicable notes and standards d. Legend and reference	6	*		
EO-03	Electrical distribution panelboard schedules including, but not limited to the following: a. Load descriptions b. Load ampacities c. Breaker sizes with number of poles	6	*		
ES-01	Electrical schematic drawings including, but not limited to following: a. All electrical, protection, and control related logic with input/output assignments b. Relay and metering drawings c. Plant interface drawings for alarm and indication d. Terminal information with tag assignments including all auxiliary contact details	10	*		

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
ES-02	All electrical wiring diagrams needed by Buyer to complete electrical and controls design. Wiring diagrams shall include, but not limited to following: a. Interconnecting diagrams for internal and external wiring with termination details for all electrical devices (electrical panels, control panels, lighting, receptacles, control switches, disconnect switches, junction boxes, instruments, valves, actuators, motors, etc.) b. All wiring by Seller, Buyer, or other party shall have clear identification to distinguish installation responsibility	10	*		
ES-03	Electrical drawings to complete power and control interface wiring for instrument, valves, actuators, etc. including, but not limited to following: a. Elementary diagrams showing control logic with input/output assignment b. Terminal designations and termination layout drawings c. Electrical schematics for motor operated valves	10	*		
ES-04	Electrical drawings to complete motor power and control wiring including, but not limited to following: a. Wiring scheme with clearly defined requirement of shield wires for bearing, thermocouple, winding RTDs, etc. b. Wiring diagram with terminal designation c. Motor space heater connections diagram including voltage and power ratings	10	*		
ES-05	Electrical grounding requirements	4	*		
GA-01	Preliminary Outline/General Arrangement Drawings containing the following information at a minimum: -Not to exceed overall dimensions and not to exceed overall weights -Equipment and panel tag numbers -North arrow -All terminal point locations for piping -Access, maintenance, and equipment pull spaces, with dimensions and orientation -Location and overall size dimensions for all electrical equipment (e.g. Devices: motors, instruments, disconnects; Panels: electrical, relay, control, PLC; Wiring Terminal Boxes: motor power, RTD, vibration, heater, MOV; Instrument Junction Boxes; Control Cabinets; etc.) -Ground pad and ground lug locations -Designated clear space under all electrical devices (e.g. panels, terminal boxes, etc.) for conduit access -Electrical working spaces with dimensions and orientation as required by electrical code -Hazardous area classification rating, if applicable -Center of gravity -Not to exceed static and dynamic loads per Section S1 to complete detailed structural and equipment interface designs (+15%/-0%), indicate on drawing margins used -All details related to the attachment of the equipment to the foundation or supporting structure, such as anchor bolt locations and details, skid/frame flange and/or baseplate thickness, grouting requirements, etc. -Platforms/stairs/ladders (if applicable to scope of supply)	8	*		

SELLER'S DELIVERABLE SCHEDULE (SDS)

Combustion Turbine Generator		For specific dates associated with the durations specified herein, see the Material Contract section.			
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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
GA-02	Final Outline/General Arrangement Drawings containing the following information at a minimum: -Overall dimensions and overall weights -Equipment and panel tag numbers -North arrow -All terminal point locations for piping -Access, maintenance, and equipment pull spaces, with dimensions and orientation -Location and overall size dimensions for all electrical equipment (e.g. Devices: motors, instruments, disconnects; Panels: electrical, relay, control, PLC; Wiring Terminal Boxes: motor power, RTD, vibration, heater, MOV; Instrument Junction Boxes; Control Cabinets; etc.) -Ground pad and ground lug locations -Designated clear space under all electrical devices (e.g. panels, terminal boxes, etc.) for conduit access -Electrical working spaces with dimensions and orientation as required by electrical code -Hazardous area classification rating, if applicable -Center of gravity -Static and dynamic loads per Section S1 to complete detailed structural and equipment interface designs -All details related to the attachment of the equipment to the foundation or supporting structure, such as anchor bolt locations and details, skid/frame flange and/or baseplate thickness, grouting requirements, etc. -Platforms/stairs/ladders (if applicable to scope of supply)	12	*		
GA-03	Preliminary 3D Model(s) per Section GR-B	6			
GA-04	Updated 3D Model(s) per Section GR-B	Monthly			
GA-05	Detailed arrangement drawings for all electrical equipment (e.g. Devices: motors, analyzers, disconnects; Panels: electrical, relay, control, PLC; Wiring Terminal Boxes: motor power, RTD, vibration, heater, MOV; Instrument Junction Boxes; Control Cabinets; etc.). Drawings shall include but not be limited to the following: a. Layout with front, rear, side, and top view. Shall include dimensions for overall size, cutout locations, cutout sizes, conduit entry locations, and conduit entry sizes. b. Indication of corresponding BOM item c. Internal panel layout including terminal and device arrangement. d. Tags for all terminal blocks, terminal numbers, device tags, etc. e. Electrical device and enclosure hazardous area classification rating, if applicable f. NEMA classification	10	*		
GA-06	Detailed connection drawing for all bolted connections (e.g. bus bar, iso-phase, non-seg, ground pads, lugs, bushing, lightning arrestors, etc.). Drawing shall contain the following information at a minimum: a. Dimensions including location and size of all bolted connections b. Flange details including dimensions for overall size, bolt locations, bolt sizes, etc. c. Clearance requirements with dimensions	10	*		

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
GA-07	Detail/Sectional Drawings with Parts List - Motor General Arrangement and Outline Dimension Drawings showing the following at a minimum: -Motor dimensions -Shaft dimensions -Mounting dimension clearances -Rotor and coupling end float limits -Approximate motor weight -Total motor weight	4			
GA-08	Detail/Section Drawings with Parts List - Turbine	20			
GA-09	Overall Arrangement Drawing - CT Power Train Package including all main and auxiliary equipment	24			
GA-10	Excitation system model	10	*		
HC-01	Electrical Hazard Classification Drawings showing classified drawings per NFPA 70 and NFPA 497. Drawings shall include scaled diagrams showing all classified areas and dimensions measured from the equipment for each area. All code references shall be provided on the drawing.	16	*		
HV-01	Cumulative Equipment Package and Individual Equipment heat rejection/loss to ambient air at maximum operating load (for HVAC sizing purposes)	8	*		
IC-01	As-Built Datalink Communication Reports including "as-built" data point list with addressing and protocol settings in both native file format and PDF format. Potential NERC CIP / Cybersecurity Sensitive	1 week prior to Delivery	*	**	
IC-02	Preliminary network architecture drawing Potential NERC CIP / Cybersecurity Sensitive	12		**	
IC-03	Final network architecture drawing Potential NERC CIP / Cybersecurity Sensitive	30		**	
IN-01	Instrument data sheets for every instrument/device furnished by the Seller, including the following information at a minimum: -Tag numbers -Service description -Calibration range -Instrument range -Length of probes -Manufacturer's make and model number -Serial number Each unique instrument type shall have its own dedicated, project-specific data sheet submitted; generic catalogue cut sheets are not acceptable for the intent of this submittal. Buyer will provide blank data sheets upon Seller request.	16			

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IN-02	Full versions of cut sheets for each instrument furnished by the Seller that include the model number breakdown	16			
IN-03	Factory Calibration Certificates for Instrumentation	4 weeks prior to Delivery	*		
IN-04	Instrument Installation Details for all shipped-loose instruments	12			
IN-05	Instrumentation Location Plan - both Plan and Elevation views	16			
IV-01	PLC HMI Graphic Screenshots	8			
LT-01	Spare Parts List (in Excel format) including unit pricing per Section GR-B	16			
LT-02	Priced List of Special Tools Required for Installation, Erection and Maintenance	16			
LT-03	Drawing List Categorized by Engineering Discipline and Cross Referenced to the Line Numbers Stated Herein per Section GR-B, including document number and title for each document	4			
LT-04	Updated Drawing List Categorized by Engineering Discipline and Cross Referenced to the Line Numbers Stated Herein per Section GR-B, including document number and title for each document	Monthly			
LT-05	List of Compressed Air Users - to include equipment tag number, usage rate (SCFM), and location (coordinates/elevation)	12	*		
LT-06	Preliminary I/O List (in Excel format) per Section GR-B, including: -Range and engineering units for all signals to DCS -Alarm and Shutdown Levels -DCS Side Terminations	12			
LT-07	Final I/O List (in Excel format) per Section GR-B, including: -Range and engineering units for all signals to DCS -Alarm and Shutdown Levels -DCS Side Terminations	20			
LT-08	Preliminary Mechanical Connection List including at a minimum the following for all terminal/interface points/connections: -All sizes, materials, and interface types/ratings, including pressure classes, connection types, and schedules -Process information such as maximum/minimum/normal design flows, temperatures, and pressures -Coordinates/orientations -Interconnection tag numbers -Pressure drops and heat loads for cooling water	6	*		

SELLER'S DELIVERABLE SCHEDULE (SDS)

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
LT-09	Final Mechanical Connection List including at a minimum the following for all terminal/interface points/connections: -All sizes, materials, and interface types/ratings, including pressure classes, connection types, and schedules -Process information such as maximum/minimum/normal design flows, temperatures, and pressures -Coordinates/orientations -Interconnection tag numbers -Pressure drops and heat loads for cooling water	12	*		
LT-10	Preliminary electrical load list shall include all electrical equipment ratings including, but not limited to the following: a. Nominal operating voltage (AC/DC) b. Phase(s) (3-Phase/1-phase as applicable) c. Efficiency and power factor d. Power requirements (kW/kVA/FLA as applicable)	4	*		
LT-11	Final electrical load list shall include all electrical equipment ratings including, but not limited to the following: a. Nominal operating voltage (AC/DC) b. Phase(s) (3-Phase/1-phase as applicable) c. Efficiency and power factor d. Power requirements (kW/kVA/FLA as applicable)	8	*		
LT-12	PLC Data Link List (in Excel) including point names, descriptions, addresses, scale, ranges, engineering units, and conversion factors	36		**	
LT-13	Sub-Supplier/Fabricator List including addresses and contacts. Updated as suppliers are added.	4			
LT-14	Equipment List (in Excel format) per Section GR-B	10			
LT-15	Line List (in Excel format) per Section GR-B	10			
LT-16	Valve List (in Excel format) per Section GR-B	10			
LT-17	Specialties List (in Excel format) per Section GR-B	10			
LT-18	Instrument List (in Excel format) per Section GR-B	10			
LT-19	Allowable maximum nozzle loads for all pressure piping connections per requirements of Section M1	6	*		
LT-20	Cable Summary/List	16			

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
MA-01	Manufacturer's Comprehensive O&M Documentation/Manual	28	*		
MA-02	Inserts for As-Builts, Test Reports, MTRs, Records produced by ITP, etc for Manufacturer's Comprehensive O&M Documentation/Manual	2 weeks prior to Delivery	*		
MA-03	Manufacturer's Comprehensive O&M Documentation/Manual, excluding the Cyber Security Annex	28	*		
MA-04	Cyber Security Annex for the Manufacturer's Comprehensive O&M Documentation/Manual NERC CIP / Cybersecurity Sensitive	28	*	**	
MA-05	Inserts for As-Builts, Test Reports, MTRs, Records produced by ITP, etc for Manufacturer's Comprehensive O&M Documentation/Manual, excluding the Cyber Security Annex	2 weeks prior to Delivery	*		
MA-06	Cyber Security Annex for the Inserts for As-Builts, Test Reports, MTRs, Records produced by ITP, etc for Manufacturer's Comprehensive O&M Documentation/Manual NERC CIP / Cybersecurity Sensitive	2 weeks prior to Delivery	*	**	
MP-01	Interconnecting Piping Detailed Isometrics	12			
PA-01	Paint/Coating/Lining application procedures with manufacturer's data sheets and inspection forms	8			

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
PA-02	Finish Coat Color Schedule	8			
PA-03	Coating Test Report Results	1 week after Test			
PD-01	Turbine Proper Systems - Piping and Instrumentation Diagrams (P&ID) showing all equipment, piping, instrumentation and controls, connection/interface points, and associated tagging for a complete, code compliant, and ready to operate system.	6	*		
PD-02	Generator Proper Systems - Piping and Instrumentation Diagrams (P&ID) showing all equipment, piping, instrumentation and controls, connection/interface points, and associated tagging for a complete, code compliant, and ready to operate system.	6	*		
PD-03	Lube Oil System - Piping and Instrumentation Diagrams (P&ID) showing all equipment, piping, instrumentation and controls, connection/interface points, and associated tagging for a complete, code compliant, and ready to operate system.	12	*		
PD-04	Hydraulic/Lift Oil System - Piping and Instrumentation Diagrams (P&ID) showing all equipment, piping, instrumentation and controls, connection/interface points, and associated tagging for a complete, code compliant, and ready to operate system.	12	*		
PD-05	All Remaining Systems - Piping and Instrumentation Diagrams (P&ID) showing all equipment, piping, instrumentation and controls, connection/interface points, and associated tagging for a complete, code compliant, and ready to operate system.	16	*		
QC-01	Quality Manual and ISO 9001 Certificate, including all Sub-suppliers	4			
QC-02	Quality Record Matrix per Special Conditions	6			
QC-03	Project Specific Inspection and Test Plan including all Sub-suppliers	4			
QC-04	Supplier Notification Form (SNF) for each Witness and Hold Point identified on the Project Specific Inspection and Test Plan.	21 days prior to Test			
QC-05	Non-Conformance Reports with Proposed Disposition	Within 24 hours of Discovering Non-Conformance			
QC-06	Factory Acceptance Test (FAT) Procedure and Acceptance Criteria	10 weeks prior to FAT			
QC-07	Factory Acceptance Test (FAT) Reports	2 weeks after FAT			
QC-08	Hydrostatic/Pneumatic Leak Test Procedures	8 weeks prior to Hydro Test			
QC-09	Hydrostatic/Pneumatic Leak Test Reports	1 week after Hydro Test			

SELLER'S DELIVERABLE SCHEDULE (SDS)

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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
QC-10	AISC Certificate	4			
QC-11	Performance Test Certificate	1 week after Test			
QC-12	Material Test Reports (MTR) traceable to material heat or cast segregated by individual tag numbers, or traceable to material heat by individual components. All MTR shall specify Country of Origin.	16			
QC-13	Welding Procedure Specifications (WPS) / Welding Procedure Qualification Records (PQR) to be utilized. Each WPS and Supporting PQRs shall be submitted as an individual document with WPS Number and Revision Number in the Title.	6			
QC-14	Weld Procedure Matrix	6			
QC-15	Non-Destructive Examination (NDE) and Impact Testing Procedures, including Brinell Hardness Testing Procedure, Positive Material Identification, UT Examination Procedure, RT Examination Procedure, PT Examination Procedure, MT Examination Procedure, etc.	6			
QC-16	Non-Destructive Examination (NDE) and Impact Testing Reports, including Brinell Hardness Testing Report, Positive Material Identification, UT Examination Report, RT Examination Report, PT Examination Report, MT Examination Report, etc.	2 weeks after Test			
QC-17	Deliver certified disclosure letter on corporate letterhead validating DHS cybersecurity compliance or work arounds for all Cyber Assets and embedded devices per Section I3 NERC CIP / Cybersecurity Sensitive	2 weeks after Delivery	*	**	
QC-18	Motor test reports including complete nameplate information and patterned after IEEE Std. 112	12			
QC-19	Structural Steel Material Test Reports (MTR) - consistent with approved fabricator identification procedures and in accordance with AISC 303, Section 6.1. At a minimum each MTR shall specify Country of Origin.	2 Weeks After Delivery to Site			

SELLER'S DELIVERABLE SCHEDULE (SDS)

Combustion Turbine Generator		For specific dates associated with the durations specified herein, see the Material Contract section.			
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Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
RE-01	Recommended Maintenance Schedule, which shall include (but not be limited to) the following: -Predictive or preventative maintenance program -Servicing procedures for dismantling and/or replacing components -Routine electrical and mechanical procedures -Any tests/checks for cleaning, lubricating, and otherwise caring for the Equipment -Instrument calibration -Maintenance of interlocks and other applicable safety features	12			
RE-02	Digital photographs of all Buyer termination points clearly showing both the Buyer's side and Seller’s side wiring, terminal block labels, terminal labels, and wiring labels. Photographs shall be submitted before equipment is shipped.	6 weeks prior to Delivery	*		
RE-03	Freeze protection requirements (min allowable ambient temperature, max exposure temperatures, min maintained process temperature, etc.) for any Seller provided equipment. Note acceptable type of freeze protection system.	8			
RE-04	Heat Tracing quantities: List of Components on equipment skid, lines including piping size and approximate lengths, class and size for all flanges and valves, factory routed tubing lengths, and inline items: specialties, instrumentation, etc. Note acceptable type of freeze protection system. Any information not available during initial submittals shall be submitted on as-built drawings before shipment including pictures of completed skids.	8			
RE-05	Pre-Operational Cleaning Guidelines	2 weeks prior to Delivery			
RE-06	Calibration certificates for all safety/pressure relief valves provided in the Seller's scope (both on-skid or shipped-loose) with set pressure greater than 15 psig [100 kPa]	4 weeks prior to Delivery			
RE-07	All requirements for Unloading, Receiving, Handling, and Long and Short Term Storage per Section GR-B	12			
RE-08	Cut Sheets - all manual and control valves	8			
RE-09	Cut Sheets - Pipe Supports	10			
RE-10	Cut Sheets - Silencers	10			
RE-11	Cut Sheets - Start-up Vent Valves including Cv or capacity/DP information	8			
RE-12	Cut Sheets - Ignition Transformer	10			
RE-13	Cut Sheets - Motor and Drive Components	4			
RE-14	Insulation Details/Specifications for all Seller-provided equipment and piping	12			
RE-15	Station Designer's Handbook	2			
RE-16	Generator requisition summary sheets	6			
RE-17	Line/Neutral cubicle drawings	8			
RE-18	Generator Protection Studies and Relay Settings	36			

SELLER'S DELIVERABLE SCHEDULE (SDS)

Combustion Turbine Generator		For specific dates associated with the durations specified herein, see the Material Contract section.			
		Kiewit Spec:	94.03.36.100		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
RE-19	Technical Feasibility Exceptions (TFEs) NERC CIP / Cybersecurity Sensitive	4 weeks prior to Delivery		**	
RE-20	Preliminary door hardware information	4			
RE-21	Final door hardware information	8			
RE-22	Complete Logistics and Transportation Plan detailing all of the steps EXW factory, including a detailed Method Statement when any of the following modes of transportation are applicable: (i) Air; (ii) Barge; (iii) Ocean; (iv) Rail; and (v) Over the Road (Heavy Haul).	8	*		
RE-23	List of cleared personal for access to sensitive documentation; first/last name and email only per Section I3	4			
RE-24	Notification of employee separation from project or company; first/last name and email only	4 hours after separation	*		
RE-25	Resumes for TFA Candidates (TFA must be qualified to commission the communication links between the equipment PLC and the plant DCS)	6			
SH-01	Engineering/Procurement/Production/Fabrication/Shipping Schedule per Section GR-B.	2			
SH-02	Updated Engineering/Procurement/Production/Fabrication/Shipping Schedule per Section GR-B.	Monthly			
SH-03	Notify Buyer of all shipments	4 weeks prior to Delivery			
ST-01	Dimensions, weights, configurations, and details of steel construction/fabrication for overall structure and all steel members and connections including but not limited to: -Structural framing members -Base plates -Anchor bolts -Stairs -Ladders -Guard rails -Metal grating -Metal deck -Fall restraint systems. Must be sealed/stamped by a P.E. registered in the jurisdiction of the project.	12			***

SELLER'S DELIVERABLE SCHEDULE (SDS)

Combustion Turbine Generator		For specific dates associated with the durations specified herein, see the Material Contract section.			
		Kiewit Spec:	94.03.36.100		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
ST-02	Joint Details, Material of Construction for Structural Welds, and Installation Requirements for Structural Bolted Connections	60 days prior to Delivery of Structural Steel			

*Liquidated Damages apply
**Cyber Security applies
***P.E. Stamp required from a P.E. licensed in the jurisdiction of the project

APPENDIX A

GAS ANALYSIS

Performance Guarantee Guidance

The following provides performance guarantee guidance for the Combustion Turbine Generator (CTG) and Selective Catalytic Reduction (SCR).

Performance Guarantees

The following parameters are recommended to be guaranteed. The approach of guarantees with no tolerance is preferred over guarantees with a test tolerance.

- CTG Net Power Output in kW
- CTG Net Heat Rate in Btu/kWh (indicate LHV or HHV)
- CTG Exhaust Flow in lb/h
- SCR Performance

Guarantee Basis Conditions

The following are recommended guarantee basis conditions.

- All guarantees shall be based on the boundary of the scope of supply
- Guarantees shall be based on 200 operating or equivalent operating hours
- Barometric pressure shall be used (not elevation)
- Exhaust pressure basis shall be at the boundary of the scope of supply. A measurement point must exist at the physical location corresponding to the guarantee basis location.
- Power factor - 0.85
- Grid frequency - 60 Hz
- Fuel gas temperature to CTG equipment terminal point - 50 °F
- CTG exhaust pressure - 12” H_2O

Recommended Liquidated Damages

Below is a summary of recommended liquidated damages.

CTG Net Power Output - $1,500 per kW

CTG Net Heat Rate - $20,000 - $50,000 per Btu/kWh (indicate LHV or HHV)

CTG Maximum Exhaust Flow – Tune machine to make right for SCR sizing and performance.

SCR Performance – Make right.

Auxiliary Power for Other Equipment - $1800 per kW

Line #	Description	Detailed Engineering	Supply of Equip, Material or Service	Constr/Erect Test/Implement	Comments
1	**Permits**				
2	Municipal Development Permit	OWNER	OWNER	N/A	Information and support may be required from Contractor as identified by OWNER
3	Stormwater Construction Permit	ENGINEER	CONTRACTOR	N/A	As required to do work
4	Building permits	ENGINEER	CONTRACTOR	N/A	As required to do work
5	Road Construction	ENGINEER	CONTRACTOR	N/A	As required to do work
6	Utility Crossing Agreements	ENGINEER	CONTRACTOR	N/A	As required to do work
7					
8	**General Conditions and Services**				
9	Site Offices, Phone/Utilities Hookup, Hi-Speed Lines, Satellite	N/A	CONTRACTOR	CONTRACTOR	
10	Site Office Eqt./Supplies, Furn., Phone/Fax Svc	N/A	CONTRACTOR	CONTRACTOR	
11	OWNER Site Offices, Phone/Fax/Utility Hookup, Hi-Speed Lines	N/A	CONTRACTOR	CONTRACTOR	
12	Temporary & Permanent Storage/Warehouse	N/A	CONTRACTOR	CONTRACTOR	
13	Construction Electric Power System	N/A	CONTRACTOR	CONTRACTOR	Distribution system and transformer within the construction site supplied by Contractor.
14	Construction Sanitary Facilities	N/A	CONTRACTOR	CONTRACTOR	Temporary system by Contractor.
15	Construction Water (NOT potable)	N/A	CONTRACTOR	CONTRACTOR	
16	Construction Water Treatment	N/A	CONTRACTOR	CONTRACTOR	
17	Construction Potable Water	N/A	CONTRACTOR	CONTRACTOR	Contractor to supply bottle service.
18	Temporary Fire Fighting System	N/A	CONTRACTOR	CONTRACTOR	
19	Personal Protection Equipment (PPE)	N/A	OWNER/CONTRACTO	OWNER/CONTRACTOR	Each pays own.
20	Safety Training Program	N/A	CONTRACTOR	CONTRACTOR	
21	First Fills	N/A	CONTRACTOR	N/A	
22	Start-up Consumables through Substantial Completion, including;				
23	Lubricating Oil	N/A	CONTRACTOR	N/A	Meet or Exceed OEM requirement
24	Ammonia	N/A	CONTRACTOR	N/A	
25	Natural gas	N/A	OWNER	N/A	
26	Operation Consumables, including;				
27	Lubricating Oil	N/A	OWNER	OWNER	After Substantial Completion
28	Ammonia	N/A	OWNER	OWNER	After Substantial Completion
29	Nitrogen	N/A	OWNER	OWNER	After Substantial Completion
30	Natural gas	N/A	OWNER	OWNER	After Substantial Completion
31	Start-up and operations process waste disposal				
32	Oil drains, flushes	N/A	CONTRACTOR	CONTRACTOR	Contractor hauls offsite until Substantial Completion.
33	First Aid Station	N/A	CONTRACTOR	CONTRACTOR	
34	Drug Testing of Crafts and CM	N/A	CONTRACTOR	CONTRACTOR	
35	Site Vehicles	N/A	CONTRACTOR	CONTRACTOR	
36	Owner & Consultant Vehicles	N/A	OWNER	OWNER	
37	Start-up and operation manual	ENGINEER	CONTRACTOR	CONTRACTOR	
38	Turnover packages	ENGINEER	CONTRACTOR	CONTRACTOR	
39	Commissioning supervision	N/A	CONTRACTOR	CONTRACTOR	Owner provides Operators
40	Commissioning craft & support	N/A	CONTRACTOR	CONTRACTOR	Contractor to supply supervision and labor
41	Stack testing	N/A	CONTRACTOR	CONTRACTOR	Subcontract
42	Performance testing, testing equipment, labor	ENGINEER	CONTRACTOR	CONTRACTOR	
43	Factory testing and shop inspections	N/A	CONTRACTOR	CONTRACTOR	Owner/Rep may witness.
44	Project management, including invoicing	N/A	CONTRACTOR	CONTRACTOR	
45	Construction management	N/A	CONTRACTOR	CONTRACTOR	
46	Bonds	N/A	CONTRACTOR	CONTRACTOR	
47	O&M Training	N/A	CONTRACTOR	CONTRACTOR	
48	Start-up and Operations Operators	N/A	OWNER	OWNER	
49	Start-up Maintenance	N/A	CONTRACTOR	CONTRACTOR	Prior to Substantial Completion
50	Operations maintenance	N/A	OWNER	OWNER	After Substantial Completion
51	Startup Spares	N/A	CONTRACTOR	CONTRACTOR	
52	Capital Spares	N/A	OWNER	OWNER	
53	Site Security - Overall Facility	N/A	CONTRACTOR	CONTRACTOR	Prior to Substantial Completion
54	Material Receiving	N/A	CONTRACTOR	CONTRACTOR	
55	Temporary Warehousing	N/A	CONTRACTOR	CONTRACTOR	
56	Stored Equipment Maintenance	N/A	CONTRACTOR	CONTRACTOR	
57	Equipment and Materials Transportation to Site	N/A	CONTRACTOR	CONTRACTOR	Included with Owner Supplied Equipment
58	Customs Clearance including Fees	N/A	N/A	N/A	
59	Special Tools	N/A	CONTRACTOR	CONTRACTOR	By vendors of Contractor or Contractor.

Line #	Description	Detailed Engineering	Supply of Equip, Material or Service	Constr/Erect Test/Implement	Comments
60	Heavy Haul	N/A	CONTRACTOR	CONTRACTOR	
61	Site clean-up and disposal of trash	N/A	CONTRACTOR	CONTRACTOR	
62	Project labor agreement	N/A	CONTRACTOR	CONTRACTOR	If Required
63	Hazardous Waste Removal and Disposal	N/A	CONTRACTOR	CONTRACTOR	Waste generated by Contractor
64	Project and Interface Schedules	N/A	CONTRACTOR	CONTRACTOR	
65	Project Controls, Resource Management, Reporting	N/A	CONTRACTOR	CONTRACTOR	
66	Monthly Progress Reports and Owner Interface Meetings	ENGINEER	CONTRACTOR	CONTRACTOR	
67	3D Model Reviews	ENGINEER	N/A	N/A	
68	Constructability Review	ENGINEER	N/A	N/A	
69	**Civil/Sitework**				
70	Site Clearing	N/A	CONTRACTOR	CONTRACTOR	
71	Process Site survey (except property limits)	N/A	CONTRACTOR	CONTRACTOR	Including topographical survey.
72	Property limits survey	N/A	OWNER	OWNER	
73	Permanent Site Benchmarks	N/A	CONTRACTOR	CONTRACTOR	
74	Soil survey, including borings	OWNER	OWNER	OWNER	Owner to provide geotechical report with bid documents. Any additional testing shall be by Contractor.
75	Construction laydown area and maintenance	N/A	CONTRACTOR	CONTRACTOR	
76	Construction Parking area and maintenance	N/A	CONTRACTOR	CONTRACTOR	
77	Temporary roads and maintenance	N/A	CONTRACTOR	CONTRACTOR	
78	Erosion/Sediment Control	ENGINEER	CONTRACTOR	CONTRACTOR	
79	Storm Drainage	ENGINEER	CONTRACTOR	CONTRACTOR	
80	Asphalt/Concrete Paving	ENGINEER	CONTRACTOR	CONTRACTOR	
81	Perimeter Fencing/Gates	ENGINEER	CONTRACTOR	CONTRACTOR	Construction and permanent fencing by Contractor.
82	Signage	ENGINEER	CONTRACTOR	CONTRACTOR	
83	Final roads and paving	ENGINEER	CONTRACTOR	CONTRACTOR	
84	Underground Piping Systems	ENGINEER	CONTRACTOR	CONTRACTOR	
85	Existing topsoil removal and storage	ENGINEER	CONTRACTOR	CONTRACTOR	
86	Final Grading of Site	ENGINEER	CONTRACTOR	CONTRACTOR	
87	Landscaping (Sidewalks, Stone, Shrubs, Trees, Sod, etc.)	ENGINEER	CONTRACTOR	CONTRACTOR	
88					
89	**Concrete Work**				
90	Excavation, Backfill & Compaction for Buildings, foundations	ENGINEER	CONTRACTOR	CONTRACTOR	Includes backfill import as necessary
91	Excavation, Backfill & Compaction for Utilities	ENGINEER	CONTRACTOR	CONTRACTOR	
92	Piling	ENGINEER	CONTRACTOR	CONTRACTOR	As Required
93	Building Foundations	ENGINEER	CONTRACTOR	CONTRACTOR	
94	Equipment Foundations	ENGINEER	CONTRACTOR	CONTRACTOR	
95	Steel Structures Foundations	ENGINEER	CONTRACTOR	CONTRACTOR	
96	Pipe Rack Foundations	ENGINEER	CONTRACTOR	CONTRACTOR	
97	Tank Foundations	ENGINEER	CONTRACTOR	CONTRACTOR	
98	Storm Water and Other Manholes and Lift stations	ENGINEER	CONTRACTOR	CONTRACTOR	
99	Retaining walls	ENGINEER	CONTRACTOR	CONTRACTOR	If Required
100	Underground Ductbanks	ENGINEER	CONTRACTOR	CONTRACTOR	
101					
102	**Structural Work**				
103	Buildings				
104	Weather Enclosures	ENGINEER	CONTRACTOR	CONTRACTOR	
105	Pipe Rack Structural Steel	ENGINEER	CONTRACTOR	CONTRACTOR	
106	Miscellaneous Pipe/Cable Tray Support Steel	ENGINEER	CONTRACTOR	CONTRACTOR	
107	Crane & Support Steel	ENGINEER	CONTRACTOR	CONTRACTOR	
108	Platforms, Stairs, Ladders, Handrails	ENGINEER	CONTRACTOR	CONTRACTOR	
109	Equipment Support Steel	ENGINEER	CONTRACTOR	CONTRACTOR	
110	Cranes				
111	Misc. Hoists	N/A	CONTRACTOR	CONTRACTOR	
112	Combustion Turbine Bridge Crane	ENGINEER	CONTRACTOR	CONTRACTOR	If Required
113	Special tools for Combustion Turbine Generator	N/A	OWNER	CONTRACTOR	
114					

Line #	Description	Detailed Engineering	Supply of Equip, Material or Service	Constr/Erect Test/Implement	Comments
115	**Mechanical/Process Equipment**				
116	Combustion Turbine Generator (CTG), including:				
117	CTG Mechanical Package	N/A	OWNER	CONTRACTOR	
118	CTG Electrical Package	N/A	OWNER	CONTRACTOR	
119	Lube Oil System	N/A	OWNER	CONTRACTOR	
120	Control Oil System	N/A	OWNER	CONTRACTOR	
121	Fuel Gas System				
122	Fuel Gas Valves for Purge Credit to Meet NFPA 85	N/A	N/A	N/A	Not required for simple cycle
123	Final Filter/Separator	N/A	OWNER	CONTRACTOR	
124	CT Inlet Cooling Modules - onboard CT/Gen coolers	N/A	OWNER	CONTRACTOR	
125	Fire Protection/Detection System	N/A	OWNER	CONTRACTOR	
126	Inlet Air System				
127	Evaporative Cooler System (with moisture separator)	N/A	OWNER	CONTRACTOR	
128	Inlet Support Structure	N/A	OWNER	CONTRACTOR	
129	Inlet Access Ladders	N/A	OWNER	CONTRACTOR	
130	Exhaust Transition	N/A	OWNER	CONTRACTOR	
131	Static Start System	N/A	OWNER	CONTRACTOR	
132	Turning Gear	N/A	OWNER	CONTRACTOR	
133	Line Termination Enclosure with CTs, VTs, Surge Arrestors, and Surge Capacitors	N/A	OWNER	CONTRACTOR	
134	Neutral Cubicle with CT, Neutral Tie Bus, Grounding Transformer, and Secondary Resistor	N/A	OWNER	CONTRACTOR	
135	CTG Isolated Phase Duct	ENGINEER	CONTRACTOR	CONTRACTOR	
136	CTG Generator Breaker	ENGINEER	CONTRACTOR	CONTRACTOR	
137	Interconnecting Cable, Cable Tray and Conduit	N/A	CONTRACTOR	CONTRACTOR	
138	Interconnecting Piping between Package Skids	N/A	CONTRACTOR	CONTRACTOR	
139	Water Wash System/Skid	N/A	OWNER	CONTRACTOR	
140	CTG Drain Tanks	N/A	CONTRACTOR	CONTRACTOR	
141	Access Platforms, Walkways and Ladders	N/A	OWNER	CONTRACTOR	
142	Anchor Bolts, Embedded Plates and Reinforcing Steel	ENGINEER	CONTRACTOR	CONTRACTOR	
143	Bed Plates, Sole Plates, Adjusting Screws, Shims	N/A	OWNER	CONTRACTOR	
144	Module/Compartment Ventilation Ductwork Connecting to Modules	ENGINEER	CONTRACTOR	CONTRACTOR	Includes ductwork from enclosures to outdoors
145	Unloading at Jobsite	N/A	CONTRACTOR	CONTRACTOR	
146	Technical Direction during Installation, Start Up & Testing	N/A	OWNER	CONTRACTOR	CTG TFA Service by OWNER only
147	Training of Operating & Maintenance Personnel	N/A	OWNER	CONTRACTOR	
148	O&M Manuals	N/A	OWNER	CONTRACTOR	
149	NOx Reduction System				
150	Aqueous Ammonia Vaporizing Skid	ENGINEER	OWNER	CONTRACTOR	
151	Dilution Air Blower	ENGINEER	OWNER	CONTRACTOR	
152	Ammonia Injection Grid	ENGINEER	OWNER	CONTRACTOR	
153	Ammonia Valves for Purge Credit to Meet NFPA 85	ENGINEER	OWNER	CONTRACTOR	
154	CTG Exhaust Expansion Joint	ENGINEER	OWNER	CONTRACTOR	
155	Stack	ENGINEER	OWNER	CONTRACTOR	
156	Transition Duct to Stack	ENGINEER	OWNER	CONTRACTOR	
157	Expansion Joint in Transition Duct to Stack	ENGINEER	OWNER	CONTRACTOR	
158	EPA Test Connections and Access Platforms	ENGINEER	OWNER	CONTRACTOR	
159	Continuous Emissions Monitoring System	ENGINEER	OWNER	CONTRACTOR	
160	FAA Lighting and Obstruction Marking for Stack	ENGINEER	OWNER	CONTRACTOR	
161	Lightning Protection	ENGINEER	OWNER	CONTRACTOR	
162	CO Reduction System	ENGINEER	OWNER	CONTRACTOR	
163	Access Platforms, Walkways and Ladders	ENGINEER	OWNER	CONTRACTOR	
164	Anchor Bolts, Embedded Plates and Reinforcing Steel	ENGINEER	OWNER	CONTRACTOR	
165	Bed Plates, Sole Plates, Adjusting Screws, Shims	ENGINEER	OWNER	CONTRACTOR	
166	Unloading at Jobsite	ENGINEER	OWNER	CONTRACTOR	
167	Technical Direction during Installation, Start Up & Testing	ENGINEER	OWNER	CONTRACTOR	
168	Training of Operating & Maintenance Personnel	ENGINEER	OWNER	CONTRACTOR	
169	Heat Rejection Systems, including;				
170	Air Cooled Heat Exchanger	ENGINEER	CONTRACTOR	CONTRACTOR	If not supplied as part of CTG package
171	Water Supply Systems				
172	Demin Water Supply	OWNER	OWNER	OWNER	Leased system
173	Demin Water Storage Tank	ENGINEER	CONTRACTOR	CONTRACTOR	

Line #	Description	Detailed Engineering	Supply of Equip, Material or Service	Constr/Erect Test/Implement	Comments
174	Plant Drains and Waste Water System				
175	Wastewater Sump	ENGINEER	CONTRACTOR	CONTRACTOR	
176	Wastewater Transfer Pumps	ENGINEER	CONTRACTOR	CONTRACTOR	
177	Drain Sump Pumps	ENGINEER	CONTRACTOR	CONTRACTOR	
178	Oil / Water Separator	ENGINEER	CONTRACTOR	CONTRACTOR	
179	Aqueous Ammonia System				
180	Ammonia Storage Tank	ENGINEER	CONTRACTOR	CONTRACTOR	
181	Ammonia Forwarding Pumps	ENGINEER	CONTRACTOR	CONTRACTOR	
182	Ammonia Unloading Station	ENGINEER	CONTRACTOR	CONTRACTOR	
183	Compressed Air system - Instrument and Service Air				
184	Air Compressors	ENGINEER	CONTRACTOR	CONTRACTOR	
185	Air Dryers and filters	ENGINEER	CONTRACTOR	CONTRACTOR	
186	Air Receivers	ENGINEER	CONTRACTOR	CONTRACTOR	
187	Compressed Gas System				
188	Carbon Dioxide Bottle Rack and Manifold	N/A	N/A	N/A	
189	Carbon Dioxide Bottles	N/A	N/A	N/A	
190	Hydrogen Bulk Storage Tank	N/A	N/A	N/A	
191	Hydrogen Gas	N/A	N/A	N/A	
192	Nitrogen Generator	N/A	N/A	N/A	
193	Fuel Gas System				
194	Natural Gas Custody Transfer Metering Station	OWNER	OWNER	OWNER	
195	Natural Gas Piping From Custody Transfer to Site Boundary	OWNER	OWNER	OWNER	
196	Natural Gas Check Metering Station	ENGINEER	CONTRACTOR	CONTRACTOR	
197	Dew Point Heater	ENGINEER	CONTRACTOR	CONTRACTOR	
198	Gas Compressors w/ Building	N/A	N/A	N/A	
199	Knock Out Tank	ENGINEER	CONTRACTOR	CONTRACTOR	
200	Drain Tank(s)	ENGINEER	CONTRACTOR	CONTRACTOR	
201	Coalescing Filters	ENGINEER	CONTRACTOR	CONTRACTOR	
202	Performance Heaters	N/A	OWNER	CONTRACTOR	
203	Gas Turbine Final Filters	N/A	OWNER	CONTRACTOR	
204	Pressure Control Stations	ENGINEER	CONTRACTOR	CONTRACTOR	
205	Pulsation Studies and Mitigation	N/A	N/A	N/A	
206					
207	**Piping**				
208	Control Valves	ENGINEER	CONTRACTOR	CONTRACTOR	
209	Motor and Air Operated Small Bore and Large Bore Valves	ENGINEER	CONTRACTOR	CONTRACTOR	
210	Large and Small Bore Piping, Valves, Devices	ENGINEER	CONTRACTOR	CONTRACTOR	
211	Pipe Supports (all Large Bore and Small Bore)	ENGINEER	CONTRACTOR	CONTRACTOR	
212	Balance of Piping, All Other Valves, Devices, and Specialties	ENGINEER	CONTRACTOR	CONTRACTOR	
213					
214	**Piping & Equipment Insulation**				
215	Piping Insulation	ENGINEER	CONTRACTOR	CONTRACTOR	Permanent and temporary
216	Mechanical Equipment Insulation	ENGINEER	CONTRACTOR	CONTRACTOR	Permanent and temporary
217					
218	**Fire Protection**				
219	Standpipes, Risers, Hose Stations, Branches, Devices (sprinkler heads,	ENGINEER	CONTRACTOR	CONTRACTOR	
220	Fire Protection				
221	Motor-driven Main, Diesel driven Back-up, and Jockey Pumps/Controllers	ENGINEER	CONTRACTOR	CONTRACTOR	
222	Underground piping to shutoff valves or hydrants	ENGINEER	CONTRACTOR	CONTRACTOR	
223	ALL Aboveground complete systems	ENGINEER	CONTRACTOR	CONTRACTOR	
224					
225	**Painting/Coatings**				
226	Structural Steel	ENGINEER	CONTRACTOR	CONTRACTOR	
227	Mechanical Equipment/Tanks	ENGINEER	CONTRACTOR	CONTRACTOR	
228	Piping	ENGINEER	CONTRACTOR	CONTRACTOR	
229					
230	**Electrical & Instrumentation**				
231	Plant Substation/Switchyard	OWNER	OWNER	OWNER	
232	HV transmission lines to nearest substation	OWNER	OWNER	OWNER	

Line #	Description	Detailed Engineering	Supply of Equip, Material or Service	Constr/Erect Test/Implement	Comments
233	Dead End Structure at highside of GSU	ENGINEER	CONTRACTOR	CONTRACTOR	
234	High Voltage System				
235	Relay Protection Control Cabinets and Metering	ENGINEER	CONTRACTOR	CONTRACTOR	
236	Main GSU Transformers	ENGINEER	CONTRACTOR	CONTRACTOR	
237	Station Service Transformers	ENGINEER	CONTRACTOR	CONTRACTOR	
238	Disconnect Switches	ENGINEER	CONTRACTOR	CONTRACTOR	
239	Iso-Phase Bus Duct	ENGINEER	CONTRACTOR	CONTRACTOR	
240	Medium Voltage Electrical Systems				
241	Relay Protection Control Cabinets and Metering	ENGINEER	CONTRACTOR	CONTRACTOR	
242	Station Service Transformers	ENGINEER	CONTRACTOR	CONTRACTOR	
243	Non-Seg Bus Duct	ENGINEER	CONTRACTOR	CONTRACTOR	
244	Switchgear, Secondary Substations, and Dry Transformers	ENGINEER	CONTRACTOR	CONTRACTOR	
245	Conduit/Cabletray/Other Raceway	ENGINEER	CONTRACTOR	CONTRACTOR	
246	Cable	ENGINEER	CONTRACTOR	CONTRACTOR	
247	Low Voltage Electrical Systems				
248	Diesel Emergency Genset	ENGINEER	CONTRACTOR	CONTRACTOR	
249	Transformers	ENGINEER	CONTRACTOR	CONTRACTOR	
250	Substations and Motor Control Centers	ENGINEER	CONTRACTOR	CONTRACTOR	
251	Load Centers	ENGINEER	CONTRACTOR	CONTRACTOR	
252	Raceway/Conduit/Cabletray/Receptacles	ENGINEER	CONTRACTOR	CONTRACTOR	
253	Instrumentation & Controls				
254	DCS	ENGINEER	CONTRACTOR	CONTRACTOR	
255	Control Panels/Desks, CRTs, Printers, etc. (Non-DCS)	ENGINEER	CONTRACTOR	CONTRACTOR	
256	Instruments/Devices (balance)	ENGINEER	CONTRACTOR	CONTRACTOR	
257	Transmitters and Process Controllers, PLC's	ENGINEER	CONTRACTOR	CONTRACTOR	
258	Control/Signal, Instrument, Phone, Data, and Fiber Optic Wiring	ENGINEER	CONTRACTOR	CONTRACTOR	
259	Instrument and Sampling System Tubing	ENGINEER	CONTRACTOR	CONTRACTOR	
260	Calibration	ENGINEER	CONTRACTOR	CONTRACTOR	
261	Uninterruptible Power Supply & 125V DC	ENGINEER	CONTRACTOR	CONTRACTOR	
262	Lighting				
263	Lighting	ENGINEER	CONTRACTOR	CONTRACTOR	
264	Pre-Eng. Steel building lighting	ENGINEER	CONTRACTOR	CONTRACTOR	
265	Outdoor/Site Lighting	ENGINEER	CONTRACTOR	CONTRACTOR	
266	Cathodic Protection	ENGINEER	CONTRACTOR	CONTRACTOR	
267	Heat Tracing	ENGINEER	CONTRACTOR	CONTRACTOR	
268	Grounding	ENGINEER	CONTRACTOR	CONTRACTOR	
269	Lightning Protection	ENGINEER	CONTRACTOR	CONTRACTOR	
270	Security and In-Plant Communications Systems				
271	Closed Circuit TV System	ENGINEER	CONTRACTOR	CONTRACTOR	
272	Gate Opener and Card Reader System	ENGINEER	CONTRACTOR	CONTRACTOR	
273					
274	**Other Construction**				
275	Construction Phase Testing, Inspection, and Check-out	N/A	CONTRACTOR	CONTRACTOR	Includes all construction phase QA testing
276	Small tools and consumables	N/A	CONTRACTOR	CONTRACTOR	Including welding rod, rags, sheet gasket, etc…
277	On-Site Quantity Surveying	N/A	CONTRACTOR	CONTRACTOR	Contractor responsible for maintaining record of actual quantities installed on the project, including materials and direct labor.
278	Contaminated Soil Testing	N/A	CONTRACTOR	CONTRACTOR	
279	Instrument Calibrations	N/A	CONTRACTOR	CONTRACTOR	
280	On-site Housekeeping, Maintenance and Rubbish Removal	N/A	CONTRACTOR	CONTRACTOR	
281	Snow Removal	N/A	CONTRACTOR	CONTRACTOR	
282	Dust Suppression	N/A	CONTRACTOR	CONTRACTOR	
283	Fall Arrest Prevention Systems	N/A	CONTRACTOR	CONTRACTOR	
284	Construction Turnover Packages (to Startup)	N/A	CONTRACTOR	CONTRACTOR	
285					
286	**Commissioning & Start-up**				
287	System Definitions/Descriptions	ENGINEER	N/A	N/A	
288	System Function Test/Commissioning Procedures	ENGINEER	CONTRACTOR	CONTRACTOR	
289	Startup Turnover Packages and Execution	N/A	CONTRACTOR	CONTRACTOR	

Line #	Description	Detailed Engineering	Supply of Equip, Material or Service	Constr/Erect Test/Implement	Comments
290	Pressure Test/Flushing	N/A	CONTRACTOR	CONTRACTOR	
291	Temporary Demin Water Supply	N/A	CONTRACTOR	CONTRACTOR	
292	DCS Check-out	N/A	CONTRACTOR	CONTRACTOR	
293	High Voltage and Other Electrical Testing	N/A	CONTRACTOR	CONTRACTOR	
294	Boiler Degreasing/Chemical & Acid Cleaning	N/A	CONTRACTOR	CONTRACTOR	
295	Systems Start-up and Commissioning (Labor, Ops, & Labor Mgmt)	N/A	CONTRACTOR	CONTRACTOR	
296	Systems Start-up and Commissioning (Technical Oversight)	N/A	CONTRACTOR	CONTRACTOR	
297	Lube Oil Flush	ENGINEER	CONTRACTOR	CONTRACTOR	
298	Noise Testing	N/A	CONTRACTOR	CONTRACTOR	
299	As-Built Drawings	N/A	CONTRACTOR	CONTRACTOR	
300	Instruction Books / Manuals	N/A	CONTRACTOR	CONTRACTOR	
301	Owner Training/Operator Training	N/A	CONTRACTOR	CONTRACTOR	Included with Owner Supplied Equipment
302	Manufacturer's Field Services	N/A	CONTRACTOR	CONTRACTOR	Included with Owner Supplied Equipment

NOTES:
1.) Contractor's detailed engineering shall incorporate basic engineering data provided in this specification.
2.) This list is not meant to be an all inclusive list of all Materials and Work for the project, but has been used to clarify scope for major items and activities.

TECHNICAL SPECIFICATIONS FOR SELECTIVE CATALYTIC REDUCTION (SCR)

94.03.30.175.02

XCEL ENERGY

KIEWIT PROJECT NO. 20038657

ISSUED: DECEMBER 11, 2020

REVISION A – ISSUED FOR REVIEW

KIEWIT
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TECHNICAL SPECIFICATIONS
TABLE OF CONTENTS

TITLE **Pages** **Revision**

TECHNICAL REQUIREMENTS

TECHNICAL SPECIFICATION 94.03.30.175.02

SELECTIVE CATALYTIC REDUCTION (SCR)

1. SCOPE: The scope of Seller supply includes equipment, materials, and services for the quantity specified in the Engineering Design Requirements (EDR) of Selective Catalytic Reduction and CO Catalytic Reduction system(s), each downstream of one simple cycle combustion turbine(CT), referred to herein as SCR systems. This Section stipulates the major design and performance criteria for the SCR systems and their associated Equipment.

1.1 Each SCR system shall include, but not limited to, the following items. The Seller shall be responsible for providing all equipment as required to provide a complete system as required to meet all guarantees. Interconnecting piping between the ammonia flow control skid and the ammonia distribution header will be by others. Foundations and erection will be by others. Erection supervision shall be offered as an option by Seller.

a. SCR and CO Catalyst.
b. SCR and CO Catalyst housing, internal supports, and seals.
c. Support framing from the combustion turbine exhaust diffuser flange up through and including the exhaust stack.
d. Exhaust stack.
e. Inlet and outlet transition ducts and all expansion joints within the Seller’s scope of supply. See EDR for expansion joints between the CTG Exhaust and the SCR inlet duct.
f. Tempering air / purge air fan skid complete with accessories.
g. Interconnecting tempering air ductwork from fans to casing.
h. Tempering air distribution within the SCR system casing.
i. Ammonia flow control and vaporization skids complete with accessories.
j. Ammonia injection grid and support structure.
k. Ammonia distribution header adjacent to the ammonia injection grid including flow control valves, flow orifices, and manometers. Header(s) shall be routed vertically up the side of the SCR with the flow control valves and associated instrumentation located as near as practical to their respective connection points to the SCR grid. Header(s) shall be equipped with expansion joints as required.
l. Silencing equipment for the SCR system and stack necessary to meet noise guarantees.
m. Access platforms, stairs and ladders for SCR system and test ports. These shall meet OSHA requirements.
n. Piping shall be shop fabricated to the maximum extent possible, i.e. 40-foot sections.
o. All instrumentation as required for a complete functioning system capable of fully remote operation, including remote startup and shutdown.
p. Test ports consisting of 2-1/2 inch pipe connections for the CEMS and for performance testing that allow traverse testing upstream and downstream of each

layer of catalyst and upstream of ammonia injection in a grid arrangement. Sampling grid(s) may be provided as an alternative.

q. Provisions shall be made such that catalytic element sampling coupons or catalyst elements can be readily accessible without disturbing other equipment and by the use of common tools.

r. All piping, valves and components in contact with aqueous ammonia shall be stainless steel upstream of the Ammonia Vaporizer and carbon steel downstream of the Ammonia Vaporizer.

1.2 The base bid shall be based on the design and materials detailed herein. Alternate design and materials submitted by the Seller will be considered.

2. DESIGN AND PERFORMANCE CRITERIA:

2.1 Seller shall design the systems and equipment in accordance with the design data and operating cases listed in the EDR. Seller shall design the systems and equipment, including selecting materials of construction to provide a minimum 30-year operating life at all operating conditions specified. It is understood that Equipment provided will require routine maintenance, major overhauls, and possible replacement during the life of the facility.

2.2 SCR systems shall be designed to ensure that stack emissions remain in compliance with the limits set forth in the EDR throughout the firing range represented by the cases in Appendix A.

2.3 The SCR, accessories, and all equipment furnished shall be capable of meeting performance guarantees continuously at any load point in the EDR and Appendix A, across the full range of ambient design conditions. The SCR shall operate in a safe, reliable and stable mode under all listed conditions without exceeding the design temperatures.

3. OPERATING CONDITIONS:

3.1 The system shall be suitable for withstanding the transient and steady state operating conditions for all gas turbine operations including starting, loading, unloading and shutdown as well as abnormal conditions including emergency shutdown or sudden full load rejection. The normal operating range of the SCR will be as stated in the EDR. Reference the information included in Appendix A for combustion turbine exhaust conditions at various site ambient conditions and operating loads. The design of equipment shall incorporate appropriate measures for the thermal stresses and metal fatigue associated with the cyclic activity of a peaking power plant.

3.2 The combustion turbines and SCR systems will be located outdoors and shall be designed for both continuous and cycling operation during any ambient conditions presented in these specifications. Each SCR system will receive and process exhaust gases from the make and model of combustion turbine shown in Table EDR. The Seller recognizes the combustion turbine model and acknowledges that the Seller is fully abreast and knowledgeable of the range of exhaust characteristics and velocity profiles and has accounted for these conditions in the Seller's offering.

3.3 The catalysts and other equipment shall be capable of withstanding short-term temperature spikes during tempering air fan failures. All material in the exhaust gas path, or otherwise subjected to exhaust temperature shall be acceptable for the design maximum gas temperature presented in Table EDR.

3.3.1 Fuel: The combustion gas turbine will burn natural gas fuel that meets the requirements listed in Appendix D – Fuel Gas Composition Analysis. The supplied fuel information shall be used for the equipment design and the performance guarantees.

4. GUARANTEES: Seller equipment shall meet the performance guarantees specified in the EDR. The guarantees for emissions, pressure drop, and noise shall be met in everyday operation under all specified operating conditions. The Contractor will conduct tests per agreed upon procedures to determine all guarantees are met.

5. FLOW MODEL(S):

5.1 Computational Fluid Dynamics (CFD) Flow Model

5.1.1 A computational fluid dynamics (CFD) flow model study based on the specific gas turbine exhaust profile data shall be provided. The study shall be conducted at a minimum of two (2) operating conditions (CT MECL and CT Full-Load) to ensure a uniform gas flow profile at the inlet to the catalyst sections. The gas velocity profile entering each catalyst module and the maximum temperature stratification shall be as required by the catalyst manufacturer. Sampling ports shall be provided to verify these parameters.

5.1.2 This CFD flow model shall be conducted, and the results shall be provided to Buyer prior to release for fabrication. If CFD flow model is not completed before fabrication, Seller will take responsibility for any modifications needed due to flow model results.

5.2 Physical Flow Model:

5.2.1 Provide a physical flow model for any new SCR reactor design or on a combustion turbine for which the supplier does not have and SCR that has been in operation for at least six months. The physical model shall be tested in the turbulent flow regime with an air flow rate with proper similitude to the gas flow rates of the full-scale installation. The modeled pressure drop shall be corrected for air/gas density to reflect full-scale conditions. The model shall incorporate or account for all internal structures of the equipment and ductwork including such items as beams, cross struts, stiffeners, and other incidental obstructions to gas flow. A detailed description of the physical model test procedures be developed and submitted to the Buyer for acceptance.

5.2.2 The physical model(s) shall be geometrically identical to the full-scale installation. The model(s) shall be constructed of clear plexiglass to permit observation during flow studies. The model shall be no smaller than 1/12th scale. The model shall be tested with air velocity of proper similitude to the flue gas velocity in the full-scale installation. The model shall take into account the effect of the flow patterns and temperature gradients from upstream equipment.

5.2.3 The Seller shall give notice to the Buyer prior to performing physical flow modeling tests. The Seller shall allow Buyer to witness all testing including the final flow model testing. The Seller shall contact the Buyer seven (7) days prior to the final testing period. The model shall be maintained in assembled condition and prepared for further testing until Buyer is in full acceptance of the flow model study report. The model shall be retained by the Seller for the life of the Project or until expiration of the warranty period. Final disposition of flow model after project completion or warranty period expiration shall be at the Buyer's discretion.

5.2.4 Flow Modeling Objectives and Requirements: CFD and/or Physical Flow Modeling Objectives:

a. Optimize the tempering air system
b. Optimize Pressure drop at all load conditions
c. Recommend duct configurations, turning vanes and other gas distribution devices
d. Achieve the level of distribution and mixing of gas and ammonia, including temperature to support the guaranteed performance.
e. Minimize non-uniform flow distribution, turbulence, and swirl by proper duct geometry and the use of gas distribution devices.

6. FUNCTIONAL TESTING: All controls, instruments, valves, dampers, control panels and auxiliaries shall be function tested prior to delivery.

7. CODE REQUIREMENTS: The equipment shall be designed and constructed in accordance with the latest applicable requirements of the applicable codes and standards, except where modified or supplemented by these Specifications.

7.1.1 The proper stamps shall be affixed to denote conformance to the appropriate codes. All data reports and inspection certificates required by the codes shall be "Engineer-Owner" type documented on a master data report provided and distributed by the Seller.

7.1.2 The Seller shall prepare a written statement of exception to any portion of the applicable codes and standards. The statement shall be submitted to Contractor for review and comment. The statement shall: 1) identify the applicable code or standard section; 2) describe what they cannot or will not do; and 3) describe what they will do in lieu of the code or standard requirement. Failure of the Seller to submit the written statement of exception to Contractor shall be understood to mean that the Seller is complying in all respects to the applicable codes and standards.

8. FOUNDATION LOAD CHART: The Seller shall provide a foundation load chart that clearly shows the vertical and horizontal design loads acting at each load point. The magnitude, direction and location of the design loads shall correspond to each load condition. Load conditions for seismic, thermal, snow and wind shall be given for both the negative and positive coordinate directions. The coordinate axes shall be relative to the equipment axes and occurrences of uplift shall be identified by the coordinate sign convention.

9. GUARANTEE CORRECTION CURVES: The Seller's guarantee correction curves will be used to determine compliance with contract guarantees at the guarantee conditions if they are not achievable during the performance test. The following curves, at a minimum, shall

be included. Provide curves for at least two representative operating condition cases (or state curve is applicable at all conditions). One curve should be at the guarantee condition and one at the governing case that sizes the catalyst. Provide each NOx reduction curve, with at least three ammonia slip concentrations in ppmvd @ 15% O_2 (if applicable). One ammonia slip should be the design slip with two curves below the design. All curves should list the case that they apply to, including key operating conditions (e.g., flue gas flow, flue gas temperature, inlet NOx concentration, ammonia slip, flue gas temperature, time in hours on the catalyst life deactivation curve). If applicable, all curves should indicate a method to correct the curves to the current time with respect to the catalyst life.

a. NOx Reduction v. Inlet NOx (ppmvd @ 15% O_2)
b. NOx Reduction v. Flue Gas Flow Rate
c. NOx Reduction v. Temperature
d. NOx Reduction v. NO/NO_2 Ratio (NO_2 content as percent of NOx)
e. Pressure Drop v. Flue Gas Flow Rate
f. Ammonia slip (ppmvd @ 15% O_2) v. Operating Time (i.e., catalyst life / deactivation curve)
g. NOx Reduction v. RMS of the NH3/NOx molar maldistribution
h. Ammonia slip (ppmvd @ 15% O2) v. RMS of the NH3/NOx molar maldistribution

10. CONSTRUCTION: The design shall be based on factory-built modules with as many shop-assembled components as possible. The design shall include provisions necessary to allow ease of construction, maintenance, and accessibility.

10.1 The Seller shall incorporate the following construction details to minimize the amount of time required to erect the SCR systems and equipment.

a. Factory installed permanent lifting lugs and guy wire lugs on all panels and duct assemblies. Lifting lugs shall not penetrate internal insulation. Internal lifting lugs and guy wire lugs shall be noted in the drawings to be removed in the field. Lifting lugs location shall be clearly identified in Seller's drawings and shall be submitted for Contractor's approval.
b. Factory installed permanent stack erection trunnions or lifting lugs.
c. Shop modularize upper support steel sub assemblies as much as possible. Seller will not be back-charged for interferences with piping or other structural steel caused by Contractor's chosen installation sequence; however, Seller shall be ultimately responsible for interferences that result from design or manufacturing errors.
d. Field-assembled connections for the stack platforms, stairs and ladders shall be bolted connections, not field-welded connections.
e. Field-assembled connections for all other platforms, stairs, and ladders shall be bolted connections.
f. Provide tension control (Lajune-type or equal) bolts in lieu of hex head bolts for

the inlet duct, stair tower, and other components except where installation of TC bolts is not possible such as handrails. Seller will not be back-charged for the installation of hex head bolts where TC bolts and/or installation tools will not fit.

g. Any joints designated as slip-critical by Seller shall be indicated on Seller's installation drawings.

h. Prefabricate upper elevation platforms in sections as large as possible to accommodate standard shipping means.

i. Erection drawings shall indicate that lifting lugs, guy wire lugs, erection trunnions, etc. located on the exterior of the casing or stack may be left in place after erection except where an interference is caused with other permanent components.

j. Seller and Contractor shall mutually approve field weld profiles (moments) in a timeframe to support Seller's engineering and delivery schedule. The field welds (moments) will be designed to be a full penetration weld in accordance with AWS standards.

k. Provide roof access holes to accommodate the use of sky climbers for construction, inspection and maintenance.

11. TEMPORARY AND SHIPPING STEEL:

11.1 Design and install temporary/shipping steel for ease of removal in the field.

11.2 All temporary/shipping steel bolting details shall be clearly shown on the Seller's drawings.

11.3 Temporary bolts used to secure temporary/shipping steel shall not be welded to their respective nuts. Nuts shall be secured to the bolts using lock washers, double nuts, "punching" the bolt threads or by using a welded tab design as required so as to not damage the bolt threads and to allow the use of impact wrench/sockets for quick removal of nuts/bolts.

11.4 Casing shall not be welded onto the truck bed. It shall be tied down with chains or bolted to the truck bed.

11.5 Seller shall furnish one (1) horizontal lifting device and/or one (1) strongback as required for erection. Seller shall provide an option to supply a second horizontal lifting device and/or a second strongback (total of two (2) each) for erection.

12. PIPE WELDING: Field welding shall be minimized as much as practical. Contractor shall have the opportunity to review and revise field weld locations shown on Seller's piping.

13. SHOP COATING: Large bore piping and fittings which will not be insulated shall be delivered to the site shop blasted in accordance with SSPC-SP6 and primed with an inorganic zinc rich primer. Engineered components such as valves, pumps, silencers, etc. shall be delivered to the site finish painted in accordance with the manufacturer's standard finish suitable for the site conditions. Seller's standard finish coating systems shall be submitted to Contractor for review and approval.

14. ACCESS PLATFORMS:

14.1 All ammonia balancing valves shall be accessible by manlift. If manlift accessibility cannot be provided, alternate means shall be provided such as davit for sky climber, etc. Davit arm shall be accessible from an SCR catalyst housing.

14.2 The SCR and CO catalyst modules will be loaded by hand and shall not require An internal monorail or hoist.

15. SHUTDOWN/MAINTENANCE DRAIN AND VENTS: Casing drains shall be provided to drain any condensation from the exhaust gas.

16. NOx CATALYST:

16.1 The NOx catalyst shall be of the low-dust type. The catalyst shall be designed to minimize pressure loss. The direction of gas flow through the catalyst shall be horizontal.

16.2 The catalyst shall be either a homogenous extruded honeycomb or corrugated type. The catalyst modules shall not be subject to de-lamination or permanent deformation of the catalyst or support material due to stresses induced by the seismic conditions, vibration, pressure and thermal conditions or combinations thereof.

16.3 The volume of NOx catalyst supplied shall be designed to control NOx and ammonia slip to the values guaranteed without requiring cleaning, regeneration, or replacement during the catalyst life guarantee period, except that vacuuming may be necessary to remove insulation or debris deposits on the catalyst face prior to placing the catalyst in service. The NOx and ammonia slip limits shall be met simultaneously and corrected to the catalyst life ammonia slip v. time correction curve. The end of catalyst life guarantee period is when the catalyst activity reaches the minimum acceptable level and requires a catalyst layer replacement as measured by the ammonia slip. The end of catalyst life NOx and ammonia slip limits specified in the EDR shall take precedence over the RFP or air permit limits when the values in the EDR are lower.

16.4 The catalyst shall be designed and sized for an NH_3/NOx molar maldistribution of 15% RMS. However, the AIG and any gas distribution devices shall be designed for the SCR and catalyst supplier's standard RMS. RMS is the Root-Mean-Square of the Deviations expressed as a percentage of the mean:

$$RMS = \frac{\sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(x_i - \bar{x})^2}}{\bar{x}} \times 100\%$$

Where n = number of data points
$\bar{x}$ = mean of NH_3/NOx ratios
x_i = NH_3/NOx ratio of point i

16.5 The catalyst shall be designed and sized for a bypass/leakage rate of gases around the catalyst per the EDR.

16.6 The NOx catalyst shall be of modular design to facilitate installation and removal of the catalyst. The catalyst modules shall be the maximum practical size to facilitate and minimize field maintenance. Any special tools required to facilitate the removal or installation of catalyst modules shall be provided. Any special tools or handling fixtures for the proper handling or unloading of the catalyst modules from a truck or rail car shall be provided. Internal tie-off lugs shall be provided for use during catalyst installation and replacement.

16.7 The NOx catalyst modules shall include sealing frame and frame steel to improve the ease of catalyst replacement and installation. The frame materials shall be compatible with the catalyst material. The sealing system shall be designed to limit exhaust gas leakage past each layer of catalyst. The sealing mechanism and materials shall provide a service life equal to or greater than the catalyst. SCR catalyst sealing system shall have tongue and groove seals. Catalyst seals shall consist of at least three adjacent, overlapping sealing surfaces in the areas where thermal expansion occurs. Blinding plates and simple pillow seals are not acceptable as the primary seal unless specifically approved by the Buyer.

16.8 The SCR shall be designed to accept future additional layers of catalyst as specified in the EDR.

16.9 Design shall incorporate sufficient catalyst to treat the exhaust gas to meet emissions levels specified without requiring cleaning, rejuvenation or replacement for the catalyst life guarantee period.

16.10 Seller shall supply testing penetrations consisting of 2-½ inch pipe connections located in each side of the casing to permit performance testing of each row of catalyst cells in the system. The test ports shall have blind flanges. The design and configuration of the test ports shall allow traverse testing before and after each row of catalyst in a grid arrangement. No permanent access provisions are required to these test ports.

17. TEMPERING/PURGE AIR SYSTEM:

17.1 A tempering air system shall ensure the catalyst operating temperatures are controllable within the range required for long life of the catalyst. The tempering air system shall inject ambient air to reduce the exhaust temperature. Seller is responsible to engineer this system to provide effective mixing of the air with exhaust gas and to ensure that the cross sectional variations in flow, velocity, temperature and concentration of NOx, CO, VOC and ammonia do not cause emissions to exceed their guaranteed values.

17.2 The tempering air skid shall be furnished pre-assembled and pre-wired to the extent practical. As a minimum, the skid shall include the following equipment.

a. Two (2) 100% tempering air fans.

b. Two (2) inlet air silencer/filters.
c. Acoustical enclosures as required.
d. System to prevent hot gas backflow into a non-operating fan.
e. Ductwork damper system to provide tempering air flow control.
f. Seller shall provide an option to include Variable Frequency Drive (VFD) Motors (Motor starter by others) and remove ductwork control damper system.

18. AMMONIA INJECTION SYSTEM:

18.1 The ammonia vaporization system shall be designed to deliver an ammonia flow that results in a sufficient volumetric ammonia to NOx ratio at the highest exhaust flow and NOx level. The ammonia feed to the vaporizer chamber shall be filtered to prevent clogging of the atomizing nozzles.

18.2 The system shall include the items below and shall be provided pre-piped and pre-wired to the maximum extent possible.

a. Two (2) 100% ammonia vaporizers with an air atomizing nozzle, or packed tower.
b. See EDR for Type of Vaporization System
   - Electric: Air Heaters (n+1 design for redundancy) and heater power panel. The maximum watt density on electric air heaters shall be 30-w/sq.in. to minimize heater burnout.
   - Hot flue gas recirculation.
c. Two (2) 100% capacity dilution air blowers or hot flue gas fans with motors. The blowers (fans) shall be skid-mounted electric motor driven centrifugal fans. The capacity shall be sufficient to dilute the ammonia at the highest flow requirement to ensure adequate mixing and so that the ammonia/air (gas) mixture is not flammable.
d. Contractor’s supplied starters for the dilution air blower motors will be supplied with standard Class 20 overload relays. If the Class 20 relays are not sufficient for starting the blower motors (at any ambient temperature conditions with or without the combustion turbine in operation) due to the long motor acceleration time, the Seller will be responsible for providing the required starters for the dilution air blower motors
e. Actuated valve on the outlet of each blower (fan).
f. Actuated valve on the inlet of each blower (fan) for a hot gas recirculation system only.
g. Aqueous ammonia flow control valves.
h. All piping and support structure from ammonia injection manifold to the ammonia injection grid (AIG).
i. Flow meters or flow orifices with transmitters for aqueous ammonia flow and dilution gas flow.
j. Strainers, including differential pressure gauge, upstream of the flow control valves.
k. Manual isolation valves
l. Actuated shut-off valve(s) or solenoid valve(s) for the aqueous ammonia and atomizing air (when applicable).

m. Local instrumentation.
n. Electric junction box where all field wiring termination points will be located.

18.3 The minimum exit temperature of the vaporizer at any load condition is 450 °F.

18.4 The ammonia injection grid shall consist of multiple, manifold pipes with holes configured and spaced for uniform distribution of the ammonia/air mixture throughout the exhaust gas flow. The AIG shall have at least two horizontal zones for the SCRs wider than 15 and with each vertical zone no larger than 7 feet. The location of the ammonia injection grid shall be such that thorough mixing of the ammonia and NOx can be achieved prior to passing through the NOx catalyst. The ammonia injection grid shall be located upstream of the NOx catalyst and shall be fabricated of stainless steel.

18.5 The ammonia injection gird shall include a permanent sample grid at the catalyst exit to be used for AIG tuning with sample lines terminating near grade or a platform.

18.6 The AIG tuning process shall be submitted to the Buyer and shall include the methodology on determining the NH_3/NOx molar maldistribution RMS.

18.7 The interconnect piping between the ammonia vaporization skid and the ammonia injection system shall be designed for insulation by others. The vaporizer skid components shall be shop-insulated by the Seller.

18.8 The sparger pipes exiting the ammonia header shall be equipped with valves and flow elements to allow balancing of the ammonia flow into the duct. The Seller shall define the control capability as part of the proposal.

18.9 The ammonia injection piping shall have local temperature and pressure indication including differential pressure gauge for each header valve.

18.10 The ammonia piping shall have a condensate drain.

18.11 Ammonia/Air Mixing Chamber.

18.11.1 The ammonia/air mixing chamber shall thoroughly mix the ammonia and air so that the gas mixture is safe and non-flammable.

18.11.2 The ammonia vaporization chamber shall have a maximum inlet temperature of the heated dilution air of 800 ˚F.

18.11.3 For systems that use hot flue gas for vaporization, provide means to cool the dilution gas fan with ambient air.

19. CO CATALYST:

19.1 The Seller shall provide a CO catalyst system to meet the air emission guarantees as stated in the EDR for CO and VOCs. The CO catalyst shall be designed and located to meet the guarantees over the full range of operation from Peak Load to Minimum Load shown in Appendix A and the full range of design ambient temperature.

19.2 The design inlet CO and VOC concentration shall be equal to 100% of the combustion turbine exhaust CO and VOC levels as given in Appendix A.

19.3 Provide access manways and catalyst loading openings in the casing sufficient to facilitate removal and installation of the catalyst modules without the need for cutting or welding of any casing components. Internal tie-off lugs shall be provided for use during catalyst installation and replacement.

20. CATALYST WARRANTY: All catalyst shall be designed to meet all emissions guarantees for a minimum catalyst life guarantee period specified in the EDR. The catalyst life guarantee is defined as the duration from initial operation until the catalyst activity reaches the minimum acceptable level and requires a catalyst layer replacement. Any failed module caused by defects in workmanship and materials shall be repaired or replaced at Contractor's option, at Seller's expense.

21. CASING:

21.1 The exhaust gas path shall be enclosed by the casing. The casing shall be furnished with steel liner from the SCR inlet up to the exhaust stack. The exhaust gas path shall be completely gas tight to prevent leakage and bypassing of hot gases within the casing, except that expansion bellows located at floor penetrations may be provided with a 3/16" maximum weep hole to allow draining of condensation from the bellows. Casing panels shall be fabricated with lifting lugs and guy wire lugs installed to minimize erection time.

21.2 The casing shall be designed to withstand the maximum combustion turbine exhaust pressure and flow rate. Unless otherwise specified in the EDR, the SCR outer casing shall be fabricated of A36 carbon steel plate at least 1/4" thick with stiffening for an internal design pressure of 20 in. w.c. in addition to wind loadings specified below.

21.3 A complete walkway layout for maintenance, accommodations for catalyst installation, sampling and replacement, adequate access doors upstream and downstream of the catalyst sections, and adequate test ports for traverse emissions testing upstream and downstream of the SCR catalyst. All flow distribution equipment, if required, shall be provided by Seller.

21.4 The catalyst modules and frame shall be designed to allow for thermal expansion without damaging the catalyst.

21.5 Design shall allow the removal of NOx catalyst through top of casing by mobile crane.

21.6 Housing structural support members, columns, and casing stiffener bars shall be external to the casing to prevent exposure to hot exhaust gases.

21.7 Internal insulation on the sides and top of the system housing shall be covered with a minimum of 14 gauge 409 stainless steel liner. Internal insulation on the floor of the housing shall be covered with a minimum of 10 gauge 409 stainless steel liner. The liner panels shall be overlapped in the direction of the flow.

21.8 Penetrations of the casing required for piping or other pressure parts shall be sealed to retain the pressure tight integrity of the casing.

21.8.1 Access manway doors shall be 18” x 24” in size, and shall be internally insulated, hinged or davited and pressure tight, with bolted closure. Seller shall provide a grab bar for each casing manway door. Penetrations shall be installed on each side of the roof panel to accommodate the use of sky climbers for construction, inspection, and maintenance. The number and location of access doors shall be acceptable to Contractor. Three (3) extra gaskets shall be provided for each manway.

21.9 Seller shall minimize the size of full penetration buttwelds on casing vertical joints. The welds shall be sized for structural integrity as required by Seller’s design.

22. DUCTS:

22.1 Duct Sections: The Seller shall provide insulated and lined duct sections. Access manways and openings as required for replacement and/or maintenance of the SCR and CO catalysts without the need for cutting or welding of any casing components shall be provided.

22.2 Transition Duct Arrangement: The expansion joint / transition duct from the combustion turbine (CT) outlet flange to the casing proper shall be provided by the Seller and shall have a transition angle as required to promote an even distribution of exhaust gas. The transition duct angle shall not exceed a 45º angle between floor and roof of transition. The Seller shall design the inlet to mate with the CT outlet flange.

22.3 Materials: Materials shall be in accordance with the requirements of the EDR.

22.4 Ductwork: The connection to the CT outlet shall be in accordance with the requirements of the EDR. All ductwork, hardware, and gaskets required for the interconnection of the CT outlet, SCR, and the exhaust stack shall be furnished by the Seller. See Appendix C for specific requirements at the CT-SCR interface. Seller shall comply with all details, recommendations and requirements from the CT supplier for this interface. Distribution vanes or perforated plate shall be provided (if required) in the SCR inlet transition section to allow uniform flow distribution to the SCR. The distribution vanes (if required) shall be constructed of 304 stainless steel.

22.5 Ducts shall be constructed of steel plate in accordance with the requirements of the EDR. Field joints shall be flanged and designed for bolting and seal welding. Angles or plates used to form flanges shall be joined to the ducts by continuous fillet welds. Templates shall be used for drilling bolt holes in flanges. Ducts shall be designed to prevent pulsations and noise generation. Each low point shall be furnished with drains. Casing drains for each low point shall be provided and shall be capped.

22.6 The floor of the ducts shall be designed to provide a rugged surface for ladders, scaffolding, etc.

22.7 All ductwork and transition sections shall be provided with an internal insulation and lagging system as specified in below. SCR outlet transition ducts, EPA ports, stacks, and in general any area accessible to personnel shall be provided with an expanded mesh barrier or thermal insulation from their bases to a height of at least eight (8) feet above grade, as required for personnel protection from temperatures exceeding 140ºF.

22.8 Ductwork shall be designed to withstand the maximum combustion turbine exhaust pressure, as measured at the combustion turbine exhaust connection, shown as "stack outlet temperature" in the EDR and Appendix A.

22.9 Turning vanes shall be provided in ductwork as required to minimize gas side pressure loss and optimize proper gas distribution.

23. MAIN EXHAUST STACK:

23.1 The Seller shall furnish one Main Exhaust Stack constructed per all requirements listed in the EDR. The stacks shall be furnished complete with supporting steel, expansion joints, interconnecting ductwork, grounding lugs, and hardware. The stacks shall be self-supporting without guying. The concrete foundation and anchor bolts for the stack will be furnished by the Buyer.

23.2 Design and construction of exhaust stack steel shall be in accordance with Section GR-A, Section S1, the EDR, and with the following codes and standards:

a. ASME/ANSI STS-1, Steel Stacks
b. AISC 360, Specification for Structural Steel Buildings

23.3 The steel exhaust stacks and supports shall be capable of enduring specified normal and abnormal design operating conditions in combination with wind and seismic loads for the design life of the facility. Effects of wind shall include along-wind and across-wind response.

23.4 Design values for yield strength and moduli of elasticity of the stack material shall depend on the composition of the material and the maximum temperature of the metal at design operating conditions, and shall be as prescribed by the ASME Pressure Vessel Code, Section VIII, Division 2, Part AM. A stack liner shall only be supplied if necessary to meet the design life for the stack.

23.5 Design calculations and design drawings of the stack(s) shall be in accordance with Section S1 Documentation and submitted to the Buyer for review prior to release for fabrication. The drawings shall indicate the size, shape, and location of all structural members and elements; specific details of connections between the members and elements; the materials of construction including protective linings and coatings; and the forces and moments imposed by the stacks on the supports for each design load condition.

23.6 The main stack shall be provided with an expanded mesh barrier for personnel protection from temperatures exceeding 140 °F at any location that is accessible from any ladder or platform around the stack.

23.7 Any stack low point, which may collect condensation, shall be furnished with a stainless steel drainpipe and 3" drain valve.

23.8 The stack shall include one: (1) clean out door not less than 2' by 2' located at the bottom of the inner wall. Access shall be provided through the outer wall to the clean out door.

23.9 The exhaust stack shall be cleaned, prepared, and the outer stack wall material shall be primed painted by the Seller with inorganic zinc primer appropriate for temperature conditions. Equipment, materials and structures shall have protective coating furnished in accordance with the Painting and Coating Specifications. In the event of a conflict in requirements, the more stringent shall apply.

23.10 Stack height and exit velocity shall be as listed in the EDR at the Guarantee Performance Case.

23.11 The Seller shall provide a bolted fit-up flanged connection (angle to angle) for the upper stack section where it attaches to the lower stack section at the damper housing connection. This bolted connection will be externally seal welded gas tight by the Buyer in the field. See additional shipping details in the Construction Article

23.12 Stack Welds: The Seller's stack design for stack field welds shall be designed with a bevel such that open-root short circuit processes (RMD, STT) can be used instead of backing bar joint details wherever possible.

23.13 There shall be no stack field welded joints with differing shell plate thickness. All welds with differing plate thickness shall be done in the shop.

23.14 CEMS and EPA Ports: Port quantities and sizes are listed in the EDR. Ports shall be evenly spaced. All ports shall be provided with ANSI Class 150 flanges with matching blind flanges, bolting hardware and gaskets. The flange bolt hole orientation shall be coordinated with Buyer's CEMS vendor. Buyer will be allowed to change the size of the ports to a smaller size at no additional cost, if such change is requested prior to or during the Buyer's review of the stack drawings. CEMS ports shall comply with all EPA requirements including those for spacing relative to disturbances.

23.15 A port for inlet NOx measurement shall also be provided and located per manufacturer's recommendations, and be as far as possible upstream of the SCR catalyst and ammonia injection location. The port shall be a 4" diameter, ANSI Class 150 flanged connection.

23.16 A caged ladder per ANSI 14.3, OSHA standards shall be provided for access to a 360º EPA platform. The platform minimum width shall be as listed in Section 1 of the EDR. The CEM and EPA sample connections shall be accessible (chest level) from this platform. The platform shall provide sufficient clearance to walk around CEMS equipment without having to climb over or under any components including electronics. Expanded metal mesh for personnel protection shall be located at the base of the stack to a height of not less than 8' above grade. Personnel protection shall also be placed at the EPA ports to a height of not less than 8' above the platform. A davit arm with a minimum capacity of 500 lbs. shall be provided to allow the attachment of a chain hoist at the EPA platform ring. The davit arm shall be positioned to allow for ease of installation and removal of CEMS probes.

23.17 Stack Base Template: The Seller shall provide a carbon steel template of the stack base plate, match marked, orientation marked, match drilled to the base plate for use in aligning and setting anchor bolts.

23.18 Welding: A detailed procedure identifying the sequence and methods for field fit up and welding of each section shall be submitted for review to Contractor. This procedure shall address distortion control of continuously welded circular sections.

24. EXPANSION JOINTS:

24.1 Expansion joints shall be provided for the interface between the SCR casing outlet and the main stack connection, and at all other locations as required to accommodate thermal expansion. Expansion joints shall be specifically designed for use in combustion turbine service.

24.2 Expansion joints shall be sized and designed by the expansion joint manufacturer to meet the conditions specified and the arrangement of the ductwork with respect to expansion, contraction, and offsets.

24.3 The nonmetallic expansion joints shall be of gas tight construction except that expansion bellows located at floor penetrations may be provided with a 3/16" maximum weep hole to allow draining of condensation from the bellows. Nonmetallic expansion joint shall be of low noise design.

24.4 The expansion joint belts shall be designed to withstand full system operating temperatures and pressures, including excursions.

24.5 Duct Connections: The Seller shall ensure that the expansion joints furnished are designed and fabricated such that the internal opening and bolt pattern lines up with the casing outlet and stack inlet flange connections. Gaskets shall be factory cut and shipped ready for installation.

24.6 Construction: The expansion joints shall be constructed in accordance with the requirements specified herein. Expansion joints shall be shipped to the Site fully assembled, where size permits, and ready for bolting to the mating flanges. The expansion joint between the casing outlet and the stack breech may require a fused joint to be completed in the field.

25. HANGERS AND SUPPORTS: All necessary hanger assemblies, miscellaneous hanger steel, and support steel for supporting all ducts shall be furnished. Hangers shall be designed for attachment to supporting framework using suitable welding brackets. Special attention shall be given to hangers around transition sections, openings, and access doors. Hanger assemblies shall be prefabricated in the Seller's shop to the greatest extent practical allowing for field adjustment during installation. Bulk supply of hanger components for field assembly is not acceptable.

26. BEARING PLATES: All low friction (greased) bearing plates required for the accommodation of duct expansion shall be furnished as required by Seller's design.

27. TRIM AND PIPING:

27.1 General: This Article covers the design and construction requirements for piping, valves, and other miscellaneous trim Equipment for the SCR system.

27.2 The Seller shall provide all supports required for the installation of all piping, valves, and piping accessories furnished by the Seller. Piping, valves, valve stations, and piping accessories furnished under these Specifications shall be supported from structural steel furnished as part of the SCR system. Valve stations shall be located on platforms to provide for adequate access.

27.3 Seismic bumpers, including all supports and restraints shall be provided by Seller where required.

27.4 Design pressure of piping systems shall be a minimum of 25 psig above the maximum pressure anticipated during operation plus 10% or 50 psig, whichever is greater. Where piping is directly or indirectly connected to the discharge of a pump, the maximum operating pressure shall be based on the pump shutoff head plus maximum suction pressure (including static head) at the pump suction connection, at a specific gravity of 1.0. Design temperature of piping systems shall be a minimum of 10 deg. F above maximum temperatures anticipated during operation, rounded to the next 5 deg. F. All carbon steel piping shall include a corrosion allowance of 0.020" minimum. All stainless steel piping shall include a corrosion allowance of 0.000" minimum.

27.5 Minimum pipe size shall be ½ inch, except for connections to equipment. Pipe sizes 1-1/4 inch, 3-1/2 inch, 5, 7 and 9 inch shall be not used except for connections to equipment.

27.6 Trim piping protruding from any pressure vessel or module shall have a shop installed coupling, or nipple.

27.7 All large bore pipe risers will be cut to length and properly machined for field welding. No random ends shall be furnished except as agreed by Contractor.

27.8 Pipe Supports: Seller shall completely detail design and furnish all pipe supports for all pipe provided under this Contract. The support locations and loads shall be accurately noted on the drawings. Contractor shall have the opportunity to review and revise field weld locations. Pipe supports shall be shop fabricated as much as possible without exceeding shipping limitations. Unistrut shall not be used for pipe supports. Small bore support pipe support restraints shall be Anvil Figure 244 or Contractor approved equal as applicable.

27.9 Seller shall palletize and clearly identify pipe supports by drawing number.

28. INSULATION:

28.1 General: The SCR casing and ductwork shall be insulated in the shop to the maximum feasible extent. All surfaces, which will be inaccessible during erection, shall be shop insulated and lagged.

28.2 Internal Insulation: The inlet ductwork, inlet transition section, the entire reactor casing, and the exhaust stack shall be internally insulated to minimize heat loss and to prevent the high combustion turbine exhaust temperatures from reaching the external surface. In addition, the insulation system shall be designed to limit the exterior skin temperature to an average of 140 deg F at all operating conditions with an ambient air temperature of 94 deg F, an emissivity of 0.09, no incident solar heating, and 1 ft/sec air velocity, or as required by OSHA, whichever is more stringent. The insulation shall be attached to the internal wall and protected by an internal liner.

28.3 The internal liner shall be provided throughout the casing, inlet ductwork, and inlet transition section. The liner material and thickness shall be adequate for the design conditions. The liner shall be attached by standoff studs and washer, or other acceptable method that permits expansion of the liner relative to the ductwork. Washers shall be the same material as the Liner. The internal liner at the seams shall be overlapped in the direction of gas flow. Seller shall provide threaded liner pins at the field seams. Seller shall not be liable for any damage to the liner and pin caused by Contractor. The internal insulation shall be designed to withstand normal maintenance without incurring damage. Insulation and liner on upward facing horizontal and semi-horizontal surfaces shall be designed to carry a concentrated 250 pound personnel walking load without crushing insulation or permanently deforming the liner. The internal insulation shall be designed to withstand water-washing operations. The insulating wall panels shall be of a lap joint design. Wall panels of the "butt-fit" design are not acceptable due to their poor fit-up characteristics. Outlet transition ducts and stack shall be provided with thermal insulation barriers or expanded metal for personnel protection.

28.4 External Insulation: Seller shall provide all required thermal insulation specifications to Contractor for all external surfaces of piping or equipment that cannot be shop insulated. Insulation and lagging for Seller supplied equipment (except as indicated below) and piping shall be supplied and installed by Contractor. Seller shall identify insulation requirements on piping and equipment drawings.

28.5 Seller shall identify all equipment access openings, inspection openings, removable heads, etc., which must be removed periodically for inspection and repairs. Seller shall provide all clearances required for thermal movement of supplied piping and equipment.

28.6 Insulation for personnel protection shall be supplied on surfaces above 140°F within three (3) feet of walkways, ladders and platforms.

28.7 Seller shall provide metal personnel protection shields or other suitable personnel protection devices at each access platform and anywhere else on the system where temperatures exceed OSHA limits.

28.8 Materials: All insulation materials shall be asbestos free and non-corrosive.

28.9 Equipment Insulation:

28.9.1 Seller shall provide removable insulation blankets for SCR Dilution Air Blowers and any other auxiliary equipment as required. The removable insulation blankets shall be sewn to fit the shapes of the individual components and shall be designed to be securely laced in place. Removable jackets may utilize hog ring sewing. The insulation core shall be in compliance with ASTM C553 for temperatures up to 850°F and ASTM C1086 for temperatures from 850°F to 1200°F. Lacing hooks and lacing wire shall be 304SS material. The outer surface of the blankets shall consist of waterproof silicon rubber impregnated glass fiber fabric, shall be gray in color, and suitable for outdoor service. The blankets shall be easily removed and reinstalled without damage to the blanket. Blankets shall be installed in accordance with the blanket manufacturer's recommendations.

28.9.2 The blankets shall also be tagged with a permanent stainless steel tag (2.5” x 0.75”) with ½” lettering and the unique equipment number identifier stamped on the tag.

29. STRUCTURAL AND MISCELLANEOUS STEEL:

29.1 General: Design and construction requirements for casing, ductwork, SCR system, and platform support steel, grating, guardrails and handrail, shall be as noted herein. Scope of supply for structural and miscellaneous steel shall be as specified herein.

29.2 Normal maintenance and operation of the SCRs shall be provided by a system of walkways, platforms, ladders, and stairs, all provided by the Seller. Platforms shall be a minimum of three (3) feet wide unless otherwise noted, with a minimum overhead clearance of seven (7) feet. Handrails, platforms, and stair tower shall have bolted connections and shop fabricated to the greatest extent possible via standard truck or ocean shipment. Speed rail and field welding are not allowed.

29.3 Ladders, handrails, handrail posts, toe plates, platform grating, and stair treads will be constructed of galvanized steel. Platforms, stairs, ladders, and handrails shall be fabricated as specified above and shall attach to the stack or casing as specified above. Seller will not be back-charged for interferences that result from an accumulation of field tolerances provided that the components are manufactured to applicable code tolerances. Seller shall be ultimately responsible for interferences that result from design or manufacturing errors.

29.4 Provide structural and miscellaneous steel required to frame and support all component parts and equipment. Provide structural steel supports for flues, ductwork, transitions, casing and stack as required.

29.5 Seller shall install all grating penetrations for large bore pipe and structural steel. Grating penetrations shall meet OSHA requirements. Seller will not be back-charged for interferences that result from an accumulation of field tolerances provided that the components are manufactured to applicable code tolerances. Seller shall be ultimately responsible for interferences that result from design or manufacturing errors.

29.6 Contractor shall supply and install electrical cable tray on the side of the casing as required to support Seller-supplied equipment located at or near the top of the casing. Seller and Contractor shall mutually agree to the location of the electrical cable trays such that the cable tray supports will be connected to and supported from the casing structure. Seller shall allocate a space 2’-0” wide x 3’-0” long from the top of concrete to the top of the casing for Contractor-supplied cable tray.

29.7 Welding: Welding of structural and miscellaneous steel shall be in accordance with all applicable codes and Seller’s standard practice. Seller shall submit structural welding details if required.

30. ELECTRICAL:

30.1 General: The SCR and auxiliaries shall conform to the requirements in the General Electrical Work Sections.

30.2 Three phase power wiring will be by others and terminated by others at the motor junction box. Seller shall furnish cable tray where cable routing to the motor crosses Seller supplied equipment.

30.2.1 Other electric wiring shall be installed in rigid galvanized conduit or liquid-tight where required, and shall be suitable for environmental conditions specified. Wiring assembly shall be in accordance with NFPA 70 requirements for area classification noted.

30.3 All instrumentation or control devices provided as part of a pre-manufactured skid assembly shall be wired to common NEMA 4 junction boxes located on the skid. Each device shall terminate on a numbered terminal block. Junction boxes shall be uniquely identified and shall be located on general arrangement plans. Terminals and wiring shall be indicated in the Seller's wiring diagrams and schematics.

30.4 All electrical instruments and components supplied shall be UL listed.

31. INSTRUMENTATION:

31.1 General: The Seller shall include all primary elements, sensors, transmitters, actuators and valves required for system control, sequencing, protection and monitoring.

31.2 Instrument List: Seller shall furnish a comprehensive instrument list that contains the instrument tag number, manufacturer, model number, calibration range, installation detail reference and design conditions as a minimum submittal.

31.3 Electronic Instrument Location Plan: An electronic list identifying the instrument tap location (X, Y and Z coordinates) for all instrumentation furnished by the Seller shall be provided.

31.4 Instruments: The following instruments shall be provided, as a minimum, for connection to the Plant DCS, or local indication as indicated. It shall be the Seller’s responsibility to ensure the type and quantity of instruments provided meets code requirements.

a. CT exhaust temperature indicators with wells
b. CT exhaust gas absolute pressure indicators
c. Differential pressure transmitter - CO catalyst
d. Differential pressure transmitter - NOx catalyst
e. Differential pressure transmitter – Total, SCR Inlet to CO Catalyst outlet
f. Tempering air duct temperature indicator
g. Tempering air duct damper position indicator
h. CTG trip request
i. CTG start interlock
j. SCR purge in progress
k. SCR common alarm
l. Dilution air fan status
m. Ammonia filter differential pressure indicator
n. Ammonia inlet pressure switch

o. Ammonia flow transmitter
p. Ammonia flow shut off valve position indicator
q. Ammonia flow control valve position indicator
r. Ammonia heater temperature transmitter
s. Ammonia mixer temperature transmitter
t. Ammonia-air injection temperature transmitter
u. Dilution air flow indicator
v. Dilution air pressure switch
w. Dilution air temperature indicator

31.5 NOx Inlet Probe: One (1) NOx inlet probe that can be moved to three vertical locations with umbilical lengths sufficient for the furthest location shall be provided.

31.6 Temperature Measurement: All necessary connections for installation of temperature measuring devices shall be furnished as required. All thermocouples shall be ISA Type K and RTDs shall be 100 ohm platinum with a 0.385 alpha.

31.7 Thermocouples: A system of permanently installed thermocouples shall be provided for monitoring critical metal temperatures throughout the SCR. Thermocouples shall be ungrounded and shall be Type K, stainless steel sheathed, and spring loaded. A system of wiring and rigid aluminum conduit shall be installed to connect all thermocouples to a junction box or boxes at locations acceptable to the Engineer. Junction boxes shall contain marked terminal blocks that denote the position of the thermocouple.

31.7.1 Thermocouples shall have weatherproof heads, with terminal blocks extending beyond the casing. For tube skin thermocouples, Seller shall supply sufficient wiring to allow termination of the thermocouples exterior to the casing.

31.7.2 Local Thermometers: Local indicating thermometers supplied with auxiliary Equipment shall be bimetallic type with 5 inch dials minimum. Local thermometers shall have adjustable angle dials. For high temperatures, or for remote mounting, thermometers shall be minimum 5 inch dial gas actuated thermometers.

31.7.3 Skid mounted instruments shall be furnished and installed as specified herein, including instrument valves, tubing, and enclosures as required. Instruments to be installed by Contractor shall be furnished loose. Pressure and differential pressure transmitters shall be furnished with manifolds and mounting brackets.

31.7.4 Instrument root valves tapped off the primary piping shall be provided by the Seller. Tubing, fittings, blowdown valves and heated instrument enclosures will be furnished by Contractor.

31.7.5 HART compatible transmitters shall be configured with a software tag compatible with the Contractor’s asset management system.

31.7.6 Calibration: All instrumentation shall be provided with a factory calibration. Certificates of calibration shall be submitted to Contractor for each instrument.

32. CONTROL SYSTEM:

32.1 The Seller shall provide a control system that will safely operate the SCR through all plant operating conditions. This control system will seamlessly integrate: tempering/purge air, ammonia vaporization/injection system, and system sequencing.

32.2 The SCR will be controlled from the plant Distributed Control System (DCS) furnished by the Contractor. The Seller shall provide documentation indicating the recommended methods for control and the system components. The documentation shall include all alarms, set points, trips, interlocks and directions for automatic sequencing of ramp rates required to achieve the life expectancy requirements identified in other sections of the contract.

32.3 Seller shall incorporate the following external inputs into the SCR control system:

a. SCR start-stop
b. Purge required
c. CEMS not in service
d. Stack NOx corrected to 15% O2
e. CTG fuel flow

32.4 Logic Diagrams: The documentation described above shall be furnished in the form of digital logic diagrams and analog SAMA diagrams. Both digital and analog logic diagrams shall be submitted for review. The logic diagrams shall be designed to provide automated startup, operation and shutdown of the SCR system. The Seller shall initiate detailed discussions with the Contractor in order to understand the control objectives, documentation format, and overall plant operation prior to initiating work on the digital and analog logic diagrams.

32.4.1 The digital and analog logic diagrams submitted shall be of a sufficient level of detail to provide programming instructions to the Plant DCS vendor for programming. All costs associated with supporting DCS factory acceptance testing at the DCS vendor’s facility of the Seller furnished logic shall be included in the contract price.

32.5 Control Narrative: In addition to the digital and analog logic diagrams described above, the Seller shall furnish a written description of the digital and analog logic diagrams. The written description shall be of a sufficient level of detail to allow the reader to understand the control philosophy of each controlled component.

END OF SECTION

SELECTIVE CATALYTIC REDUCTION
Engineering Design Requirements (EDR)

Description	Units	Quantity/Entry
1. General		
Quantity of SCR Systems = No. of CTs)	--	4
Fuel Sulfur	gr/100 dscf	
Fuel Sulfur of ULSD	ppmw	
Site Elevation	ft ASL	981
Seismic Data per ASCE 7-16		
Site Class	--	D
Mapped Spectral Response Accelleration Parameters	S_s=	0.045g
	S_1=	0.032g
Site Coefficients	F_a=	1.6
	F_y=	2.4
Occupancy Category	--	III
Seismic Importance Factor for Occupancy Category III	I=	1.25
Seismic Design Category	--	A
2. COMBUSTION TURBINE		GE LM6000
3. CT EXHAUST CONDITIONS AT MAX LOAD, NATURAL GAS FUEL		
Mass Flow	lb/hr	4,600,000
Gas Temperature	°F	1146
NOx	ppmvd @ 15% O2	9.0
CO	ppmvd @ 15% O2	4.0
VOC (as CH_4)	ppmvd @ 15% O2	1.0
SO_2	lb/hr	1.3
PM10/PM2.5 (front and back halves, USEPA Method 5/202 or 201A/202)	lb/hr	8.8
H_2SO_4	lb/MMBtu	TBD
CO_2	lb/hr	TBD
HCHO	ppbvd @ 15% O2	TBD
4. CT EXHAUST CONDITIONS AT MIN OPERATING LOAD, NATURAL GAS FUEL		
Mass Flow	lb/hr	2,800,000
Gas Temperature	°F	1160
NOx	ppmvd @ 15% O2	9.0
CO	ppmvd @ 15% O2	10.0
VOC (as CH_4)	ppmvd @ 15% O2	3.0
SO_2	lb/hr	0.8
PM10/PM2.5 (front and back halves, USEPA Method 5/202 or 201A/202)	lb/hr	8.0
5. CT EXHAUST CONDITIONS AT MAX LOAD, LIQUID FUEL - ULSD		
Mass Flow	lb/hr	NA
Gas Temperature	°F	NA
NOx	ppmvd @ 15% O2	NA
CO	ppmvd @ 15% O2	NA
VOC (as CH_4)	ppmvd @ 15% O2	NA
SO_2	lb/hr	NA
PM10/PM2.5 (front and back halves, USEPA Method 5/202 or 201A/202)	lb/hr	NA

SELECTIVE CATALYTIC REDUCTION
Engineering Design Requirements (EDR)

Description	Units	Quantity/Entry
H_2SO_4	lb/MMBtu	TBD
CO_2	lb/hr	TBD
HCHO	ppbvd @ 15% O2	TBD
6. CT EXHAUST CONDITIONS AT MIN OPERATING LOAD, LIQUID FUEL - ULSD		
Mass Flow	lb/hr	NA
Gas Temperature	°F	NA
NOx	ppmvd @ 15% O2	NA
CO	ppmvd @ 15% O2	NA
VOC	ppmvd @ 15% O2	NA
SO_2	lb/hr	NA
PM10/PM2.5 (front and back halves, USEPA Method 5/202 or 201A/202)	lb/hr	NA
7. OPERATING CONDITIONS:		
CT Exhaust Gas Temperature Ramp Rate	°F/min	
CT Exhaust Gas Temperature Variation at Catalyst Inlet	°F	
Exhaust Gas Flow Variation at Catalyst Inlet	% RMS	
Ammonia to NOx Ratio Variation at Catalyst Inlet for catalyst design	% RMS	15%
Ammonia to NOx Ratio Variation at Catalyst Inlet for SCR design	% RMS	by Seller
Alkali Metals in Fuel	ppmw	
Alkali Metals in DeNOx/turbine Water	ppmw	
Alkali Metals in Ammonia Reagent	ppmw	
8. EXPECTED OPERATING PROFILE		
Annual Operation	hrs/yr	877
Annual Starts	starts/yr	100
CT operating on Natural Gas	% of generation	100%
CT operating on Liquid Fuel	% of generation	0%
Typical dispatch mode	Daily / Long Term	Daily
9. GUARANTEED MAXIMUM EMISSIONS - NATURAL GAS (1-hour running average for CEMS measured pollutants)		
Minimum CT load where emissions gurantees are applicable	%	60%
NOx (USEPA Method 7E)	ppmvd @ 15% O2	2.0
CO (USEPA Method 10)	ppmvd @ 15% O2	3.0
VOC (as CH4) (USEPA Method 25A and 18)	ppmvd @ 15% O2	2.0
Ammonia (NH_3) Slip - Steady state operation (USEPA Method CTM-027 or 320)	ppmvd @ 15% O2	5.0
Ammonia (NH_3) Slip - Non Steady state operation (USEPA Method CTM-027 or 320))	ppmvd @ 15% O2	TBD
PM (front half filterable only, USEPA Method 5)	lb/hr	TBD or delete
PM10/PM2.5 (front and back halves, USEPA Method 5/202 or 201A/202)	lb/hr	10.0
H_2SO_4 (USEPA Method 8 or CTM-013)	lb/MMBtu	TBD
CO_2 (USEPA Method 3A or 40CFR98)	lb/hr	TBD
HCHO (USEPA Method 320)	ppbvd @ 15% O2	TBD
NOx Reduction Efficiency (based on inlet loading below)	%	78%

Description	Units	Quantity/Entry
Time to reach compliance (after CT reaches min load below)	minutes	15
10. GUARANTEED MAXIMUM EMISSIONS - ULSD (1-hour running average for CEMS measured pollutants)		
Minimum CT load where emissions gurantees are applicable	%	50%
NOx (USEPA Method 7E)	ppmvd @ 15% O2	TBD
CO (USEPA Method 10)	ppmvd @ 15% O2	TBD
VOC (as CH4) (USEPA Method 25A and 18)	ppmvd @ 15% O2	TBD
Ammonia (NH_3) Slip - Steady state operation (USEPA Method CTM-027 or 320)	ppmvd @ 15% O2	TBD
Ammonia (NH_3) Slip - Non Steady state operation (USEPA Method CTM-027 or 320))	ppmvd @ 15% O2	TBD
PM (front half filterable only, USEPA Method 5)	lb/hr	TBD
PM10/PM2.5 (front and back halves, USEPA Method 5/202 or 201A/202)	lb/hr	TBD
H_2SO_4 (USEPA Method 8 or CTM-013)	lb/MMBtu	TBD
CO_2 (USEPA Method 3A or 40CFR98)	lb/hr	TBD
HCHO (USEPA Method 320)	ppbvd @ 15% O2	TBD
Time to reach compliance (after CT reaches min load below)	minutes	TBD
11. GUARANTEED CATALYST LIFE		
Catalyst life performance guarantee period	hours	24,000
12. GUARANTEED STATIC PRESSURE DROP (SCR inlet to stack pressure drop port)		
Pressure drop without future catalsyst	in. w.c.	9
Pressure drop with future catalsyst	in. w.c.	
13. GUARANTEED NOISE REQUIREMENTS:		
Near Field Limit (3 ft distance and 5 ft above grade)	dBA	85
Far Field Limit (at 400 ft and 5 ft above grade) per casing	dBA	55
Far Field Limit (at 400 ft and 5 ft above grade) per stack	dBA	52
14. AIR DUCT DESIGN:		
Duct Material	--	A36 C.S
Duct Minimum Thickness	in	0.25
Finish paint/coating	--	Seller's Standard
15. GAS DUCT DESIGN:		
Casing Material	--	A36 C.S
Casing Minimum Thickness	in	0.25
Casing maximum external temperature	°F	140
Liner Material	--	409 SS
Liner Minimum Thickness - floor	ga	11
Liner Minimum Thickness - other	ga	14
Casing insulation thickness	in	6
Casing insulation type	--	8 lb/ft3 ceramic fiber
Maximum Exhaust Gas Temperature	°F	1200
Finish paint/coating	--	Seller's Standard
Expansion Joint between CTG Exhaust Duct and SCR inlet duct	--	By Purchaser
Expansion Joint between SCR and Stack	--	Included
Duct Material (by gas temperature)	≥ 750°F	409 SS
Duct Material (by gas temperature)	< 750°F	A36 CS (1/4" min)
16. SCR DESIGN:		
Catalyst design basis: NH3/NOx Distribution	% RMS	15%

SELECTIVE CATALYTIC REDUCTION
Engineering Design Requirements (EDR)

Description	Units	Quantity/Entry
Catalyst design basis: Bypass/leakage of gases around catalyst	%	1%
Orientation of SCR Reactor	Horizontal/Vertical	Horizontal
Construction type (Modular, C-Section, Harps)	--	Sellers Option
Location	Indoors/Outdoors	Outdoors
Casing Material	--	A36 C.S
Casing Minimum Thickness	in	0.25
Casing maximum external temperature	°F	140
Liner Material	--	409 SS
Liner Minimum Thickness - floor	ga	11
Liner Minimum Thickness - other	ga	14
Casing insulation thickness	in	4
Casing insulation type	--	8 lb/ft3 ceramic fiber
Maximum Exhaust Gas Temperature	°F	1200
Finish paint/coating	--	Seller's Standard
Number of catalyst future layers	--	
17. AMMONIA VAPORIZATION AND INJECTION SYSTEMS		
Ammonia type	Aqueous / Anhyd.	Aqueous
If Aqueous, concentration	%	19%
Type of vaporization	--	Hot Flue Gas
Quantity of hot gas or dilution air fans	--	2 x 100%
Quantity of inlet valves for gas or air fans	--	2
18. TEMPERING AIR SYSTEM		
Quantity of tempering air fans	# x %	3 x 50%
Location of termpering air fans	--	Outdoors
Motor Voltage/Phase/Hertz	--	
17. STACK DESIGN		
Stack damper to store residual heat	Yes/No	No
Height	ft	200
Diameter	ft	By Seller
Maximum Exhaust Gas Temperature	°F	1200
Minimum Stack Gas Temperature	°F	180
Stack Shell Material	--	A36 C.S
Stack Shell Minimum Thickness	in	0.25
Stack Shell Corrosion Allowance	in	0.125
Stack Shell maximum external temperature	°F	130
Liner Material	--	409 SS
Liner Minimum Thickness - floor	ga	11
Liner Minimum Thickness - other	ga	14
Stack Shell insulation thickness	in	4
Stack Shell insulation type	--	8 lb/ft3 ceramic fiber
Minimum Exit Velocity	ft/sec	60
Stack Damper	--	N/A
CEMS Platform	--	included
CEMS Platform minimum width	ft	3.5
CEMS Ports	--	
Number	--	2
Diameter	in	4
EPA Ports	--	
Number	--	4

Description	Units	Quantity/Entry
Diameter	in	6
Spare Monitoring Ports	--	
Number	--	2
Diameter	in	6
Port Location	--	
Minimum Distance from Downstream Disturbance	stack diameters	2.0
Minimum Distance from Upstream Disturbance	stack diameters	0.5
FAA Lighting	--	N/A
8. Field Services (option price)		
Erection Support	man-days	60
Commissioning / Startup	man-days	10
Operator Training	man-days	2

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
BM-01	Compiled Bill of Materials (in Excel format) including all subvendor equipment, appurtenances, etc.	8 weeks prior to Delivery			
CA-01	Exhaust Stack Design Calculations	8			
CN-01	System Control Philosophy Narratives (including Startup and Normal Operating Conditions) with detailed description of all permissives, alarms and trip set points for all devices. Deliverables shall not have network architecture drawings attached	14	*		
DA-01	Data Sheets - Catalyst	4			
DA-02	Motor Nameplate Data	8			
DA-03	Nameplate drawings including a nameplate voltage connection diagram for all electrical equipment	6			
DA-04	Motor thermal damage curve including each of the curves listed below and plotted on one graph: 1. Thermal limit curve at cold (ambient temperature) condition for locked rotor 2. Thermal limit curve at hot (operating temperature) condition for locked rotor 3. Thermal limit curve at cold (ambient temperature) condition for running overload 4. Thermal limit curve at hot (operating temperature) condition for running overload 5. Time-current motor acceleration curve at 110% of rated voltage 6. Time-current motor acceleration curve at rated voltage 7. Time-current motor acceleration curve at 90% of rated voltage 8. Time-current motor acceleration curve at 80% of rated voltage	6	*		
DA-05	Motor speed versus torque and current curves indicated at rated voltage, 90% of rated voltage, and 80% of rated voltage	6	*		
DA-06	Consecutive number of starts with the motor at ambient temperature and at operating temperature. Cool down time between starts with the motor at ambient temperature and at operating temperature.	6	*		
DA-07	Superimposed speed-torque curves for each motor driven equipment match. Speed-torque curves shall include the motor speed-torque curves at 80% of rated voltage and at 110% of rated voltage, superimposed on the driven equipment speed-torque curve during acceleration.	6	*		
DA-08	Motor Data - Parameters for relay settings including voltage imbalance limits and current imbalance limits	6	*		
DA-09	Motor Data - Winding and bearing temperature alarm and trip setpoints	6	*		
DA-10	Preliminary Motor Data Sheets per Section GR-B, including data sheets for any motor space heaters.	8	*		
DA-11	Final Motor Data Sheets per Section GR-B, including data sheets for any motor space heaters.	16	*		

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
DA-12	Preliminary Stack Foundation Load Table/Requirements (Dead/Live Weight, COG, Wind, Thermal, Seismic), Anchor Bolts, and Baseplate Details. Must be sealed/stamped by a P.E. registered in the jurisdiction of the project.	8	*		***
DA-13	Final Stack Foundation Load Table/Requirements (Dead/Live Weight, COG, Wind, Thermal, Seismic), Anchor Bolts, and Baseplate Details with Seismic Calculations for foundation design. Must be sealed/stamped by a P.E. registered in the jurisdiction of the project.	12	*		***
DA-14	Detailed termination connection details for all Buyer wiring terminations (e.g. terminal blocks, breakers, bolted connections, grounding lugs, bus bar, etc.) including, but not limited to: a. Minimum wire size b. Maximum wire size c. Maximum number of wires d. Termination type (e.g. screw clamp, ring lug, spring-cage, push-in, NEMA hole pattern, etc.)	10			
ES-01	Electrical schematic drawings including, but not limited to following: a. All electrical, protection, and control related logic with input/output assignments b. Relay and metering drawings c. Plant interface drawings for alarm and indication d. Terminal information with tag assignments including all auxiliary contact details	10	*		
ES-02	All electrical wiring diagrams needed by Buyer to complete electrical and controls design. Wiring diagrams shall include, but not limited to following: a. Interconnecting diagrams for internal and external wiring with termination details for all electrical devices (electrical panels, control panels, lighting, receptacles, control switches, disconnect switches, junction boxes, instruments, valves, actuators, motors, etc.) b. All wiring by Seller, Buyer, or other party shall have clear identification to distinguish installation responsibility	10	*		
ES-03	Electrical drawings to complete power and control interface wiring for instrument, valves, actuators, etc. including, but not limited to following: a. Elementary diagrams showing control logic with input/output assignment b. Terminal designations and termination layout drawings c. Electrical schematics for motor operated valves	10	*		
ES-04	Electrical drawings to complete motor power and control wiring including, but not limited to following: a. Wiring scheme with clearly defined requirement of shield wires for bearing, thermocouple, winding RTDs, etc. b. Wiring diagram with terminal designation c. Motor space heater connections diagram including voltage and power ratings	10	*		
ES-05	Electrical grounding requirements	4	*		

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
GA-01	Preliminary Outline/General Arrangement Drawings containing the following information at a minimum: -Not to exceed overall dimensions and not to exceed overall weights -Equipment and panel tag numbers -North arrow -All terminal point locations for piping -Access, maintenance, and equipment pull spaces, with dimensions and orientation -Location and overall size dimensions for all electrical equipment (e.g. Devices: motors, instruments, disconnects; Panels: electrical, relay, control, PLC; Wiring Terminal Boxes: motor power, RTD, vibration, heater, MOV; Instrument Junction Boxes; Control Cabinets; etc.) -Ground pad and ground lug locations -Designated clear space under all electrical devices (e.g. panels, terminal boxes, etc.) for conduit access -Electrical working spaces with dimensions and orientation as required by electrical code -Hazardous area classification rating, if applicable -Center of gravity -Not to exceed static and dynamic loads per Section S1 to complete detailed structural and equipment interface designs (+15%/-0%), indicate on drawing margins used -All details related to the attachment of the equipment to the foundation or supporting structure, such as anchor bolt locations and details, skid/frame flange and/or baseplate thickness, grouting requirements, etc. -Platforms/stairs/ladders (if applicable to scope of supply)	4	*		
GA-02	Final Outline/General Arrangement Drawings containing the following information at a minimum: -Overall dimensions and overall weights -Equipment and panel tag numbers -North arrow -All terminal point locations for piping -Access, maintenance, and equipment pull spaces, with dimensions and orientation -Location and overall size dimensions for all electrical equipment (e.g. Devices: motors, instruments, disconnects; Panels: electrical, relay, control, PLC; Wiring Terminal Boxes: motor power, RTD, vibration, heater, MOV; Instrument Junction Boxes; Control Cabinets; etc.) -Ground pad and ground lug locations -Designated clear space under all electrical devices (e.g. panels, terminal boxes, etc.) for conduit access -Electrical working spaces with dimensions and orientation as required by electrical code -Hazardous area classification rating, if applicable -Center of gravity -Static and dynamic loads per Section S1 to complete detailed structural and equipment interface designs -All details related to the attachment of the equipment to the foundation or supporting structure, such as anchor bolt locations and details, skid/frame flange and/or baseplate thickness, grouting requirements, etc. -Platforms/stairs/ladders (if applicable to scope of supply)	10	*		
GA-03	Erection/Installation Drawings for all equipment, including shipped-loose components such as piping isometrics, etc. Must be sealed/stamped by a P.E. registered in the jurisdiction of the project.	16			***
GA-04	Preliminary 3D Model(s) per Section GR-B	6			

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
GA-05	Updated 3D Model(s) per Section GR-B	Monthly			
GA-06	Detailed arrangement drawings for all electrical equipment (e.g. Devices: motors, analyzers, disconnects; Panels: electrical, relay, control, PLC; Wiring Terminal Boxes: motor power, RTD, vibration, heater, MOV; Instrument Junction Boxes; Control Cabinets; etc.). Drawings shall include but not be limited to the following: a. Layout with front, rear, side, and top view. Shall include dimensions for overall size, cutout locations, cutout sizes, conduit entry locations, and conduit entry sizes. b. Indication of corresponding BOM item c. Internal panel layout including terminal and device arrangement. d. Tags for all terminal blocks, terminal numbers, device tags, etc. e. Electrical device and enclosure hazardous area classification rating, if applicable f. NEMA classification	10	*		
GA-07	Detailed connection drawing for all bolted connections (e.g. bus bar, iso-phase, non-seg, ground pads, lugs, bushing, lightning arrestors, etc.). Drawing shall contain the following information at a minimum: a. Dimensions including location and size of all bolted connections b. Flange details including dimensions for overall size, bolt locations, bolt sizes, etc. c. Clearance requirements with dimensions	10	*		
GA-08	Detail/Sectional Drawings with Parts List - Motor General Arrangement and Outline Dimension Drawings showing the following at a minimum: -Motor dimensions -Shaft dimensions -Mounting dimension clearances -Rotor and coupling end float limits -Approximate motor weight -Total motor weight	4			
GA-09	Detail/Section Drawings with Parts List - Stack assembly with elevation view	16	*		
HV-01	Cumulative Equipment Package and Individual Equipment heat rejection/loss to ambient air at maximum operating load (for HVAC sizing purposes)	4	*		
IN-01	Instrument data sheets for every instrument/device furnished by the Seller, including the following information at a minimum: -Tag numbers -Service description -Calibration range -Instrument range -Length of probes -Manufacturer's make and model number -Serial number Each unique instrument type shall have its own dedicated, project-specific data sheet submitted; generic catalogue cut sheets are not acceptable for the intent of this submittal. Buyer will provide blank data sheets upon Seller request.	16	*		
IN-02	Full versions of cut sheets for each instrument furnished by the Seller that include the model number breakdown	16			
IN-03	Factory Calibration Certificates for Instrumentation	4 weeks prior to Delivery	*		

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
IN-04	Instrumentation Location Plan - both Plan and Elevation views	16			
LT-01	Spare Parts List (in Excel format) including unit pricing per Section GR-B	24			
LT-02	Drawing List Categorized by Engineering Discipline and Cross Referenced to the Line Numbers Stated Herein per Section GR-B, including document number and title for each document	4			
LT-03	Updated Drawing List Categorized by Engineering Discipline and Cross Referenced to the Line Numbers Stated Herein per Section GR-B, including document number and title for each document	Monthly			
LT-04	List of Compressed Air Users - to include equipment tag number, usage rate (SCFM), and location (coordinates/elevation)	8	*		
LT-05	I/O List (in Excel format) per Section GR-B, including: -Range and engineering units for all signals to DCS -Alarm and Shutdown Levels -DCS Side Terminations	12			
LT-06	Mechanical Connection List including at a minimum the following for all terminal/interface points/connections: -All sizes, materials, and interface types/ratings, including pressure classes, connection types, and schedules -Process information such as maximum/minimum/normal design flows, temperatures, and pressures -Coordinates/orientations -Interconnection tag numbers -Pressure drops and heat loads for cooling water	4	*		
LT-07	Preliminary electrical load list shall include all electrical equipment ratings including, but not limited to the following: a. Nominal operating voltage (AC/DC) b. Phase(s) (3-Phase/1-phase as applicable) c. Efficiency and power factor d. Power requirements (kW/kVA/FLA as applicable)	4	*		
LT-08	Final electrical load list shall include all electrical equipment ratings including, but not limited to the following: a. Nominal operating voltage (AC/DC) b. Phase(s) (3-Phase/1-phase as applicable) c. Efficiency and power factor d. Power requirements (kW/kVA/FLA as applicable)	8	*		
LT-09	Equipment List (in Excel format) per Section GR-B	4			
LT-10	Line List (in Excel format) per Section GR-B	12			
LT-11	Valve List (in Excel format) per Section GR-B	12			
LT-12	Specialties List (in Excel format) per Section GR-B	12			
LT-13	Instrument List (in Excel format) per Section GR-B	16			

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
MP-01	Piping - Plan View (Including Customer Connections)	18			
MP-02	Piping - Right Side Elevation (Including Customer Connections)	18			
MP-03	Piping - Left Side Elevation (Including Customer Connections)	18			
MP-04	Interconnecting Piping Detailed Isometrics	12			
PA-01	Paint/Coating/Lining application procedures with manufacturer's data sheets and inspection forms	8			
PA-02	Finish Coat Color Schedule	8			
PA-03	Coating Test Report Results	1 week after Test			
PD-01	Piping and Instrumentation Diagrams (P&ID) showing all equipment, piping, instrumentation and controls, connection/interface points, and associated tagging for a complete, code compliant, and ready to operate system.	6	*		
QC-01	Quality Manual and ISO 9001 Certificate, including all Sub-suppliers	4			
QC-02	Quality Record Matrix per Special Conditions	6			
QC-03	Project Specific Inspection and Test Plan including all Sub-suppliers	4			
QC-04	Supplier Notification Form (SNF) for each Witness and Hold Point identified on the Project Specific Inspection and Test Plan.	21 days prior to Test			
QC-05	Non-Conformance Reports with Proposed Disposition	Within 24 hours of Discovering Non-Conformance			
QC-06	AISC Certificate	4			
QC-07	Material Test Reports (MTR) traceable to material heat or cast segregated by individual tag numbers, or traceable to material heat by individual components. All MTR shall specify Country of Origin.	8			
QC-08	Motor test reports including complete nameplate information and patterned after IEEE Std. 112	6			
QC-09	Structural Steel Material Test Reports (MTR) - consistent with approved fabricator identification procedures and in accordance with AISC 303, Section 6.1. At a minimum each MTR shall specify Country of Origin.	2 Weeks After Delivery to Site			
RE-01	Manufacturer's Standard O&M Manual(s) per Section GR-B	8			

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
RE-02	Recommended Maintenance Schedule, which shall include (but not be limited to) the following: -Predictive or preventative maintenance program -Servicing procedures for dismantling and/or replacing components -Routine electrical and mechanical procedures -Any tests/checks for cleaning, lubricating, and otherwise caring for the Equipment -Instrument calibration -Maintenance of interlocks and other applicable safety features	12			
RE-03	Digital photographs of all Buyer termination points clearly showing both the Buyer's side and Seller's side wiring, terminal block labels, terminal labels, and wiring labels. Photographs shall be submitted before equipment is shipped.	6 weeks prior to Delivery	*		
RE-04	Freeze protection requirements (min allowable ambient temperature, max exposure temperatures, min maintained process temperature, etc.) for any Seller provided equipment. Note acceptable type of freeze protection system.	4			
RE-05	Heat Tracing quantities: List of Components on equipment skid, lines including piping size and approximate lengths, class and size for all flanges and valves, factory routed tubing lengths, and inline items: specialties, instrumentation, etc. Note acceptable type of freeze protection system. Any information not available during initial submittals shall be submitted on as-built drawings before shipment including pictures of completed skids.	4			
RE-06	Pre-Operational Cleaning Guidelines	2 weeks prior to Delivery			
RE-07	All requirements for Unloading, Receiving, Handling, and Long and Short Term Storage per Section GR-B	24			
RE-08	Preliminary Field Erection Procedure Manual	6 months prior to Delivery			
RE-09	Final Field Erection Procedure Manual with detailed Erection Drawings	4 months prior to Module Delivery			
RE-10	Cut Sheets - Control Valves (Steam, Feedwater, Motor Operated Valves, Level Control Valves, etc.)	10			
RE-11	Cut Sheets - all manual and control valves	8			
RE-12	Insulation Details/Specifications for all Seller-provided equipment and piping	12			
RE-13	Complete Logistics and Transportation Plan detailing all of the steps EXW factory, including a detailed Method Statement when any of the following modes of transportation are applicable: (i) Air; (ii) Barge; (iii) Ocean; (iv) Rail; and (v) Over the Road (Heavy Haul).	8	*		
RE-14	Final O&M Manual (including but not limited to Final As-Builts, Test Reports, MTRs, Records produced by ITP, etc.) for the entire scope of the Seller's design.	4 weeks after Delivery	*		
RE-15	Dynamic Thermal Analysis	20	*		
RE-16	Gas Side CFD Flow Model Study Results	20	*		

SELLER'S DELIVERABLE SCHEDULE (SDS)

Selective Catalytic Reduction (SCR)		For specific dates associated with the durations specified herein, see the Contract.			
		Kiewit Spec:	94.03.30.175.02		
Line No.	**Engineering Submittal Description/Title**	**Date Due Weeks After Award**	**LD**	**Cyber Security**	**P.E. Stamp**
SH-01	Engineering/Procurement/Production/Fabrication/Shipping Schedule per Section GR-B.	2			
SH-02	Updated Engineering/Procurement/Production/Fabrication/Shipping Schedule per Section GR-B.	Monthly			
ST-01	Dimensions, weights, configurations, and details of steel construction/fabrication for overall structure and all steel members and connections including but not limited to: -Structural framing members -Base plates -Anchor bolts -Stairs -Ladders -Guard rails -Metal grating -Metal deck -Fall restraint systems	6			
ST-02	Joint Details, Material of Construction for Structural Welds, and Installation Requirements for Structural Bolted Connections	60 days prior to Delivery of Structural Steel			
ST-03	Module Lifting Sled Drawing/Detail	6 weeks prior to Initial Delivery			

*Liquidated Damages apply
**Cyber Security applies
***P.E. Stamp required from a P.E. licensed in the jurisdiction of the project

APPENDIX A

GAS TURBINE PERFORMANCE

APPENDIX B

SCR SYSTEM PERFORMANCE GUARANTEES

SCR SYSTEM PERFORMANCE GUARANTEES

1. EMISSIONS: The Seller shall guarantee emissions of the SCR/CO system in accordance with the SCR Engineering Design Requirements (EDR). Stack testing or the certified CEMS monitoring equipment will be used to verify emissions. The Seller shall correct, at the Seller's expense, Equipment that does not meet the specified guarantees due to reasons caused by the Seller.

The Seller is responsible for providing SCR and CO catalysts such that stack emissions will remain in compliance with the emissions guarantees as stated in the SCR EDR. The stack emissions shall remain in compliance at all combustion turbine loads shown in Appendix A at any site ambient condition from minimum to maximum.

Guarantees shall be based upon the combustion turbine exhaust data given in Appendix A.

VOC emissions are defined as total hydrocarbons excluding methane and ethane and are expressed in terms of methane.

Seller shall not be responsible for start-up emissions when post combustion air pollution control equipment is not able to be in operation. Seller shall be responsible for start-up emissions when the SCR catalyst temperature is greater than the minimum catalyst temperature required for ammonia injection.

2. PRESSURE DROP: Total pressure drop is defined as the static gas-side pressure loss from the SCR ductwork inlet to the exhaust stack inlet, including the inlet duct, distribution grid, CO catalyst Bay, SCR catalyst, and exhaust stack. The SCR stack temperature will be measured utilizing a stack traverse at or near the stack outlet. Ports for the stack traverse shall be supplied by Seller.

The total pressure drop corrected to the guarantee point volumetric flow shall not exceed the value specified in the SCR EDR.

END OF SECTION

APPENDIX C

CTG INTERFACE DETAILS

APPENDIX D

CTG FUEL SPECIFICATION

MASTER SPECIFICTION
FOR

600 Volt Non-Segregated Phase Bus Duct

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
12-10-2014	1.0	New

600 VOLT NON-SEGREGATED PHASE BUS DUCT

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

GENERAL

DESCRIPTION

****
Insert project-specific description items (i.e. new construction project, replacement project, project location, etc.). Revise the following *example* as required:
****

The 600 V non-segregated phase bus duct shall be designed and constructed for use on a 480 V, 3-phase, 60 hertz, high-resistance grounded, delta system.

Bus duct provided under these Specifications shall include all fittings, bus-to-equipment terminations, supports, flexible connectors, accessories, connection hardware and any special tools required for a complete installation.

SUMMARY

Reference Drawings

The following drawings, included in Appendix 4, contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Bus Duct Layouts
- Transformer Connection Details
- Switchgear Connection Details

Technical Proposal Documentation

See Appendix 2 for technical proposal requirements.

APPLICABLE CODES AND STANDARDS

- State and local codes, laws, ordinances, rules and regulations
- ANSI – American National Standards Institute
- ASTM – American Society for Testing and Materials
- ICEA – Insulated Cable Engineers Association
- IEEE – Institute of Electrical and Electronic Engineers
- NEMA – National Electrical Manufacturer's Association

- NFPA – National Fire Protective Association
- OSHA – Occupational, Health and Safety Administration
- UL – Underwriter's Laboratories

In the event of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

DESIGN & CONSTRUCTION FEATURES

1. **Environmental**

   Non-segregated bus duct shall be manufactured to withstand site environmental conditions. See Appendix 4 for site specific environmental conditions.

2. **Ratings**

   Non-segregated bus duct ratings shall be as specified in Appendix 2 Data Sheets.

BUS CONSTRUCTION

1. Bus duct construction shall be in accordance with IEEE C37.23.

2. Bus duct shall be furnished as a complete assembly of rigidly supported conductors, housed in a 3-phase enclosure without barriers between the phase conductors.

3. The bus conductors shall be copper and shall be designed to carry rated continuous current without exceeding the temperature rise requirements specified by IEEE and NEMA standards.

4. The current carrying capacity shall be based on actual service conditions including skin and proximity effects, the effects of the bus insulation, the bus duct enclosure, and ambient temperature.

5. The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the momentary current.

6. All bus duct shall have fully insulated conductors and conductor joints. All phase conductors shall be insulated via fluidized bed epoxy coating except at bolted terminations and connection points. Insulating materials shall be water resistant, flame retardant and rated for continuous operation at 105°C. The insulation level of the combined system shall meet or exceed IEEE C37.23 requirements.

7. All bolted joints, expansion joints, and bus connections shall have insulated, removable boots with nylon fasteners. Removable boots shall overlap bus bar insulation on each conductor insulated by the boot. The length of overlap on each conductor shall not be less than 2 inches at expansion joints and not less

than 1 inch at other connections.

8. All bus conductor connections shall be bolted with silver-plated connection surfaces having minimum contact resistance.

9. Expansion joints shall be furnished, where required, to prevent mechanical stress in bus supports and connections throughout the ambient temperature range listed in Appendix 4.

EQUIPMENT TERMINATIONS

1. Braided flexible connectors and bus duct termination enclosures/fittings shall be provided for bus-to-equipment terminations.
2. Removable, flexible, braided connectors shall be supplied to provide electrical insulation between bus duct and equipment, to isolate equipment vibration and to facilitate equipment removal.
3. Flexible connectors shall have a continuous current rating equal or greater than bus conductors.

BUS ENCLOSURE

1. Indoor sections of bus duct shall be furnished with non-ventilated dust-tight enclosures. Outdoor sections of bus duct shall be furnished with non-ventilated weatherproof enclosures with gasketed, peaked top covers.
2. Bus enclosures shall be fabricated from aluminum not less than 1/8-inch thick.
3. Wall flanges and airtight vapor barriers shall be furnished at each transition from indoor to outdoor bus duct.
4. Fire barriers shall be provided in accordance with NFPA. As a minimum, 2-hour rated fire barriers shall be provided where bus duct penetrates firewalls and building walls.
5. Enclosure finish shall be light gray per ASTM D1535.

SPACE HEATERS

1. Outdoor bus duct sections shall be furnished with space heaters to prevent condensation of moisture within the bus duct.
2. Space heater capacity shall be as required to maintain the compartment and the bus duct internal temperature above the dew point shown in Appendix 4.
3. Heaters shall be located and thermally insulated to prevent painted surface or bus insulation damage, degradation or discoloration.
4. Heaters shall be rated at 240 VAC and be rated for operation at 120 VAC.
5. Space heaters shall be controlled by an adjustable thermostat, factory set to account for site conditions listed in Appendix 4.

GROUND BUS

1. An integral ground bus shall be furnished in accordance with IEEE C37.23.
2. Provisions to ground the ground bus to the station grounding system shall be provided at every terminal end of bus duct runs, at each indoor-to-outdoor transition and at every equipment termination.

INFRARED INSPECTION VIEWING PANES

1. Infrared (IR) inspection viewing panes (ports) shall be installed to permit thermography inspection of equipment connections. IR ports shall be oriented to allow inspection from ground level.
2. IR ports shall provide a NEMA rating equal to, or greater than, that of the enclosure in which it is installed.
3. IR ports shall be NFPA 70E compliant.
4. IR ports shall be 3” minimum diameter and shall consist of reinforced polymeric optic material with removable protective covers.

OUTDOOR BUS DUCT SUPPORTS

1. Supports shall be ASTM A36 carbon steel and shall be designed to withstand environmental loads (wind, snow, seismic, etc.) listed in Appendix 4.
2. Support spans shall be 12 feet or less.
3. Finish
    a. Supports shall be galvanized by the hot dip process in accordance with ASTM A-123 except that all shapes shall receive 3.0 ounces of zinc per square foot of surface area. Supports are to be galvanized both inside and out after all cutting, punching, welding and cleaning have been completed.
    b. Finished galvanized surfaces must be uniform in color, appearance and texture and must be free of excessive roughness, pimples, lumpiness and runs.
4. Each support shall have a NEMA 2-hole ground pad located at its base.
5. Support locations shall meet NEC working clearance requirements and shall be at least 3 feet from equipment to allow maintenance access.
6. Support locations shall be reviewed with Company to ensure unobstructed clearance for doorways, forklift access, roadway access, personnel egress and headroom prior to installation.

INDOOR BUS SUPPORTS

1. Indoor supports shall be galvanized steel and designed to be supported from overhead building steel.
2. Support spans shall be 12 feet or less.
3. Support locations shall meet NEC working clearance requirements and shall be at least 3 feet from equipment to allow maintenance access.
4. Support locations shall be reviewed with Company to ensure unobstructed clearance for doorways, forklift access, personnel egress and headroom prior to installation.

TESTING

Testing requirements are defined in Appendix 6.

DELIVERABLES

Deliverable requirements are defined in Appendix 1.

PROPOSAL DATA REQUIREMENTS

Seller shall provide proposed equipment data in accordance with Appendix 2.

SITE CONDITIONS

Site conditions are defined in Appendix 4.

QUALITY ASSURANCE

QA/QC requirements are defined in Appendix 5.

PACKAGING STORAGE & SHIPPING

Packing, shipping storage requirements are defined in Appendix 7.

PERFORMANCE GUARANTEES

****
Fill in Appendix 3 as required
****

SOUND CONTROL REQUIREMENTS

****
Fill in as required
****

INSTRUMENTATION & CONTROL REQUIREMENTS

****
Fill in as required
****

MATERIALS & WELDING

****
Fill in as required and revise Appendix 5 accordingly.
****

CLEANING, PAINTING & COATING

****
Fill in as required and revise Appendix 5 accordingly.
****

SPARE PARTS
****
Fill in as required
****

APPENDICES TO SPECIFICATION

****
Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE MANUFACTURERS

APPENDIX 1

DELIVERABLES

****
The following is a list of minimum suggested deliverables and deliverable information. Revise per project requirements as required:
****

Manufacturer drawings:

1. Bus duct plan and elevation drawings showing phasing arrangement, weights and detailed dimensions.
2. Bus duct connection details.
3. Schematics and wiring diagrams showing customer connections for bus duct heaters.
4. Bus duct support types, details, anchor bolt plan, and support locations.
5. Bus duct nameplate data.

Test data:

1. Factory and field test data/test report. See Appendix 6 for details.

Operation and Maintenance Manuals:

1. Operation and maintenance (O&M) manuals shall include the following minimum information:
   a. Installation instructions.
   b. Operating instructions.
   c. Maintenance instructions.
   d. Nameplate data.
   e. Assembly drawings.
   f. Bill of Material with vendor part numbers.
   g. Recommended spare parts list.
   h. Certified (final) test reports
   i. Storage and Handling instructions.
   j. Special tools required for installation, operation and/or maintenance.
   k. Warranty Information

QA/QC:

Seller's QA/QC Inspection and Test Plan (ITP)

****
Include project-specific requirements for the following:
****

- Seller Deliverable Schedule
- Deliverable Format
- Deliverable Quantities

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

600V NON-SEGREGATED BUS DUCT DATA SHEET

Seller shall provide the following minimum technical data applicable to the equipment in the proposed scope of supply.

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

600V NON-SEGREGATED BUS DUCT	UNITS	REQUIREMENTS	SELLER RESPONSE
Manufacturer		Seller	
City & Country of Manufacture		Seller	
Duty Cycle		Continuous	
ELECTRICAL PARAMETERS:			
Bus Conductor Material		Copper	
Enclosure Material		Aluminum	
Rated Nominal Voltage	kV	0.48	
Rated Maximum Voltage	kV	0.635	
Operating Frequency	Hz	60	
Rated Continuous Current at Max Ambient	A	3000	
Power Frequency Withstand (1 min., dry)	kV, RMS	2.2	
Rated Momentary Current (10 cycle, asym.)	kA, RMS	78	
Rated Short-Time Current (1 sec, sym.)	kA, RMS	69	
Rated Temp Rise Above Max Ambient	°C	65	
Total Electrical Loss at Rated Current	Watts/3-phase foot	Seller	
FINISH			
Color		ASTM D1535, Light Gray	

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

600V NON-SEGREGATED BUS DUCT

****
The following additional information shall also be included with proposals:

1. Seller variances or exceptions to the specification.
2. Itemization of proposed estimated materials.
3. Add/deduct pricing for bus duct cost per lineal foot, each type of bus duct fitting, and flexible connectors.

****

APPENDIX 3

PERFORMANCE GUARANTEES

****
Typically, non-segregated phase bus systems do not have performance guarantees associated with them. However, consider all project-specific requirements to determine the applicability of this Appendix.
****

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

****
In addition to revising this spec to correspond to project-specific requirements, update all Appendix highlighted areas with project-specific data.
****

SITE CONDITIONS

LOCATION

Xcel Energy's Cherokee Station site is located in Adams County, CO at 6198 Franklin St.   Denver, CO 80216.

METEOROLOGICAL DATA

Table 1 below lists the major site conditions which are based on ambient weather conditions taken from several data references. The following abbreviations apply to this table:

DBT: Dry Bulb Temperature

MCWB: Mean coincident wet bulb for a given dry bulb temperature

AMSL: Above Mean Sea Level

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

TABLE 1 – MAJOR SITE CONDITIONS

PARAMETER	DATA
Site Elevation	5131 feet AMSL
Site Ambient Conditions	
Record low dry bulb temperature: MCWB for record low DBT:	-29°F -29°F
99% winter design dry bulb temperature: MCWB for 99% winter design DBT:	-5°F -8°F
Average winter dry bulb temperature: MCWB for average winter DBT:	-35°F -29°F
Annual average dry bulb temperature: MCWB for annual average DBT:	50°F 39°F
Summer 1% dry bulb temperature: MCWB for summer design 1% DBT: (Comparable to ASHRAE cooling, 0.4% occurance)	95°F 70°F
Record high dry bulb temperature: MCWB for record high DBT:	105°F 72°F
Dry bulb temperature for ISO System Accrediation: MCWB for ISO System Accrediation DBT:	95°F 70°F
Relative Humidity Range	0% to 100%
Annual Average Percipitation	18 inches
Maximum 24 Hour Rainfall Total	3 inches
Annual Average Snowfall	60 inches
Maximum 24 Hour Snowfall Total	48 inches

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

WIND LOADING

Wind loads shall be in accordance with the IBC. Basic wind design parameters are as follows:

DESCRIPTION	CHEROKEE	NOTES
Classification of Structure Category	III	Ref. ASCE 7-05, Section 1.5
Exposure	C	Ref. ASCE 7-05, Section 6.56
Wind Importance Factor	1.15	
Reference Wind Velocity, V	90 mph	3 sec. gust @ 33 ft. above ground. Ref. ASCE 7-05

SEISMIC CRITERIA

Structures shall be designed using the seismic criteria in the IBC as applicable to Colorado. Basic seismic parameters, per the IBC, are as follows:

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration at a short period (0.2 seconds), $S_s = 0.217g$.

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration a 1 second period), $S_s = 0.056g$.

Seismic Importance Factor, $I_E = 1.25$.

Based on the information presented in the Geotechnical Report, the project site has been assigned to Site Class D, to be verified by a site-specific geotechnical report.

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

REFERENCE MATERIALS

The following drawings contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Bus Duct Layouts
- Transformer Connection Details
- Switchgear Connection Details

APPENDIX 5

QA/QC (Including Inspection Test Plans)

****
Revise this Appendix accordingly per project-specific requirements.
****

QA/QC

INSPECTION AND TEST PLANS

Seller shall submit their standard Inspection and Test Plan (ITP) for approval in accordance with Appendix 1 requirements.

QA/QC INSPECTIONS/REPORTING

****
Determine frequency of Xcel inspections of Seller's facilities during fabrication, prior to delivery, etc. and add requirements to this section as required. Review Xcel Intranet QA/QC Toolbox for various tools and templates for the following, as project requirements dictate:

- Shop inspection reports
- Non-conformance reports
- Release for shipment, etc.

Add these documents to this Appendix as required.
****

APPENDIX 6

STARTUP, TESTING AND COMMISSIONING

****
The following are minimum suggested testing requirements. Revise per project requirements as required:
****

Factory Testing:

1. Perform standard factory tests in accordance with IEEE C37.23.
2. Submit test data/test reports in accordance with Appendix 1.

Shop Tests:

1. Perform standard shop tests in accordance with IEEE standards.

****
Depending on project requirements, determine whether factory field support is required to startup/commission non-seg bus systems. Minimum commissioning considerations are as follows:

- Construction/installation inspections
- International Electrical Testing Association (NETA) standard field tests (e.g. bus high potential testing, etc.)
- Anti-condensation system/controls commissioning

****

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

<u>PACKAGING, SHIPPING AND STORAGE</u>

Seller shall prepare equipment for shipment following successful completion of factory testing and resolution of QA/QC non-conformances (see Appendix 5 for additional details.

Seller shall prepare equipment to withstand any possible damage or loss due to rough handling or exposure to weather during transit or extended outdoor storage (up to two (2) years).

Seller shall install all required covers to protect equipment from rain, hail, wind, dust, snow and environmental conditions detrimental to the equipment.

Equipment shall be adequately sealed and protected during shipment to prevent corrosion, foreign matter egress and freeze damage which could result from the presence of residual water.

Lifting points and centers of gravity shall be clearly marked on the shipped equipment.

Shipping structural bracing shall be installed as required to allow for field handling, skidding and hoisting.

Equipment supplied with space heaters shall have heater leads accessible without requiring disassembly of shipping containers.

Threaded outlets shall have plugs or caps installed prior to shipping.

Ancillary materials which are “shipped loose” shall be in separately boxed and re secured to the main equipment containers.

Seller shall provide the following minimum unloading/handling information:

- Shipping weight and dimensions of each article
- Pick points
- Rigging requirements
- Weight distribution
- Center of gravity
- Sensitivities
- Hazards

A QA/QC inspection certification, signed by the Seller shall be issued to the company prior to shipment. A copy of this certificate shall be included with the Bill of Lading.

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

Shipping documentation shall include the following minimum information:

- Company Destination (Plant, Unit)
- Company Agreement number
- Sellers order number
- Date shipped
- Shipping origin
- Company equipment tag information
- Seller’s equipment identification information
- Shipment tracking information
- Shipment description
- Shipment quantity
- Gross weight
- Special handling requirements
- Identification of spare equipment
- Barcode, RFID, or similar material control information

Seller shall coordinate all deliveries with Company prior to shipment. Coordination shall include resolution of QA/QC non-conformances, delivery schedule, unloading/handling requirements, and storage requirements.

APPENDIX 8

ACCEPTABLE MANUFACTURERS

****
The following list contains the typically preferred manufacturers. Coordinate with Xcel Sourcing to determine final bid list:
****

Acceptable manufacturers are as follows:

- Azz-Calvert
- Eaton Cutler-Hammer
- Delta-Unibus
- Technibus

MASTER SPECIFICTION
FOR
4160 Volt Non-Segregated Phase Bus Duct

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
12-5-2014	1.0	Enhancements; Required Format

4160 Volt Non-Segregated Phase Bus Duct

GENERAL

DESCRIPTION

The 4160V non-segregated phase bus duct shall be designed and constructed for use on a 4160V, 3-phase, 60 Hertz, 3-wire, resistance grounded (2.4 ohm) system.

All indoor and outdoor bus duct, including fittings, bus duct supports, and conductor flexible conductors shall be furnished in accordance to these Specifications.

One 4160V bus duct shall be required from each auxiliary power transformer secondary flange connection of each unit auxiliary power transformer to a Switchgear lineup or Secondary Unit Substation, etc.

SUMMARY

Bus Duct Layout

Refer to the site layout and powerhouse layout drawings for location and orientation of powerhouse and auxiliary power transformer equipment.

The following estimated bus duct lengths, number of supports, and fittings may be used for bidding purposes (per bus duct run).

- Outdoor bus duct length/run –
- Indoor bus duct length/run –
- Fittings (quantity) –
- Outdoor supports (quantity) / run –

Include separate additional add/deduct pricing in proposal for elbows and a cost per foot of bus for final price adjustments.

Reference Drawings

The following drawings are being submitted as part of this specification:

- Bus Layout
- One-Line Diagram
- Three-Line Diagram
- Site Layout
- Aux Transformer Outline
- 5kV Non-Seg Bus Auxiliary Transformer

Technical Proposal Documentation

The following information shall be included with the bid proposal:

- Any variances or exceptions which the Manufacturer has to the specifications
- Attached data sheets to be filled-out as completely as possible
- Estimated materials
- Manufacturer's literature pertinent to proposed equipment.

Approved Manufacturers

- Delta-Unibus
- Calvert/AZZ
- Cutler-Hammer
- ABB
- Square D

APPLICABLE CODES AND STANDARDS

- State and local codes, laws, ordinances, rules and regulations
- ANSI – American National Standards Institute
- ASTM – American Society for Testing and Materials
- ICEA – Insulated Cable Engineers Association
- IEEE – Institute of Electrical and Electronic Engineers
- NEMA – National Electrical Manufacturer's Association
- NFPA – National Fire Protective Association
- OSHA – Occupational, Health and Safety Administration
- UL – Underwriter's Laboratories

In case of conflict or disagreement between codes and standards, the most stringent conditions shall govern.

TECHNICAL REQUIREMENTS

Design & Construction Features

1. **Environmental**
   The following ambient and site conditions shall be used in the design of all furnished equipment:
   - Site Location
   - Site Elevation, Feet (above mean sea level)
   - Atmospheric Pressure (psia)
   - Maximum Design Temperature, degrees F
   - Minimum Design Temperature, degrees F
   - Design Wind Speed, per ANSI C2 (mph)
   - Snow Load (pounds per square foot)
   - Seismic Zone (UBC)
   - Electrical Classification
   - Exposure to solar heat in the areas of outdoor installation

2. **Ratings**

Bus duct shall be furnished with the following voltage ratings:

- Nominal voltage: 4.16 kV rms
- Rated maximum voltage: 4.76 kV rms
- Rated power frequency dry one-minute withstand voltage: 19 kV rms
- Rated impulse withstand voltage: 60 kV peak

Bus duct shall be furnished with the following current and short-circuit ratings:

- Continuous rated current: 2,000 amps rms
- Short-circuit current withstand, asymmetrical (10 cycle rating): 65,000 amps rms or greater

Bus Construction

1. Bus duct construction shall be in accordance with ANSI Standard C37.23, and other applicable requirements of Codes and Standards stated in these Specifications.
2. Bus duct shall be furnished as a complete assembly of rigidly supported conductors, housed in a 3-phase enclosure without barriers between the phase conductors.
3. The bus conductors shall be copper or aluminum alloy and shall be designed to carry rated continuous current without exceeding temperature rise requirements specified in IEEE and NEMA standards. The current carrying capacity shall be based on actual service conditions including skin and proximity effects, and the effects of the bus insulation, the bus duct enclosure, and the ambient temperature.
4. The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the momentary current.
5. All bus conductor connections shall be completed by bolting. These connections shall be silver-plated for copper bus and tin-plated for aluminum. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through the ambient temperature range from 20ºF to 100ºF. Expansion joints shall be furnished where required.
6. Except at bolted terminations and connection points, all phase conductors in bus duct shall have a "Noryl" or equal sleeve type insulating material. All bolted joints; expansion joints; and bus connections, factory or field; and connections between the bus conductors and transformer terminals shall be insulated with removable boots. Removable boots shall be designed to overlap permanent insulation on each conductor in the connection insulated by the boot. The length of overlap on each conductor shall not be less than 2 inches at expansion joints, and not less than 1 inch at other connections. The insulating rating of bus, joint, connection, and termination insulation shall be not less than the voltage rating of the equipment.
7. Taps or connections shall be provided, as required, to accommodate auxiliary equipment such as lightning and surge protection, generator controls, metering and relaying, and current and potential transformers.
8. Removable covers shall be provided to permit access to the interior of the enclosure.

BUS ENCLOSURE

1. Indoor sections of bus duct shall be furnished with non-ventilated dust-tight enclosures. Outdoor sections of bus duct shall be furnished with non-ventilated weatherproof enclosures.
2. The bus enclosures shall be fabricated from aluminum not less than 1/8-inch thick.
3. Wall flanges and airtight vapor barriers shall be furnished at each transition from indoor to outdoor bus duct. In addition, a fire barrier, with 2-hour rating, shall be provided when penetrating firewalls.
4. After fabrication, all metal work of the enclosures shall be thoroughly cleaned and any steel work shall be phosphorized, or equivalent, and shall be painted with gray ANSI 61, or equivalent, gray paint.

SPACE HEATERS

1. Outdoor bus duct sections shall be furnished with space heaters to prevent condensation of moisture within the bus duct.
2. The heaters shall be located and thermally insulated such that no painted surface or bus insulation shall be damaged or discolored. Space heater capacity shall be as required to maintain the compartment and the bus duct internal temperature above the dew point. Voltage normally applied to the space heaters will be 120 V. Space heater voltage rating shall be 240 V.
3. Space heaters shall be controlled by an adjustable thermostat, factory set at manufacturer’s recommended setpoints.

GROUND BUS

1. A ground bus shall be furnished which will electrically connect together all equipment connected to the bus duct. The ground bus shall be capable of carrying rated bus short-circuit current.
2. Provisions shall be made at each transition from indoor to outdoor bus duct to connect the enclosure to the station grounding system.

OUTDOOR BUS DUCT SUPPORTS

1. Supports shall be designed to withstand all environmental loads (wind, seismic, etc.). Support spans shall be 12 feet or less.
2. Finish
    a. Supports shall be galvanized steel in accordance with ASTM A36.
    b. Structures shall be galvanized by the hot dip process in accordance with ASTM A-123 except that all shapes shall receive 3.0 ounces of zinc per square foot of surface area. Structures are to be

galvanized both inside and out after all cutting, punching, welding and cleaning have been completed.

c. Finished galvanized surfaces must be uniform in color, appearance and texture and must be free of excessive roughness, pimples, lumpiness and runs.

3. Each support shall have a standard NEMA (2 hole) ground pad located at its base.

4. Manufacturer shall consider equipment maintenance access when locating supports. Support locations shall be at least 3 feet from equipment to allow room for equipment maintenance.

INDOOR BUS SUPPORTS

1. Indoor supports shall be galvanized steel and designed for hanging supports from building overhead steel. Support spans shall be 12 feet or less.

EQUIPMENT TERMINATIONS

1. Manufacturer shall furnish all flexible connectors and bus termination fittings for equipment terminations, for the termination of the busbars to the transformers and switchgear.

SEISMIC REQUIREMENTS

[Fill in as required]

SOUND CONTROL REQUIREMENTS

[Fill in as required]

ELECTRICAL REQUIREMENTS

[Fill in as required]

INSTRUMENTATION & CONTROL REQUIREMENTS

[Fill in as required]

MATERIALS & WELDING

[Fill in as required]

CLEANING, PAINTING & COATING

[Fill in as required]

PACKAGING & SHIPPING

[See Appendix 7]

STORAGE & HANDLING PROCEDURES

[See Appendix 7]

SPARE PARTS

[Fill in as required] Commissioning spares to be included/supplied with the equipment.

QUALITY ASSURANCE

[See Appendix 5]

DELIVERY REQUIREMENTS

[Fill in as required]

FIELD SERVICE

[Fill in as required]

TESTING

Material Testing & Inspection

1. **Factory Tests**
   a. Perform standard factory tests in accordance with ANSI C37.23.
   b. Include certified test reports in instruction books.

2. **Shop Tests**
   Routine shop tests shall be performed in accordance with IEEE Standards.

   The Manufacturer is responsible for all costs associated with the tests and for correcting deficiencies and retesting in the event of a test failure.

3. **Field Testing**
   [Fill in as required]

INSTALLATION

1. Contractor shall install bus duct and outdoor supports in accordance with Manufacturer's instructions and drawings.
2. Install power wiring to bus duct space heater circuits from 120/208 or 120/240 volt distribution panel.

MANUFACTURER'S DATA SUBMISSION SCHEDULE

General

Provide Company address and responsible individual.

[Fill in as required]

Drawings / Manuals

1. Submittals

Submit approval drawings, final drawings, instruction books, and technical proposal per Factory Tests, above.

a. Perform standard factory tests in accordance with ANSI C37.23.
b. Include certified test reports in instruction books.

2. Approval Drawings

Shop approval drawings shall include at least the following:

a. Bus duct layout and arrangement showing phasing arrangement, weight, and detailed dimensions.
b. Bus duct support details, anchor bolt plan, and support locations.
c. Bus duct ratings
d. Schematics and wiring diagrams showing customer connections for bus duct heaters.
e. Bus duct connection details.
f. Bus duct grounding details.
g. Complete information for tightening of all electrical connections secured with bolts of studs shall be included on erection and assembly drawings. The information furnished shall include torque wrench settings or complete details of other tightening procedures recommended for bus joints and connector attachments.

3. Final Drawings and Manuals

Submit final "as-built" drawings and manuals.

[Specify format for drawings and the number of manuals required.]

The instruction books shall include, but not be limited to:

a. Complete service and repair manuals.
b. Complete parts list with vendor part numbers and a recommended spare parts list.
c. Bill of materials
d. Certified test reports
e. Storage and Handling instructions
f. Installation instructions

g. Complete set of as-built drawings
h. Contact information for warranty issues or service on equipment.

4. Technical Proposal Documentation

The following information shall be included with the bid proposal:

a. Any variances or exceptions which the Manufacturer has to this and referenced Specifications.
b. Attached data sheets to be filled out as completely as possible.
c. Estimated materials
d. Manufacturer's literature pertinent to proposed equipment.

TECHNICAL DATA

Site Data

[See Appendix 4]

Technical Data by Company

[See Appendix 4]

Technical Data by Manufacturer

[See Appendix 2]

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. **DELIVERABLES**
2. **PROPOSAL DATA REQUIREMENTS**
3. **PERFORMANCE GUARANTEES**
4. **SITE CONDITIONS AND REFERENCE MATERIALS**
5. **QA/QC (Including Inspection Test Plans)**
6. **STARTUP, TESTING, AND COMMISSIONING**
7. **PACKAGING, SHIPPING, AND STORAGE**

1. DELIVERABLES

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule B)

Seller's Data Submission Schedule

Specifier – Add discussion of options and criteria that must be addressed

Documentation

Specifier – Add discussion of options and criteria that must be addressed including drawings, parts lists, O&M manuals

2. PROPOSAL DATA REQUIREMENTS

(To be inserted in the Bid Form)

NONSEGREGATED BUS DUCT DATA SHEET

Manufacturer shall provide the following data applicable to the equipment in the proposed scope of supply.

DATA SHEETS			
NON-SEGREGATED PHASE BUS DUCT (NSPBD)			
Manufacturer Name & Address			
Project			
Facility Location			
Delivery Date			
	UNITS	REQUIRED	SUPPLIER RESPONSE
Net Weight (not shipping weight)			
Complete equipment	lb		
Heaviest piece to handle during erection	lb		
Steel support structures only	lb		
Weight per foot of assembled three-phase bus and enclosure	lb		
Overall Dimensions, Assembled			
Width and height of assembled bus enclosure	in		
Length of largest shipping section	ft		
Bus Structure			
Rated voltage	V	5,000	
Operating voltage	V	4,160	
Frequency	Hz	60	
High potential withstand test at factory on assembled structure			
Rated 60 Hz dry withstand (1 minute)	kV	19	
Rated 60 Hz dew withstand	kV	15	
Impulse withstand (B!L) - full wave	kV	75	
Rated dc, dry withstand	kV	27	
High potential withstand test in field on assembled structure - 60 Hz for one minute	kV		
Continuous current rating	A	3,000	
Rated short circuit withstand which the conductors, supports, housing are mechanically braced to withstand	asym A	40,000	
Bus conductors			
Material (state grade)		Copper	
Conductivity at 20° C	%IACS		

Number of conductors per phase			
Type of conductor (bar, tube, rod, etc.)			
Dimensions of each conductor			
Width	In		
Depth	In		
Diameter	In		
Thickness	In		
Phase spacing, center-to-center	In		
Bus conductor supports			
Material used (ASTM designation)			
Insulation class			
Withstand potential tests Supplier			
Dry	kV		
Dew	kV		
Wet	kV		
Impulse- full wave	kV		
Bus Enclosure			
Shape (rectangular or round)			
Outside dimensions			
Width	in		
Depth	in		
Material (state grade and temper)			
Conductivity at 20°C	%IACS		
Thickness	in		
Type of material of gaskets			
Are short circuiting bands used on cross hanger members? (Answer Yes or No)			
Bus conductor insulation			
Materials used (ASTM designation)			
Insulation class			
Operating voltage and phase	V		
Maximum temperature rise above an outside maximum ambient of 50°C when carrying rated current			
Main bus conductors and connection	°C	65	
Bus enclosures (accessible) °C	°C	40	
Bus enclosures (in-accessible) °C	°C	70	
Material and size of ground conductor			
Will bus be shipped in factory assembled sections?			
Heaters			
Voltage	V	480	
Rating	W		

3. PERFORMANCE GUARANTEES

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule number)

Specifier – Add discussion and criteria that must be addressed, include Acceptance Criteria

4. SITE CONDITIONS AND REFERENCE MATERIALS

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule number)

Specifier – Add discussion and criteria that must be addressed

Maximum Temperature, F	
Minimum Temperature, F	
Humidity Range	
Site Elevation, ft	
Seismic Design Criteria	

5. QA/QC (Including Inspection Test Plans)

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule number)

Specifier – Add discussion and criteria that must be addressed

6. STARTUP, TESTING, AND COMMISSIONING

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule number)

Specifier – Add discussion and criteria that must be addressed

7. PACKAGING, SHIPPING, AND STORAGE

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule number)

Specifier – Add discussion and criteria that must be addressed

8. Approved Vendors / Suppliers

Non-Seg Bus Duct

- Calvert
- Unibus/Powell
- Square D
- Cutler-Hammer

MASTER SPECIFICTION
FOR
Distributed Control System (DCS)

Revision A

REVISION HISTORY

Date	Revision	Change Description
12-2-2015	1	New

****
This specification is only for design, supply, and site technical assistance. Installation is typically performed by another contractor using other specifications.

In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.

Modify “Seller” to “Emerson” for Emerson Ovation DCS per Master Service Agreement.
****

GENERAL

DESCRIPTION

****
Insert project-specific description items (i.e. new construction project, replacement project, project location, etc.)
****

SUMMARY

Seller shall supply, program, test, configure and deliver complete a Distributed Control System (DCS) capable of performing all control, monitoring, trending, reporting, alarming, and interface functions as described in this specification. This specification sets forth the minimum requirements for the design, materials, fabrication, inspection, and testing of the DCS. Seller shall be responsible for integrating all DCS components, subsystems, and other systems into a complete and operable DCS, as well as the system testing, documentation, delivery, supervision and field support as described in this specification. Seller shall include, as a minimum, all required system hardware, operator/engineering workstations, foreign device interfaces, cabinets for DCS devices, system cables, system software applicable to all user requirements, application software, DCS testing, on-the-job training, and documentation.

All equipment shall be designed for continuous duty and to operate in the environmental conditions routinely anticipated in a power plant environment, but in any event not less severe than the environmental conditions described in this specification and attachments. The Seller shall specifically and clearly describe any modifications to the specified temperature and humidity, plant electromagnetic, and radio frequency environments that the proposed DCS will require in order to provide operation fully complying with these specifications.

Company shall be responsible for the following:

a. Receiving, unloading, storing, and field erection of all equipment and materials (unless specifically identified in the technical specifications)
b. Foundations and foundation anchor bolts
c. Permanent electric wiring to connect equipment terminal boxes to the plant electrical equipment supplied by Others.
d. Solvents and cleaning materials.
e. Operating personnel for startup and tests.

Seller shall allow Company personnel access to its factory during DCS assembly and for witness testing. Seller shall provide DCS manufacturing schedule and updates to the schedule to the Company. Travel costs for Company personnel for site factory visits are the responsibility of the Company.

APPLICABLE CODES AND STANDARDS

- State and local codes, laws, ordinances, rules and regulations
- Achilles Level 1 Certified
- ANSI - American National Standards Institute
- ASCE – American Society of Civil Engineers (7-10)
- ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
- IBC – International Building Code
- IEC – International Electrotechnical Commission (61131-3 and 1000-4-5)
- IEEE - Institute of Electrical and Electronic Engineers (472-1974 and 802.4)
- ISA – Instrumentation Society of Automation
- ISO – International Organization for Standardization (9000/9001)
- NEMA - National Electrical Manufacturer's Association
- NFPA - National Fire Protection Association
- UL - Underwriter's Laboratories

In the event of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

****

Update project-specific requirements (i.e. quantities, monitor sizes, time server, etc.).

To bid multiple sellers:
Update all highlighted sections to generic descriptions since these are Emerson Ovation specific.

****

1. GENERAL

The DCS shall be redundant down to, but not including, the I/O modules. The control system shall be designed and implemented such that no single point of failure will result in a plant shutdown, cause damage to plant equipment, or present an operational safety hazard.

The DCS shall be designed to prevent component power up (or initialization) from causing an unsafe situation.

All DCS components and software supplied for this project that become shall be the latest hardware available at the time of the hardware cutoff date.

2. HARDWRE

A. Processors (Controllers):

Controllers shall be Seller’s OCR1100 (or newer), and meet the requirements of IEC. All controller modules shall be capable of being removed and/or inserted into the system while power is applied and shall meet the fault tolerant requirements of IEEE.

Each processor shall have a redundant network connection to the data highway (control system network).

B. GPS Clock:

Seller shall supply one (1) network time server capable to synchronize the DCS processors and workstations to within 1 millisecond of coordinated universal time for time dependent functions such as sequence of events and alarm reporting. A Symmetricom XLi 1U processor, GPS timing engine, and M12 based antenna (or engineer approved equal) shall be provided. The satellite clock shall be provided with a rack mounting kit, antenna, 50 ft. cable, with antenna mounting bracket, and additional instruction manuals (one for each copy of DCS documentation provided). The GPS receiver shall run the Network Time Protocol and shall have at least eight (8) Multicode IRIG-B (AM) output ports and one (1) additional Ethernet port for Company use.

C. Workstations:

All workstations and servers shall be provided with Microsoft's Windows 2007 or Microsoft's Server 2008 operating platforms (or newer), and shall be supplied with all of Seller's recommended software patches.

D. Workstation Monitors:

Seller shall provide Seller's standard twenty-four (24) inch Dell Ultrasharp Series and forty (40) inch monitors (or Company approved equal). Quantity to be supplied per Appendix 2.

All monitors furnished with the DCS shall be industrial quality diagonal high-resolution (1920x1200 or greater), high contrast (1000:1 or greater), vertically flat, non-interlaced, color monitor, and suitable for continuous-duty operation. Maintenance and adjustment shall be easily accomplished and shall be performed without removal of the unit from its mount. Local controls shall be provided on each monitor for contrast, brightness, tint, and focus.

****
Monitors: Update project-specific requirements for quantities, monitor sizes, and if stands are required.

To bid multiple sellers:
Modify highlighted sections to generic descriptions since these are Emerson Ovation specific.
****

E. **Engineering/Database Workstation(s):**
Seller shall provide Microsoft Windows-based, multi-screen engineer workstations with two (2) twenty-four (24) inch monitors per workstation. Quantity of engineering workstation to supply as shown in Appendix 2.

As a minimum, each engineering workstation shall be a rackmount server class machine and shall include a Pentium Xeon 2 GHz processor with 2 MB cache, 4 GB SDRAM, internal DVD +/- RW drive, four (4) internal 300GB hard drives (2 – RAID 1), RD1000 internal drive with removable 160GB media, dual twenty-four (24) inch monitors, dedicated heavy-duty 104 key PS/2 style QWERTY keyboard and separate optical mouse designed for industrial use in a continuous duty operation, all necessary communication hardware, and all software and operating systems. The engineering workstation shall be configured as an operator workstation and engineering/database server, and shall be provided with three (3) floating Ovation Developer Studio licenses. Two (2) additional temporary Developer Studio licenses shall be provided for startup and commissioning.

****
Workstations: Modify highlighted technical sections per Seller’s proposals as workstation specifications are frequently changing.

To bid multiple sellers:

Modify highlighted sections to generic descriptions since these are Emerson Ovation specific.
****

F. Operator Workstation(s):

Seller shall provide Microsoft Windows-based, multi-screen operator workstations with multiple monitors per workstation. Quantity of operator workstation to supply as shown in Appendix 2.

As a minimum, each operator workstation desktop shall include a Pentium Dual Core or Core 2 Duo 2.2 GHz processor with 2 MB cache, 1 GB SDRAM, internal 250 GB hard drive, internal DVD+/-RW drive, four (4) monitors, video cards and drivers capable of driving at least four (4) monitors of different sizes, speakers that audibly annunciate system and process alarms, dedicated heavy-duty 104 key PS/2 style QWERTY keyboards and separate optical mouse designed for industrial use in a continuous duty operation, all necessary communication hardware, and all software and operating systems. Each operator workstation shall be configured to function as an engineering workstation with appropriate login security level.

G. Historian:

Seller shall provide a rackmount historical storage, retrieval and log server workstation, complete with an external "hot swappable", rackmount, disk RAID array storage system (no empty slots), three (3) internal 300GB hot swap hard drives (RAID 5), internal DVD RAM drive, with the latest technology data storage capabilities for long term data storage and retrieval as well as perform all functions of a normal operator/engineering workstation. The historian shall include a twenty-four (24) inch display, Microsoft Excel add-on, and 10,000 data point license (at a minimum). Quantities shown in Appendix 2.

The historian server shall be provided with all the necessary hardware, software and a storage interface medium such as Oracle with OBDC, or equivalent. The historian shall include a report/log generator for recording and archiving of plant data, which shall be designed for ease of use, and configured for creating and storing multiple custom displays and reports with automatic printing options. Any and all points in the DCS shall be available for report generation. Seller shall provide eighteen (18) pre-configured report formats designed to generate reports with varying quantities of points. At a minimum, Seller shall provide reports formats designed for 8, 16, 32, 64 and 80 point reports. Seller shall provide reports formats designed to export to Microsoft Excel properly and report formats designed to directly print properly.

As a minimum, the data historian shall record all hardwired I/O, analog process variables, and significant status variables (e.g. all digital manual rejects). Additional data to be logged shall include, but not be limited to, history of process alarms, operator changes, and system errors. It shall also acquire continuous process history to support logs and trends and provide the source data for management reports and operational logs.

Historian external storage capacity (RAID) shall be sized to allow data to be sampled at a default 1.0 second rate for non-SOE points and 0.1 for SOE points and accumulated for 5 years. Varying the sampling rate shall make it possible to store more points or for longer periods. For the purpose of preliminary sizing of the system, for storage and licensing, the Seller shall use the Estimated DCS I/O Count in Appendix 2, with two hundred fifty (250) percent additional soft points shall be used.

The historical trend shall be for up to at least thirty (30) days.

Data shall be archived at least every thirty (30) days.

H. Asset Management System (AMS):

****

AMS is Emerson specific and project specific. Modify accordingly for multiple sellers and/or project.

****

Seller shall provide a rackmount Asset Management Server with a licensed number of points greater than the total number of Hart capable instrumentation on the complete project. All Hart capable points known before factory acceptance testing shall be configured in the factory prior to delivery. All Hart capable points remaining shall be added at Site with technical assistance. The AMS servers shall have the capability for one (1) client. For the purpose of preliminary sizing of a system, licensing shall use the applicable estimated DCS analog I/O count in Appendix 2 with 20% additional.

I. Domain Server:

A rackmount Domain Server shall be provided per Appendix 2, complete with four (4) Ethernet ports, internal DVD +/- RW drive, four (4) internal 300GB hard drives (2 - RAID 1), and an RD1000 internal drive with removable 160GB media. Prior to the Factory Acceptance Test (FAT), the Seller shall configure three (3) access levels: Administrator, Maintenance, and Operator. The Seller shall use this server to disable all unused ports and services to harden other workstations. Additional access levels shall be configurable by the Company based on plant design and access level.

J. Anti-Virus Server:

****

Anti-Virus is project specific. Many sites request or have an Ovation Security Center that includes anti-virus. Discuss CIP requirements with plant contact and Subject Matter Expert prior to sending specification to Seller(s).
****

A rackmount server shall be provided per Appendix 2. The server shall integrate seamlessly into the DCS network and will only be required for commissioning the system prior to the DCS's integration into the existing Ovation Security Center.

K. Performance Workstation:

****

Global Performance Advisor is Emerson and project specific. Discuss requirement with plant contact and Subject Matter Expert prior to sending specification to Seller(s).
****

A rackmount Global Performance Advisor (GPA) shall be provided per Appendix 2 and configured for new 2x1 combined cycle. Configurations shall include turbines, heat recovery steam generators (HRSG), cooling tower, medium voltage motors/pumps, and condenser.

L. Computer Cabinet:

****

Some sites are mounting all their computers remotely in a rack in a cleaner room, and some sites will still stuff them under or on top of desks. Discuss requirement with plant contact and Subject Matter Expert prior to sending specification to Seller(s).
****

One (1) Dell server cabinet shall be used to rackmount the Historian with external RAID drives, GPA server, Domain server, Anti-Virus server and the engineering/database server. A KVM switch shall be used to connect the GPA Server, Domain Server, and Anti-Virus Server to a single keyboard, mouse and monitor. The database server, Historian and other workstations with dedicated monitors and keyboards shall utilize fiber optic KVM extenders.

M. Printers:

Printers shall be suitable for a control room environment. They shall be able to print at least one hundred thirty-two (132) characters per line and utilize multiple fonts. All workstations shall be configured to allow printing to any of the network connected printers on the system. Printers shall be furnished with a one-year supply of ink/toner cartridges.

Color Laser Printers (quantity per Appendix 2): Each printer shall meet the following minimum capabilities:

- Selectable paper size up to 11" X 17"
- Print speed of minimum fifteen (15) pages per minute
- Two individual paper trays for 8½" X 11" and 11" X 17" sheets

- Input paper tray capacity of minimum 250 sheets each size
- User replaceable toner cartridge
- Minimum resolution of 1200 X 1200 dpi
- Duty cycle of minimum ten thousand (10,000) pages per month
- Printing mechanism shall not require specially treated paper
- Buffer large enough to store two graphic screen prints
- Ethernet connectivity

Each printer shall be equipped with any control or interface devices (e.g. print servers) necessary to interface it directly to the local network and to operate in conjunction with the operator and/or the engineering workstations. All network connected printers shall be capable of printing any screen displayed on any workstation including logic, graphic screens, and reports.

N. Spare Capacity:

The DCS shall allow for future expansion and provide spare capacity within the system. The Seller shall confirm that the proposed control equipment will be supported by the Seller with the supply of spares and replacement parts being guaranteed for the expected useful life. The Seller shall provide guarantees on hardware.

The DCS spare requirement shall be in accordance with Appendix 2 or this section, whichever requirement is more stringent. All percentages shall be rounded up to the next highest number.

- At each I/O cabinet area, the Seller shall supply a minimum of twenty (20) percent installed, unused spare capacity for each type of I/O available in the cabinet, excluding specialty modules.
- An additional minimum twenty (20) percent spare slots and space for twenty (20) percent spare modules shall be provided in each I/O cabinet area to allow for future installation of I/O modules.
- Each control processor shall be equipped with the amount of functional capacity and memory required to perform its control functions under all process conditions, plus a minimum spare capacity of fifty (50) percent. The required size and quantity of the processors is to be determined by the Seller based on extensive experience in power plant control system design and the information contained in this specification.
- Each router and Ethernet switch shall be sized with twenty (20) percent installed spare capacity.

O. Spares:

Seller shall provide one (1) complete set of parts indicated in the Seller's documentation requiring to be replaced during the construction, testing, startup, and commissioning phases of the project.

All spares supplied shall be strictly interchangeable with the parts that they are intended to replace and shall be of the same quality as the original parts.

In addition, Seller shall provide a complete listing of recommended spare parts. The spare parts shall include those required for all on-base and off-base equipment and materials including sub-sellers furnished under this agreement. The recommended spare parts lists shall be submitted in two separate lists. The lists include:

Recommended Start-Up Spare Parts List – The startup spare parts list shall include a listing of all consumables required to operate the Seller supplied equipment through startup and commissioning. This list shall include those parts which, based on past experience, the Seller recommends having available to replace parts that may fail during start-up.

Recommended Operational Spare Parts List – This list shall include those parts which, based on its maintenance guidelines, routine operation, and past experience, the Seller believes may require replacement in the first 24 months of plant operation.

The lists shall comply with the following:

- Lists shall be in Excel Format.
- Lists shall be inclusive for and applicable to all equipment components, auxiliaries, accessories, and materials being furnished under this agreement.
- Lists shall indicate whether the recommended spare is a stock item or a special-order item.
- Lists shall be identified with the Company's specification number, equipment tag number and equipment description.
- Lists shall classify the relative criticality of parts based on the Seller's experience and shall list the recommended quantities to be stocked.

P. RFI/EMI Protection:

****

The RFI/EMI section is for bidding new sellers or new hardware with limited industrial experience. Remove section for Xcel's standard DCS sellers like Emerson Ovation and Invensys Foxboro.

****

The DCS system and components shall not operate incorrectly or sustain damage from the influence of radiated or cable-conducted radio frequency fields or electromagnetic interference typically found in an electric power generation facility.

The system shall be supplied with provisions for protecting against system errors and hardware damage resulting from electrical transients on power or signal wiring. These transients include those generated by switching large electrical loads, by power line faults, and due to lighting strikes which induce surges on power or signal cables. Either the IEEE Standard 472-1974 or IEC Standard 1000-4-5 shall apply to all system power inputs and signal inputs from field devices. The Seller shall describe the method it intends to use to provide this protection in its proposal.

Portable FM transceivers will be used by plant personnel for communications purposes during startup and commissioning. The transceivers will operate in the 300 to 5,000 MHz range (UHF). Input power will be 5 watts and power output will be 3.5 to 4.0 watts. The DCS shall not exhibit any adverse effects which may be produced within the Seller's systems and not impose any restrictions on the use of such communications equipment and Seller's equipment shall not cause RFI interference to user's hand held radios.

EMI protection against hardware damage and system errors shall be provided for the equipment being furnished. Errors caused by EMI shall not exceed ±0.1 percent of span for exposure to field strengths of 30 volts/meter over the frequency range of 20-100 MHz.

RFI protection against hardware damage and system errors shall be provided for the equipment being furnished. Errors caused by RFI shall not exceed ±0.1 percent of span for exposure to field strengths of 10 volts/meter over the frequency range of 10-1000 MHz. A certified test report shall be required in the proposal to verify this performance. Seller's equipment shall meet all applicable RFI emissions standards.

3. I/O CABINETS AND NETWORK HARDWARE

A. General:

All I/O and network equipment shall be housed in cabinets and enclosures.

Final cabinet layouts shall be subject to Company's approval. DCS cabinet doors and panels shall be fitted with dust tight seals. DCS cabinets (located in an environmentally controlled area) for the processors, communication cards, power supplies and I/O modules shall conform to NEMA 1 standards. DCS cabinets shall be NEMA 12 with side covers. Cabinets will be installed in electrically unclassified areas, except where noted otherwise. The Seller shall design and supply a rigid, self-supporting freestanding cabinet for incorporation within a suite of bolted cabinets. Cabinets shall be completely fabricated, assembled, wired and tested before leaving the Seller's factory.

****
The duct burner section is project specific for a combined cycle plant.
****

The HRSG duct burner DCS cabinets shall be designed to meet the requirements of NFPA 85 and shall include a relay panel with watchdog timers. Relay panel shall be designed by Seller to remove energy from igniters and safety valves per duct burner seller's documentation.

The I/O cabinets shall be designed for top or bottom entry of field cables.

Fans shall be provided in redundant pairs with integral filters, and shall be fused such that a fan failure does not trip the circuit breaker feeding the cabinet power.

A temperature alarm shall be provided for each cabinet with active electronics. These cabinet temperatures shall be available for display on the system status graphics and shall alarm at extreme temperatures.

Each cabinet or enclosure provided shall be clearly labeled with a nameplate containing the tag number, controller number, description and branches (front and rear). Where cabinets contain multiple sections, each section shall have its own nameplate. Where cabinets have front and rear access, each side shall be provided with a nameplate.

Nameplates shall be made from laminated plastic, white background, with black letters. All nameplates shall be permanently attached, and engraving shall be subject to Company review and approval.

All major system components located inside of cabinets or enclosures shall be clearly labeled and identified with the tag number or an equipment/device number that is referenced in the vendor drawings. This shall include electronic equipment, terminal block assemblies, fuse blocks, power supplies, media converters, network equipment, and any other device requiring maintenance or service.

Cabinets shall utilize lockable, vertically hinged doors. Hinges shall allow easy removal of the entire door. All door locks shall be provided with the same lock and key combination, and a minimum of two keys for each door shall be provided.

****
Remote I/O is project specific and requirements need to be discussed with plant contact. Lately projects have gone away from control through networking due to UOR incidents.

Recommend redundant network connections to each Ovation controller with remote I/O to prevent controller faults.
****

Remote I/O shall not be used.

All I/O branches shall be provided with full baseplate installation.

All DCS controller cabinets and DCS I/O cabinets shall have a width of thirty-two (32) inches.

The DCS cabinets shall be designed such that each set of redundant controllers shall have no more than sixteen (16) branches. The Seller shall add additional sets of redundant controllers as necessary at each location. As a minimum, the Seller shall provide a minimum of eight (8) redundant controllers with automatic failover as follows: One (1) for Unit 05 HRSG, one (1) for Unit 06 HRSG, one (1) HRSG 05 duct burner BMS, one (1) HRSG 06 duct burner BMS, one (1) STG, one (1) water treatment, one (1) cooling tower, one (1) medium-voltage electrical enclosure.

Controller redundancy will be provided in a one-to-one fashion; no more than one microprocessor will be backed-up by the redundant processor.

Equipment cabinets shall have cooling fans that exhaust from the top of the cabinet and filtered cooling air shall enter from the bottom.

DCS cabinets requiring Modbus serial connections shall include provisions for mounting (on DIN rail) and powering the associated serial-to-fiber media converters. Additionally, space shall be provided for mounting (on DIN rail) the associated fiber optic patch panel. The media converters and fiber optic patch panels shall be pre-installed and pre-wired at the factory.

B. Power Distribution and Grounding:
Each cabinet or equipment receiving power shall be provided with a main circuit breaker or breakers which shall be the point of interface to the power sources. The proper coordination of branch circuit protective devices shall be the Seller’s responsibility. All breaker trips shall be alarmed in the DCS.

Two (2) power sources shall be available to each cabinet containing power supplies, processors, fans and cabinet lights. Two (2) essential service feeds shall be provided from the Site's Uninterrupted Power Source (UPS) system and/or essential service bus (supplied at 120 VAC). Additionally, two (2) essential service feeds (120 VAC) connected to an auto-transfer switch within the DCS cabinet shall be provided to each cabinet requiring routed power for digital outputs. Seller's system shall be fully functional if either of the essential service feeds is energized to the controller and I/O power supplies. The intent of this requirement is that no single point of failure in power feed, or power supply, shall degrade or interrupt the normal functioning of the Seller's system.

****

Different sites have different power source standards. Modify accordingly (ie AC versus DC, UPS versus house power).

****

The standard power supply terminals shall be factory wired out to easily accessible terminal blocks. These terminal blocks shall be screw down type capable of receiving a 12 AWG sized ring-tongue lug with covers to prevent accidental contact with power source.

Seller shall provide redundant power supplies, diode isolated, and fused to a common bus. Each power supply shall be loaded to not more than fifty (50) percent of its maximum capacity upon shipment. Faulty power supplies shall be able to be removed/replaced with the system on-line. Seller shall provide additional redundant power supplies as necessary at every controller location to maintain a maximum power supply loading of sixty (60) percent. Power supplies shall be internally monitored and alarm when out of tolerance from the DCS.

A grounding jumper shall be installed between the cabinet door and the cabinet on all DCS cabinets to ensure a solid ground is provided for the cabinet door. A shield bus bar shall be installed on the side of each cabinet.

Seller shall provide all interconnecting wiring and cables (wire or optical fiber) required for connections within cabinets and between the various physically separated items in Seller's scope of supply in accordance with the network overview drawing provided.

Recovery of the system after power failure must be automatic, with control loops and sequence control placed back into the failsafe position.

C. Network Equipment:

All network cabinets and server cabinets will be powered by redundant separate 120VAC UPS power sources.

Where fiber optic cable is used, Seller shall provide (in each originating and remote location), a fiber optic patch panel and media converters (if required). Each remote controller and workstation location patch panel and set of media converters shall be capable of terminating the required fiber plus one hundred (100) percent spare capacity. The network cabinet location patch panel and media converters shall be capable of terminating the required fiber plus twenty (20) percent spare capacity. In no case shall the patch panel violate the minimum bending radius required for the fiber optic cable. Fiber optic connectors shall be ST type. Patch cables between media converters and patch panels shall be provided by Seller.

A media converter chassis shall be factory installed near the respective fiber optic patch panel within a Seller provided cabinet at each originating and remote location and the chassis power shall be factory wired to a power supply terminal strip in the same cabinet.

All network equipment necessary for Seller's system to operate shall be provided, and located in a network equipment cabinet. Network equipment shall be powered by redundant feeds provided by Company. The network equipment cabinet shall be located over a raised floor, and shall accommodate bottom entry cabling. Network equipment shall be redundant to the extent that no single power feed or equipment failure shall disrupt normal operation of the data highway. The network cabinet shall be provided with ten units (10U) of spare space for rack mounted equipment provided by Others. The Seller shall provide a DCS fiber optic patch panel(s) for DCS fiber and shall be adequately sized to allow twelve (12) bulk fiber optic cables (with six pairs of fiber in each cable) to be terminated.

Seller shall only provide Cisco brand switching, firewall and routing equipment. The use of hubs is forbidden.

Controllers shall be dual-homed.

A Seller DMZ router shall be provided in the DCS network, and shall be installed in the network cabinet. Seller shall connect the DMZ to the DCS network. Company will connect the DMZ to Company's network. Company will establish the technical requirements for the DMZ router and size the hardware to properly handle all the required functions, timing requirements, alternate routings, and allow for future expansion with Seller's assistance.

4. COMMUNICATIONS

A. General:

The communications network is a set of elements that transfers information between processors, workstations, switches, routers, controllers, or other devices that constitute the system. “Data Highway” refers to the controller network, and any network architecture internal to the Seller’s system. “Datalink” refers to a third-party interface with other systems or devices.

All communication networks shall be provided with error checking and diagnostics and shall alert the operator to faults in the system (i.e. loss of communication) through alarm messaging and system status graphics.

Communications interfaces shall be replaceable on-line without interruption to the system.

All outside communications to any control system shall be accomplished in cooperation with Company such that the Company’s data security requirements are met.

B. Data Highway:

The data highway shall be fault tolerant, redundant (to the processor bus interface level), and shall continuously monitor the highway performance, and log and transmit all system diagnostic alarms for display.

The data highway equipment shall be capable of transmission over a distance of a minimum of five thousand (5000) meters.

Seller shall supply all necessary hardware, highway cables, and connectors required for the system within each controller cabinet and between each connected I/O expansion cabinet. Seller shall install fiber optic patch panels in all controller cabinets and connect fiber optic jumper cables between the fiber optic patch panels and media converters.

Redundant data highway shall be active at all times. Each shall be able to operate independently for indefinite period of time with no system degradation.

Microprocessor based controllers or controller server systems shall be dual redundant configuration. The backup equipment shall have parallel access to the data highway and shall continuously update while in the backup state. The intent of this requirement is to maintain the status of the backup equipment current with the primary equipment such that transfer of information from the failing primary controller to the secondary controller is not required. It is also the intent of this requirement that failure of one branch of redundant data highway shall not result in failing to the backup controller.

In no case shall data propagation times be longer that two hundred (200) milliseconds.

The data highway shall also provide the following:

- No single point of failure or single loss of power shall cause communications to cease functioning
- An upset in plant conditions shall not cause the data highway to operate in a degraded mode. Bandwidth shall be capable of maintaining required update time under upset conditions
- Data highway rate shall be a minimum of one hundred (100) Mbps
- Variables in the system-wide global database shall be uploaded a minimum of once per second with compatibility of updating once per second with compatibility of updating critical variables every tenth (1/10) of a second to all controllers in the system.

C. Datalink:

Interface capability shall be provided to allow communication using industry standard protocols. The various types of communication specified in Appendix 2 shall be supported. The DCS system shall accept daisy chained or communication protocols that are series segments to the DCS without the need for separate modules at the DCS. Fieldbus, Profibus, and DeviceNet shall not be used in any system. Protocols to be supported include, but are not limited to:

- Modbus (Serial and TCP/IP)
- EIA RS-232/422/485
- Allen-Bradley DH+
- HART
- GSM
- DNP3.0

****

Different sites have different datalink standards. Modify according to the plant's requirements.

****

Systems interfaced with include, but are not limited to:

- Programmable Logic Controllers (PLCs)
- Compressor control systems

- Turbine control systems
- Remote Terminal Units (RTUs)
- HART enabled field devices

****
Different projects have different interfaces. Modify accordingly.
****

The system shall support redundancy all datalink interfaces.

All datalinks shall alarm on loss of communication.

Datalinks shall enable the DCS to control and monitor equipment on a supervisory level.

5. I/O MODULES

A. General:

The Seller shall terminate all process I/O in an arrangement that will assure that electrical characteristics are matched and will support construction/installation. The Seller shall not terminate process I/O in a particular order solely to satisfy Seller requirements. Process I/O identifying codes, termination locations, functional descriptions, and electrical characteristics shall be submitted by the Seller for approval by Company. Each block and terminal shall be suitably identified in accordance with termination drawings and wire lists.

Inputs and outputs servicing complementary pairs of equipment shall be assigned to separate I/O modules and branches. Redundant instrumentation shall be terminated on separate branches.

All hardwired signals shall be terminated to the controller's I/O in which the logic for the signal is being processed in. All I/O not meeting this requirement shall be flagged and reviewed with Company for acceptance.

The Seller shall furnish all redundant power supplies required for powering remote transmitters that are not self-powered. All transmitters will be of either the two-wire or four-wire type. Transmitter circuits shall be individually fused or current limited. The fuses shall be located in the I/O cabinets. Bridge circuits and power supplies required for resistance temperature detectors and slide wires shall be provided in the I/O cabinets.

Seller shall reduce the amount different I/O group types to the extent possible.

Any required peripheral or auxiliary equipment for signal conditioning, impedance matching, load balancing, ground detection, surge protection, and other similar functions shall be furnished and installed by Seller.

****
Recommend removing the rest of the general section below for known DCS sellers (Ovation and Foxboro). Standard equipment from these sellers is acceptable and well tested.
****

The I/O modules shall be capable of accepting the input/output signals described below and used in conjunction with the controller modules described herein.

All inputs and outputs shall be individually able to be removed from scan and forced to an operator determined value from any operator workstation. A forced points log shall be generated to display and identify by tag any forced points.

Provision shall be included to allow all inputs to be able to be deleted from and restored to alarm status.

The quality of all inputs shall be determined, and classified as good, questionable, forced, or bad. When bad quality of a value occurs, it shall be clearly displayed and alarmed. The system shall include the capability to set the upper and lower limits of each analog input that determines good or bad quality.

I/O modules shall be replaceable without removing any wiring.

All low voltage digital I/O and temperature inputs (RTD, T/C) and all analog I/O shall be capable of being electrically isolated from other I/O, incoming power cables, and from all cabinet wiring.

Terminal blocks for analog signals shall be sized to receive 16 thru 14 AWG wire.

Terminal blocks for digital signals shall be sized to receive 16 thru 14 AWG wire.

Circuit protection shall be provided such that a fault on one channel will not cause other channels to fail.

Individual status lights shall be provided for each digital input and each digital output on a direct-wired I/O module. I/O module slots shall accept either input modules or output modules as required.

****

**Recommend removing sections marked with a double asterisk section below for known CS sellers (Emerson Ovation and Foxboro) with a list of model numbers and quantities from final proposal, but *verify model numbers first*. Standard equipment from these sellers is acceptable and well tested.

****

B. Analog Input:

Analog input modules shall be installed and configured in the factory such that unused or spare channels on the module do not create an alarm for the module or its associated I/O branch. All unused channels shall be capable of being put back in service if necessary by Company.

**Conversion to engineering units shall be software based, such that each point on any I/O module can have its own range.

**Provision for different conversion types which shall include linear, thermocouple, RTD, flow compensation, polynomial approximation for special input and all other types required for this application. Each of the conversion types shall have the capability to handle different ranges for the variable.

**Analog inputs shall contain over/under range protection to protect the equipment from ground faults and high voltage.

**The DCS system and components shall be capable of supporting the latest version of HART protocol communications with transmitters and control valves. Analog I/O shall have the required loop resistance to support HART communications. Analog I/O modules capable of reading the HART protocol on the milliamp signal shall be provided.

**All analog I/O's shall check for quality.

C. Analog Input (4-20 mA) Modules:

Each analog input channel shall be capable of HART communication.

**Analog inputs shall be furnished with individual analog-to-digital converters, accuracy better than +/- 0.10% of span.

**The choice of internal (loop) or external (field) power source shall be individually selectable on a per point basis.

D. Analog Input (TC) Modules:

The cold junction compensation (CJC) value shall be available for display to the operator and shall have adjustable alarm limits. CJC shall be provided on a per module basis.

**Thermocouple input modules shall be designed so that different thermocouple types can be mixed on each module. This shall include as a minimum ungrounded and grounded thermocouples of type K. The system shall include selectable linearization for thermocouples, and CJC.

**All thermocouple inputs shall be checked for open circuit with each thermocouple scan. The delay between the check and the determination of an open circuit condition shall not be more than one (1.0) second.

**Series mode signal-to-noise rejection ratio shall be not less than one thousand to one (1,000:1) for thermocouples.

E. **Analog Input (RTD) Modules:**
**The system shall be compatible with 2-wire, 3-wire and 4-wire RTD types.

F. **Analog Output Modules:**
Analog output modules shall be installed and configured in the factory such that unused or spare channels on the module do not create an alarm for the module or its associated I/O branch. All unused channels shall be capable of being put back in service if necessary by the Company.

**Analog outputs shall be individually fused or current-limited and shall produce 4-20 mA DC current loops capable of driving 750-ohm loads at 24 volts DC.

**Analog outputs shall be capable of producing 1-5 VDC or 0-10 VDC signal levels if required. Using a shunting resistor to achieve these outputs is acceptable.

**Analog outputs shall be furnished with individual digital-to-analog converters, accuracy better than +/- 0.25% of span.

**Failure mode pre-selection is required, allowing analog outputs to be configured to fail open, fail closed, or fail last upon loss of communication with the control processor.

**Optical isolation shall be provided for all analog outputs.

**An open loop shall result in indication of bad quality

**All analog outputs shall be open circuit and short circuit protected.

**An individual integral HART modem shall be provided for each analog output channel.

G. Discrete Input Modules:
All digital inputs shall be 60-48VDC power. Input modules with onboard DC wetting voltage are acceptable. Additionally, fail-safe condition checking of digital inputs shall be done such that a failure of a digital input module will not allow for the controller to detect a "set" state of the input signal. The option to disable all points on a module based on a ground fault detection shall be disabled.

**Discrete inputs from field devices will be dry contacts, and both momentary and/or maintained.

**Contact input modules shall be able to be located in any processor I/O cabinet.

**Contact inputs shall be provided with contact bounce filtering. The filter shall delay contact inputs to protect against input device bounce and electrical noise on input lines.

**Sensing modules for contact inputs shall be high impedance. Interrogation voltage for contact inputs used for data acquisition and/or control shall be provided from DCS generated 48VDC source as required. The choice of internal or external power source shall be individually selectable on a per module basis.

**Each discrete input module shall be current-limited to protect against field short circuits.

**All discrete inputs shall have sequence of events capabilities with a resolution of one (1) millisecond.

H. Pulsed Input Modules:
**The DCS shall be able to receive inputs from periodic (or pulse) input devices. A periodic input shall be defined as: A zero based pulse, rectangular wave or sinusoidal wave form with amplitude of 24 volts DC, and rate of 0 to 50,000 pulses per second (50 KHz frequency).

I. **Discrete Output Modules:**
DCS powered 120VAC outputs are to be provided for solenoid operated valves, as defined in the I/O list. The DCS cabinet breaker(s)

feeding these DCS powered digital outputs should be sized to be capable of providing current up to one (1) amp per valve assuming that fifty (50) percent of the valves on any module will be operated simultaneously. These breakers shall also be monitored by the DCS and alarm when field power is not available.

Power distribution terminal blocks shall be provided for all 120VAC solenoid valves identified in the I/O list.

The discrete output points shall be designed to accept supply power for contact outputs either from I/O power supplies within the Seller's systems or from an external power source (field selectable).

**Discrete output modules shall be provided to switch either DC or AC loads as specified by the I/O list. Relays shall be provided for all discrete output points.

**Each relay output shall be able to switch a minimum of ten (10.0) amps @ 250VAC or three (3.0) amps @ 125VDC (with embedded arc suppression circuitry; arc suppression should be external to allow ease of replacement, without having to replace the whole module) with all outputs on a module active at the same time.

**Higher current ratings of up to ten (10) amps AC/DC may be required in some cases, and shall be provided by interposing plug-in relays if the I/O modules or relay type terminal blocks cannot support this requirement. This shall not require separate relay cabinets.

**Contacts outputs shall close within fifteen (15) msec.

**Fail-safe features required on discrete outputs include a configuration option to fail open or fail closed on loss of communication with the control processor. Internal circuit protection for output modules shall be provided such that a fault on one output does not cause other outputs to fail.

6. SOFTWARE

A. General:

The DCS shall be programmed utilizing Seller's most current revision of Ovation software, release Ovation 3.5 (or newer). Minor software revision upgrades (such as 3.5.1 to 3.5.2, 3.5.3) and Seller verified operating system patches shall be provided and installed up to twelve (12) months after receipt of DCS workstation equipment on Site.

Seller shall program and implement complete control logic for a complete DCS system. Seller will be provided with P&IDs, graphic sketches, logic diagrams, and control narratives for guidance. Seller shall use Company's standard Emerson logic macros.

Program documentation (including interlock and alarm setpoints as well as setpoints required by the programming algorithms) showing the implementation of the templates and narratives shall be submitted for review in accordance with the deliverable schedule. The program documentation submitted for review shall be in Seller's standard logic format. In addition, all programming documentation submitted shall indicate all setpoints and cross references required to determine that the software will perform as required by the templates and narratives.

Seller shall submit all logic diagrams for the system in sufficient time for complete engineering review of the logics and incorporation of comments on the logic into the system programming prior to FAT. System logics shall be submitted in at least three equal packages, spaced thirty (30) calendar days apart, with the final package submitted in sufficient time for a review period and incorporation of logic comments into the system prior to the initiation of the FAT. Late submittal of logics, or submittal of substantially non-compliant logics, by Seller shall be equivalent day-for-day to late delivery of the DCS system and subject to the liquidated damages in Appendix 3.

****

Liquidated damages should be discussed with Sourcing prior to issuing specification since most Master Service Agreements (MSA) already address damages.

****

A complete set of software program packages shall be provided to implement the control functions of the DCS. Seller shall be responsible for developing, debugging, and testing all software programs used. A set of maintenance software programs shall also be provided to perform on-line and off-line diagnostic functions for both the hardware and software components of the system.

The software to be furnished shall include any and all proprietary and non-proprietary software utilized or required in any way for configuration, programming, debugging, operation or maintenance of the system hardware and/or control programs and display screens. This shall include any configuration automation programs or utilities, software add-ons, collections of algorithms or configuration blocks including utilities or programs available to the Seller's configuration and programming personnel.

The Seller shall furnish all necessary software license(s) for each software package provided. The Seller shall also furnish a backup copy of all licenses and programs contained in the package in a binder. One (1) set shall be delivered to the Site separately from the system hardware.

****
Add software license details and quantities in final proposal to this section.
****

****
Different projects and sellers have different controller scan rates. Modify accordingly or remove. Control Tasks below are Emerson Ovation specific.
****

Controller Scan Rates
Control Task 1 - Unit Protection – fast loops at 100ms (ie unit trips)
Control Task 2 - Analog Control – slow loops at 1000ms (ie temperature control)
Control Task 3 - Data Acquisition – 500ms
Analog Control – medium loops at 250 to 500ms (ie pressure and flow controls)
Discrete/Logic Control – 250 to 500ms

Bad signal quality shall be alarmed and the process control loop should be placed in manual.

Redundant instruments shall use the 2XMTR algorithm. Triple redundant instruments shall use the “Median Select” algorithm.

Each process variable, set point, position feedback, and demand signal shall be check for excessive deviation and shall alarm at a minimum.

Notes should be added to control sheets to clarify complicated control or to indicate scaling where possible. (Necessary for consistency and ease of troubleshooting).

****
Highlighted below are project specific requirements. The first one is a plant specific requirement, the second is a project specific requirement. Modify accordingly.
****

All points must have an English description. Output point descriptions should start with a verb or contain the words “demand” or “command”. (i.e. Open BFP 1A Discharge Valve).

The water treatment system shall be programmed in the DCS. As such, the Seller shall be required to work with the water treatment vendor (US Water) to program the system in accordance with the vendor's requirements (utilizing the project logic macros and graphic symbols).

B. System Database:

All letters used in the database and point definition shall use capital letters. Only exception is for engineering units that call for distinction (ie. mA - milliamps versus MA – mega-amps).

Software shall also be provided to reinitialize communication devices from permanently stored data following a computer failure. Re-initialization shall restore the devices to continue performing the functions that were in progress prior to the failure without operator intervention. The devices to be reinitialized shall include display screens and demand logs.

System software shall be password protected. This shall include database configuration and logic modification. All passwords shall be provided to Company.

Strict adherence to the point naming, alarm priority, and characteristic standards is required. (Necessary for consistency and ease of troubleshooting).

All points that leave a control sheet (internal or I/O) must have a custom name per the point naming standards and a custom description. No points leaving a control sheet should be allowed to have default names or descriptions. (Necessary for consistency and ease of troubleshooting).

C. Re-initialization:

Software and hardware shall be provided to reinitialize the system following a computer failure or long-term power failure.

The re-initialization software shall contain necessary programs for Company to install all operating system and application programs onto the system memory with a series of screens displaying guidance messages throughout the entire installation process.

The software shall cover all aspects of the installation process including checking each type of memory for defects, testing system hardware for the proper functioning of each component, and procedures for installing individual programs.

D. Control Functionality:

Critical Logic: Company's critical logic shall be integrated as-is unless Seller identifies areas of code violations or high risk of equipment damage. Seller shall notify Company of all areas of concern identified by Seller for immediate resolution.

Digital logic shall be programmed without the use of complex Boolean algorithms (such as NOR, NAND, Exclusive OR). Typically the use of AND, OR and NOT along with special functions such as flip-flops, time delays, one-shots are to be used. (Ease of reading control sheets and ease of trouble shooting).

All tripping signals from triple redundant instrumentation shall be based on two (2) out of three (3) voting logic with bad quality signals voting to trip. The bad quality signal monitors shall check the actual signal input from the individual instruments, not the median or any other compensated signal.

If a field signal becomes unavailable or bad, protection of the control output shall be provided (e.g., reject to manual, etc.).

****
Items remaining are Emerson Ovation specific. Modify accordingly.
****

Analog control will flow top to bottom and discrete (digital) control will flow left to right.

Digital control and analog control will not be mixed on the same control sheet. Exceptions are where digital control points are necessary on analog algorithms and where analog points are needed to determine digital logic (e.g. high limit of a pressure). (Ease of reading control sheets and ease of troubleshooting).

All inputs to PID algorithms and all outputs from MA Stations shall have custom names.

Function blocks shall be included after all MA Stations to allow for linearizing or inverting signals.

All function blocks shall have a function graph.

E. Point Identification:

****
Point identification is project specific. Modify accordingly.
****

A typical variable identification tag shall be composed as follows:

1) 2 alpha-character for Plant System Code

2) 2 alpha-character for Plant Sub-System Code
3) Up to 4 alphanumeric characters for Function Code Identifier
4) 2 numeric characters as Unit Identifier
5) 3 numeric characters as equipment/line number
6) 2 numeric characters for Sequence number
7) 1 trailing alpha-character for redundant instrumentation (if required)

F. Display Modes:

Overview Display: An overview display shall enable the operator to determine the overall operation of a large segment of the plant. This overview shall have page connections to all other display screens. Navigation shall be designed to take only two clicks of the mouse to get to any piece of equipment from any graphic (not including faceplate).

Graphic Displays: Dynamic interactive graphics of all sections of the plant shall be able to be displayed on any operator workstation. Graphic displays shall use symbols from a library of standard/user defined graphic symbols. Different plant systems shall be displayed on different pages.

Graphics Configuration: Seller shall provide complete graphics configuration for all operator interface functions for plant operation. This includes interface to all functionalities controlled by the DCS as well as summary displays (for example, turbine monitor screens) for items monitored by the DCS. Seller shall submit draft and final screen displays to Company for review in accordance with the deliverable schedule.

Seller shall utilize the Company's standard graphic symbols.

Each PID shall be able to be displayed as a faceplate with an analog type display of variables such as measured process variable, set point and controller output. Faceplates shall have a scale in engineering units with appropriate divisions.

Pointers (arrows) or any other identifiable symbols shall display high/low limits of output and alarm limits for process variables. In the case of status inputs, these shall be displayed with an indication of status (e.g., open or closed, etc.).

All rotating equipment shall have a graphic start and stop button on a graphic screen.

Seller shall arrange the control systems graphics in a hierarchical or tree structure starting with plant overall performance summary with branching into each major component; CTGs, HRSGs, STG, condenser, SWYD/SWGR, and BOP. Company will supply sketches for all required DCS graphic displays, text displays, and faceplate displays along with descriptions of dynamic actions, such as color changes, alarm messages, pop-up window, etc.. Graphics will incorporate Emerson's latest combine-cycle standard macros and Company's standard macros for equipment operation. Equipment with permissives to start or stop shall use Emerson's Diagnostic Window Center, and details of all the permissives and their current status will be displayed. Equipment with automatic functionality will have indication of the current automatic or manual status on the macro (or next to the macro), such that the status is visible on the main graphic without opening a faceplate.

Motors larger than 480VAC shall show run times, thermal capacity, thermal capacity alarm, estimated trip time on overload, average motor load, average motor current, motor speed and temperatures on the graphic if I/O is available.

G. Alarm Functions:
Alarming shall be programmed per Company's and/or Site's standards.

The DCS shall be capable of alerting the operator to abnormal process conditions or internal control system faults. All alarms generated shall be able to be displayed on an operator workstation using color change. Alarm displays shall comply with ANSI/ISA-18.1-1979 - (R2004) and ANSI/ISA-18.2-2009.

The DCS shall alert the operator to each alarm with an audio and a visual signal. Regardless of the current display on the screen, the operator shall be able to call up the relevant alarm display with a single keystroke or mouse click. The system shall be designed so that all alarms can be acknowledged from any operator workstation.

Alarms and interlocks shall be designed based upon an "open to alarm" philosophy.

First-Out Alarms & Sequence of Events: The DCS shall provide a first out alarm resolution capacity. In the case of an avalanche of alarms, the system shall be able to discriminate between them by time and date tagging the alarms in the order of their occurrence. Repeat contacts, if specified, shall be available from the DCS generated alarms and for the field instruments alarms to be interfaced with external hard wired annunciators. The audio alarm must have a minimum of five discernible tones. However, more than five tones are preferred. The tones shall be assignable depending on alarm priority, or the kind of alarms (e.g., process alarms, operation error, and diagnostic alarms).

7. MEETINGS

A. Kick-off Meeting:

Seller shall attend a project kick-off meeting within two (2) weeks after the Company's contract award with the Seller. The following subjects, as a minimum, shall be discussed:

- Project organization and working protocol
- Seller's project implementation plan
- Overall project schedule
- Overall configuration
- System jobsite training (operators and technicians)
- Documentation format

B. Design Review Meetings:

Two (2) design review meetings be conducted with all parties involved to incorporate all of the Company's total requirements and preferences. There shall be at least two (2) design reviews prior to final system configuration. As a minimum, these meetings shall address the following:

- Hardware configuration
- System interface
- I/O database
- Software configuration (logic and functionals)
- Graphic displays
- Control logic
- Historian configuration
- Alarming
- Datalinks, and protective relaying.

C. Web-based Meetings:

Control logic shall be verified with simulation by Company prior to Factory Acceptance Test through two (2) web-based meetings with the Seller. Timing of web-based meetings shall be determined by the Seller.

D. Weekly Meetings:

Weekly conference call meetings with web conferencing shall be conducted between Seller and Company team members to discuss the status of the project. An action item list shall be maintained and discussed during these calls. Timing of weekly meetings shall be determined during kick-off meeting.

8. SERVICES

A. Field Services:

See Appendix 6 for service representative requirements.

B. Project Management:

Seller shall include an experienced project manager to plan, control, monitor and report the status of the overall project.

Seller shall be responsible for, but not limited to, the following:

- Project kick-off meeting
- Weekly review meetings with web conferencing.
- System configuration and hardware manufacturing schedule.
- Detailed development and implementation schedule.
- Contract administration and monthly status reports.
- Initialization and verification of the system hardware at the Seller's factory.
- System Shipment
  Upon completion of the factory acceptance testing, Seller's project manager shall ready system hardware, software and documentation for shipment to Site. Project manager shall contact Company to coordinate an acceptable date for delivery prior to shipment.
- Overall Project Follow Up
  The Contractor's project manager shall provide overall project follow-up to ensure that the project is executed according to the agreed upon scope and schedule, and all punchlist items have been closed.

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE

1. Deliverables

****
The following is a list of minimum suggested deliverables and deliverable information. Revise per project requirements as necessary:
****

Software:
Software updates shall be provided for the duration of the warranty period.

Manufacturer Drawings and Documentation:
Documentation shall be provided for editing, loading and configuration of Seller's system and any sub-system within the Seller's scope. Where third-party hardware is utilized, Seller shall include manufacturer's operation and instruction manuals and cut sheets.

Deliverables shall be in accordance with the schedule located within.

All deliverables shall be submitted in electronic format. O&M Manuals shall be submitted in hard copy and electronic format. All "as shipped" drawings shall be provided in file format per Company's Vendor Drawing Standard.

Seller shall provide the following documentation as a minimum requirement:

a. Dimensioned outlined drawings (English dimension units).
b. System layout drawings.
c. Heat load and electrical load requirements.
d. Cabinet nameplate drawings.
e. Cabinet panel layout, schematics and wiring diagrams.
f. Monthly progress reports.
g. Project schedule.
h. Drawings and data with Company's interface.
i. QA/QC documentation.
j. Hardware documentation manuals (electronic and three (3) hard copies).
k. Termination list.
l. Database provided in Microsoft Access or Microsoft Excel format.
m. Mutually agreed upon factory acceptance testing forms.
n. Mutually agreed upon start-up and commissioning checklist forms.

Sensitive documentation shall be provided through Seller's FTP service only. Sensitive documentation to be determined during kick-off meeting.

Operation and Maintenance (O&M) Manuals:
O&M manuals shall include the following minimum information:

a. Installation instructions

b. Operating instructions
c. Maintenance instructions
d. Nameplate data
e. Manufacturer drawing/documentation
f. Bill of Material with vendor part numbers
g. Cut sheets and brochure data for all transformer auxiliary equipment
h. Recommended spare parts list
i. Certified (final) test reports
j. Storage and Handling instructions
k. Special tools required for installation, operation and/or maintenance
l. Warranty information

****

Include project-specific requirements for the following:

- Seller Deliverable Schedule
- Deliverable Format
- Deliverable Quantities
- Monthly Status Reports

****

2. PROPOSAL DATA REQUIREMENTS

DISTRIBUTED CONTROL SYSTEM (DCS) DATA SHEET

Seller shall provide the following minimum technical data applicable to the equipment in the proposed scope of supply.

DISTRIBUTED CONTROL SYSTEM	REQUIREMENTS	SELLER RESPONSE
Manufacturer	Seller	
Model	Seller	
Location of Assembly:		
City, State	Seller	
Country	Seller	
HARDWARE PARAMETERS:		
Operator Workstation(s):		
Quantity		
Computer Manufacturer	Seller	
Computer Model	Seller	
Hard-drive size(s)	Seller	
RAM	Seller	
Monitor Manufacturer and Model No.	Seller	
Monitor Quantity and Size(s)		
Monitor Stand Included		
Heat and Electrical Load	Seller	
Desktop or Rackmount		
Engineering Workstation(s):		
Quantity		
Computer Manufacturer	Seller	
Computer Model	Seller	
Hard-drive size(s)	Seller	
RAM	Seller	

Monitor Manufacturer and Model No.	Seller	
Monitor Quantity and Size(s)		
Monitor Stand Included		
Heat and Electrical Load	Seller	
Desktop or Rackmount		
Domain Server(s):		
Quantity		
Computer Manufacturer	Seller	
Computer Model	Seller	
Hard-drive size(s)	Seller	
RAM	Seller	
Monitor Manufacturer and Model No.	Seller	
Monitor Quantity and Size(s)		
Monitor Stand Included		
Heat and Electrical Load	Seller	
Desktop or Rackmount		
Historian Workstation(s):		
Quantity		
Computer Manufacturer	Seller	
Computer Model	Seller	
Point count of license(s)		
Hard-drive size(s)	Seller	
RAM	Seller	
Monitor Manufacturer and Model No.	Seller	
Monitor Quantity and Size(s)		
Monitor Stand Included		
Heat and Electrical Load	Seller	
Desktop or Rackmount		
Anti-Virus Server:		
Quantity		

Computer Manufacturer	Seller	
Computer Model	Seller	
Hard-drive size(s)	Seller	
RAM	Seller	
Monitor Manufacturer and Model No.	Seller	
Monitor Quantity and Size(s)		
Monitor Stand Included		
Heat and Electrical Load	Seller	
Desktop or Rackmount		
Additional Monitors:		
Quantity and Size(s)		
Printer(s):		
Quantity		
Manufacturer and Model No.	Seller	
Color or B/W printing		
Print size(s)		
DCS Controllers:		
Quantity		
Manufacturer/Model	Seller	
Processor type/speed	Seller	
SOE resolution (msec)	Seller	
Maximum I/O per controller	Seller	
Operating temperature limits	Seller	
Controller Cabinets:		
Enclosure type	NEMA 12	
Cabinet Lights	120V (house power)	
Cabinet Fan(s)	24VDC (fused)	
Heat and Electrical Load	Seller	
Height x Width x Depth & Weight		

Extended I/O Cabinets:		
Enclosure type	NEMA 12	
Cabinet Lights	120V (house power)	
Cabinet Fan(s)	24VDC (fused)	
Heat and Electrical Load	Seller	
Height x Width x Depth & Weight		
GPS Time Server:		
Manufacturer and Model No.	Seller	
Estimated I/O Counts:		
Digital Inputs		
Digital Outputs		
Analog Inputs (4-20mA)		
Analog Inputs (TC)		
Analog Inputs (RTD)		
Analog Outputs		
Non-redundant Datalinks (quantity/# of points)		
Redundant Datalinks (quantity/# of points)		
Network:		
Network Switch(es)		
Network Router(s)		
DMZ Router(s)		
Network Media Converters		
Media Converter Racks		
Software:		
Number of custom main Graphics		
Number of macro Graphics		
Service(s):		

Days of field service assistance		
Number of trips		
Days of phone support		
Days of training		
Quantity of documentation for students in training		
Hardware Factory Acceptance Testing (days)		
Software Factory Acceptance Testing (days)		
Design Review (days)		
O&M Manuals:		
Hardcopies		

Seller shall provide, with bid, preliminary drawings showing: quantity of cabinets, door access requirements, dimensions and weights of cabinets, and an overview of network topology. Seller shall also provide heat rejection requirements of all power consuming Seller provided hardware. In addition, the Seller shall state any required cable separation, grounding and shielding requirements.

Seller's quality manual and project specific quality plan be submitted with Seller's bid material.

Seller shall state with the proposal the power requirements at each location for the equipment supplied. Seller shall list separate requirements for essential service feeds and utility power feeds.

Adds/Deletes:
Seller shall provide line item pricing to add and delete I/O modules, cabinets, power supplies, and controllers as necessary for changes in point counts during the design process. Delete pricing shall be valid until the hardware cutoff date. Add pricing shall be valid until the cabinet shipment date.

****
The following additional information shall also be included with proposals:

1. Seller variances, clarifications, and exceptions to the specification.
2. Itemization of proposed estimated materials.
3. Recommended spare parts list with pricing.

Documentation:

Seller shall provide, with offer, a list and examples of its standard deliverables. Deliverables should include (but are not limited to):

- Network and Communications Overview Drawing
- Termination Lists (Hardcopy and Excel format)
- Cabinet, Console, and I/O Module Layout Drawings
- Power Consumption Drawings
- Functional logic drawings based upon Engineer's narrative for review

****

3. PERFORMANCE GUARANTEES

****
Revise Appendix 3 according to project-specific requirements.

Discuss with Sourcing the Master Service Agreement terms already established with DCS sellers to determine what performance guarantees (LDs) to add.
****

DCS Final Acceptance:
Completion will be based on Seller providing the completed Site acceptance testing documentation and provide deliverables listed in Appendix 1 to Company no later than thirty (30) days after completion; Company will provide approval. If applicable, the Release and Indemnity shall be executed by Seller and delivered to Company.

Maintenance of Work Progress:
Late submittal of logics, or submittal of substantially non-compliant logics, by Seller shall be equivalent day-for-day to late delivery of the DCS equipment. Late delivery of successful FAT, or delivery of hardware and software to Site per agreement delivery schedule shall be subject to termination on default.

4. SITE CONDITIONS AND REFERENCE MATERIALS

****
Include project-specific site location and condition requirements.

****

Site location:

Company's Cherokee Station site is located in Adams County, CO at 6198 Franklin St. Denver, CO 80216.

Meteorological data:

Table 1 below lists the major site conditions which are based on ambient weather conditions taken from several data references. The following abbreviations apply to this table:

DBT:	Dry Bulb Temperature
MCWB:	Mean coincident wet bulb for a given dry bulb temperature
AMSL:	Above Mean Sea Level

TABLE 1 – MAJOR SITE CONDITIONS

PARAMETER	**DATA**
Site Elevation	5131 feet AMSL
Site Ambient Conditions	
Record low dry bulb temperature: MCWB for record low DBT:	-29°F -29°F
99% winter design dry bulb temperature: MCWB for 99% winter design DBT:	-5°F -8°F
Average winter dry bulb temperature: MCWB for average winter DBT:	-35°F -29°F
Annual average dry bulb temperature: MCWB for annual average DBT:	50°F 39°F
Summer 1% dry bulb temperature: MCWB for summer design 1% DBT: (Comparable to ASHRAE cooling, 0.4% occurrence)	95°F 70°F
Record high dry bulb temperature: MCWB for record high DBT:	105°F 72°F
Dry bulb temperature for ISO System Accreditation: MCWB for ISO System Accreditation DBT:	95°F 70°F
Relative Humidity Range	0% to 100%
Annual Average Precipitation	18 inches
Maximum 24 Hour Rainfall Total	3 inches
Annual Average Snowfall	60 inches
Maximum 24 Hour Snowfall Total	48 inches

Seismic Criteria:

Structures shall be designed using the seismic criteria in the IBC as applicable to Colorado. Basic seismic parameters, per the IBC, are as follows:

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration at a short period (0.2 seconds), $S_s = 0.217g$.
Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration a 1 second period), $S_s = 0.056g$.
Seismic Importance Factor, $I_E = 1.25$.
Based on the information presented in the Geotechnical Report, the project site has been assigned to Site Class D, to be verified by a site-specific geotechnical report.

HVAC Design (typical):

TABLE 2 – TYPICAL INDOOR CONDITIONS

Building / Area	Indoor Temp.		Humidity Control	Minimum Ventilation Rate, Based on 15°F Temp Rise	Particulate Filtration Efficiency	Pressurization
	Max °F	Min °F	%RH	Ac / h	%	
Turbine building electrical rooms	74	68				
Control Room	74	68	50	ASHRAE STD-62	High / Low	Positive
PDC enclosures	74	68	N/A	ASHRAE STD-62	ASHRAE STD-62	Neutral

Reference Materials:

****

Note for DCS Ovation projects: Revise Appendix 4 to include Emerson Ovation control standard reference materials. Also, check with plant contact for site-specific control system standard reference materials if DCS is going into an existing facility.

Minimum existing plant materials to consider:

- Graphic and logic macros
- Alarm list configurations and priority levels
- Graphic color standards (ie. Red = close)
- Graphic navigation and hierarchy

****

5. QA/QC (Including Inspection Test Plans)

****
Revise this Appendix accordingly per project-specific requirements.
****

Inspection and Test Plans:

Seller shall submit their standard Factory Acceptance Test documents or Inspection and Test Plan (ITP) for approval in accordance with Appendix 1 requirements.

Quality Assurance and Quality Control:
Seller shall have in effect at all times, a QA/QC program that clearly establishes the authority and responsibility of those responsible for the quality system. Persons performing quality functions shall have sufficient and well-defined authority to enforce quality requirements that initiate, identify, recommend and provide solutions to quality problems and verify the effectiveness of the corrective action. The quality system shall provide for the planned and systematic control of all quality-related activities performed during design. Implementation of the system shall be in accordance with the Seller's quality manual and project specific quality plan.

Quality assurance and testing shall be designed to meet ISO 9000/9001 QA/QC procedures.

Inspection:
Company representative(s) will at a time (or times) mutually agreed to, visit the Seller’s facilities and inspect system progress with respect to software and hardware. The intent of such a visit will be to confirm that the typical logic used for various devices as well as the method for displaying field status information is in accordance with the project requirements, and that the hardware is constructed in accordance to Seller’s provided drawings and Company’s specifications prior to shipment. The items tested may include (but are not limited to):

- Hardware production progress
- Quality and Workmanship of hardware
- Confirmation that hardware provided matches drawings submitted
- Typical graphic status displays (permissive pop-ups, M/A stations, transmitter select blocks, standard and cascade PID loops, etc.)
- Logic template testing

During an inspection, the Seller shall make available to the Company a complete set of the latest Revision of hardware drawings.

****

Determine frequency of Company inspections of Seller's facilities during fabrication, prior to delivery, etc. and add requirements to this section as required. Review Company Intranet QA/QC Toolbox for various tools and templates for the following, as project requirements dictate:

- Shop inspection reports
- Non-conformance reports
- Release for shipment
- Site delivery receipt

Add these documents to this Appendix as required.
****

Factory Acceptance Test:
Two (2) formal Factory Acceptance Tests (FAT) shall be conducted in accordance with a written test procedure. The Seller shall furnish a written test procedure to the Company per the deliverable schedule for approval and revision. Company and/or Others will witness the entire FAT. The first FAT shall include complete testing and acceptance of all hardware provided by the Seller. The second FAT shall include complete testing and acceptance of all software.

Prior to staging the FAT, a full functional test of the programmed logic and graphics, and comprehensive test of the complete system shall be performed by the Seller. The purpose of this test is to ensure that reasonable measure has been taken to identify and correct programming errors before the FAT. Documented proof that the comprehensive system test has been completed shall be required prior to the start of the FAT. (100% I/O testing is required for the hardware test.)

The duration of the FAT will be in accordance with Appendix 2. Seller shall provide, at no additional cost, additional testing time. Seller shall include additional time for implementation of changes resulting from the FAT prior to shipment.

The Seller shall demonstrate that the DCS has capability to communicate with all defined foreign device interfaces (datalinks) at the FAT. (Such testing shall include simulation of protocols by Seller provided emulator(s) and/or Company provided field devices such as PLCs).

The seller shall furnish the following for the duration of the FAT:

- Complete system available for testing (all hardware and software)
- Sufficient number of trained personnel
- One complete set of "as built" functional logic diagrams with index for Company's use at the FAT
- One complete set of system reference manuals
- One complete set of Seller supplied drawings

- Any required testing equipment (may include: emulator(s) to test operation of input or output signals, multi-meters, signal generators, and emulator(s) to test datalink operation)

Testing procedure will typically include, but is not limited to:

- Demonstration of all modulating control loop action
- Demonstration of all operator interface function
- Demonstration of single point communication and power failure immunity
- Demonstration of spare capacity
- Demonstration of historical logging, reporting, and trending
- Demonstration of processor scan time and loading
- Operator keyboard functions
- On-line editing/tuning function
- Point forcing
- Display and printing routines
- Variable calculations
- Control logic testing
- Alarm output, management, and priority functions
- Demonstrate functionality of bumpless controller fail-over and power supply redundancy

Seller shall provide tie-back simulation logic to be used during the FAT. The simulation logic shall tie the control system outputs to their associated inputs in order to close the control loops and allow for control logic testing. Simulation logic shall be provided to Company at completion of software FAT.

It is expected that the Seller make minor adjustments and corrections that may be discovered during the FAT. If serious defects in design and performance are discovered, the FAT shall be discontinued and the test be repeated at Seller's expense after the necessary corrections are made.

The equipment shall not be shipped until a successful FAT has been completed as determined by the Company.

Upon completion of the test, and prior to shipping the system, Seller shall provide the Company with a complete "as shipped" system backup on suitable media.

All steam flow calculations and algorithm parameters shall be set according to site-specific process conditions prior to the FAT.

Completion and sign-off by Company of successful FAT does not relieve Seller of the requirements of this specification.

6. STARTUP, TESTING, AND COMMISSIONING

Site Pre-Energization Inspection:
At Company's request, Seller shall fully inspect power, grounding, network, etc. connections, prior to system energization at Site. Seller shall verify system is ready for energization.

Site Acceptance Test (SAT):
The DCS shall be completely tested at the job site after energization. All site testing shall be witnessed by representatives of the Engineer and/or Company. Seller shall provide a SAT procedure to be approved by Company. Schedule and scope of SAT shall be at Company's discretion. SAT will typically include (but is not limited to) demonstration of:

- All hardware
- All communication systems
- Alarms
- Graphics
- Reports
- Printing

Service Representatives:
Service representatives shall be technically competent, factory trained, experienced in the installation and operation of the equipment, and authorized by the Seller to perform the Work stipulated.

The duties of Seller's technical service representatives may include, but may not be limited to, the following:

a. Provide technical advice to assist the installation the equipment.
b. Inspect and complete all site acceptance testing documentation provided by Seller for the equipment after installation and directing any changes or adjustments required to assure proper operation.
c. Provide technical direction during startup and initial operation of the equipment.
d. Direct any warranty work.
e. Demonstrate to Company's personnel the operation and maintenance of the equipment.
f. Provide services required as a condition to providing the warranties and guarantees specified.
g. Make any required programming changes to the application software provided with the equipment.
h. Submit a service report to Company with information on whether or not the equipment is ready for operation.

i. Install patch and software updates during the commissioning phase.

All personnel who visit the Site are required to complete safety training before they are allowed to work. Seller shall provide a minimum of forty-eight (48) hours notice, in order for the Company to arrange for the safety training, before arriving at the Site.

Service personnel shall be at the Site at the times required to meet the overall construction schedule. The Seller will be notified as far in advance as possible when service personnel will be required. Service personnel shall not be removed from the Project without Company's approval.

Service personnel shall maintain a master set of as-builts of all drawings and data submitted. Prior to leaving the site, the service personnel shall submit a copy of all as-built drawings and data to the Company. The master set of as-builts shall be returned to the Seller for incorporation of comments and final submittal of all affected drawings and data to the Company.

Upon completion of installation and inspections, field service representatives shall submit a written report to the Company, including test data, daily reports and certification that the equipment is properly installed and ready for operation.

Service personnel supplied by the Seller shall follow Company's prescribed procedures on keeping records of service time and activities of service personnel while at the project Site. The following procedures shall be followed:

Upon arrival at the Site, the service representatives shall make their presence known to the Company and supply the Company with the following information:

- Name of representative(s)
- Company Name
- Company Purchase Order Number
- Local address and phone number
- Service to be performed

The service representative shall give the Company a written timesheet and daily report of the Work they performed each day. The representative must clear with the Company for any period spent away from the project for other than normal off-time and advise the Company how a representative can be reached in the event of an emergency.

7. PACKAGING, SHIPPING, AND STORAGE

Seller shall prepare equipment for shipment following successful completion of factory acceptance testing and resolution of QA/QC non-conformances (see Appendix 5 for additional details).

Shipping shall be FOB jobsite, freight prepaid and allowed.

Delivery address:

****

Insert project-specific shipping address for jobsite or electrical enclosure vendor's site.

****

Cabinets may be broken down into smaller sections to allow for ease of shipment and installation.

Seller shall prepare equipment to withstand any possible damage or loss due to rough handling during transit.

Lifting points shall be clearly marked on the shipped equipment and eye-bolts shall be installed as required to allow for field handling, skidding, and hoisting.

Ancillary materials that are "shipped loose" shall be separately boxed and secured to a pallet for shipping and handling.

Seller shall provide the following minimum unloading/handling information:

- Shipping weight and dimensions of each article
- Pick points
- Rigging requirements
- Sensitivities

A QA/QC inspection certification, signed by the Seller shall be issued to the company prior to shipment. A copy of this certificate shall be included with the Bill of Lading.

Shipping documentation shall include the following minimum information:

- Company destination (Plant, Unit)
- Company agreement number
- Sellers order number
- Date shipped
- Shipping origin
- Company equipment tag information
- Seller's equipment identification information
- Shipment tracking information

- Shipment description
- Shipment quantity
- Gross weight
- Special handling requirements
- Identification of spare equipment
- Barcode, RFID, or similar material control information

Seller shall coordinate all deliveries with Company prior to shipment. Coordination shall include resolution of QA/QC non-conformances, delivery schedule, unloading/handling requirements, and storage requirements.

MASTER SPECIFICTION
FOR

Emergency Power Supply System

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
3-4-2015	1.0	Enhancements; Required Format

EMERGENCY POWER SUPPLY SYSTEM

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.

****

GENERAL

DESCRIPTION

****
Insert project-specific description items (i.e. new construction project, replacement project, project location, etc.).
****

SUMMARY

****
Insert project-specific scope of work summary items. Revise the following *example* as required
****

Seller shall design, test and deliver [quantity], [fuel type], [service duty rating] emergency power supply systems (EPSS). EPSS ratings shall be as specified in Appendix 2.

Seller shall be responsible for the following:

a. Design, testing and delivery of EPSS as specified herein.
c. Field assembly
e. Field testing
f. Operation and maintenance training for site personnel.

Company shall be responsible for the following:

a. Foundation(s)
b. Equipment unloading and setting
c. Single-point auxiliary power connection
d. Control connections
e. Grounding connections

Company personnel shall be able to access factory during EPSS assembly and to witness testing. Seller shall provide manufacturing schedule and schedule updates. Travel costs for Company personnel for site factory visits are the responsibility of the Company.

Reference Drawings

The following drawings, included in Appendix 4, contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Control and Protection Schematic Diagrams
- Auxiliary equipment connection details.
- EPSS Load List:

Technical Proposal Documentation

See Appendix 2 for technical proposal requirements.

APPLICABLE CODES AND STANDARDS

- State and local codes, laws, ordinances, rules and regulations
- ANSI - American National Standards Institute
- ASTM - American Society for Testing and Materials
- ICEA - Insulated Cable Engineers Association
- IEEE - Institute of Electrical and Electronic Engineers
- NEMA - National Electrical Manufacturer's Association
- NFPA - National Fire Protection Association
- OSHA - Occupational, Health and Safety Administration
- UL Underwriter's Laboratories

In the event of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

ENVIRONMENTAL

EPSS shall be manufactured to withstand site environmental conditions. See Appendix 4 for site specific environmental conditions.

****

Coordinate fuel specifications, emission requirements, fuel storage, acoustic requirements, etc. with Xcel Environmental prior to finalizing spec. Insert additional requirements in this section and in Appendix 2 as required.

****

RATINGS

EPSS ratings shall be as specified in Appendix 2 Data Sheets.

DESIGN & CONSTRUCTION FEATURES

1. EPSS system shall be mounted on a common steel base and housed in an enclosure per Appendix 2.

2. EPSS shall be equipped with all auxiliary equipment required to locally and remotely operate the unit.

3. EPSS shall be provided with all electrical equipment, including transformers, required to operate EPSS low voltage equipment from Owner-provided single-point auxiliary power connection.

4. All EPSS motor starters, breakers and related electrical equipment shall be integral to the EPSS.

ENGINE

1. Engine shall be a low-emission, liquid-cooled engine in accordance with Appendix 2.

****

Coordinate fuel specifications, emission requirements, etc. with Xcel Environmental for additional engine-related specifications. Insert additional requirements in this section and in Appendix 2 as required.

****

VIBRATION ISOLATION

1. Engine and generator shall be mounted to the common steel base with vibration isolation mounts. Isolation mounts shall not amplify seismic forces.

ENCLOSURE

1. EPSS shall be fully enclosed in an integral weatherproof enclosure.
2. Enclosure shall provide access for routine maintenance and removable sections for major maintenance access.
3. Enclosure lighting shall be provided with switches at each access point.
4. See Appendix 2 for enclosure acoustical requirements.

5. Each phase conductor shall be installed in a weather-tight and dust-tight enclosure. The enclosure shall be electrically bonded to eliminate induced currents in the surrounding metallic structures.
6. Each bus and each electrical connection between bus enclosures shall provide a continuous path for currents equal to the maximum current ratings of the enclosed bus.
7. Contractor shall provide bus transition sections for connection of bus duct to the following equipment:

FIRE DETECTION

1. Fire/heat detection per NFPA shall be provided to detect fire inside the enclosure.
2. Fire detection system shall include a fire alarm control panel with remote alarm connections.
3. Fire alarming shall include an external fire alarm horn and strobe.
4. Fire detection shall not falsely activate during normal operation.

STARTING SYSTEM

1. An electric starting system shall be supplied with the following minimum equipment:
    a. Batteries
    b. Battery charger

   c. Battery rack
   d. Battery heating pads (if required)
   e. Cell connectors
   f. Auxiliary components required to start EPSS without external AC power available.
2. Starting system shall not require an external AC power supply for starting or operation.
3. Battery shall be sized to provide a minimum of five (5) starts with 30 seconds cranking for each start attempt.
4. Battery charger shall be sized to fully recharge the battery within 12 hours, minimum.
5. Battery charger shall have a charger trouble alarm, loss of power alarm and an automatic equalize timer for fast recharge.
6. DC motor-driven equipment shall be provided as required (e.g. startup fuel priming pump, etc.).

LOADING

1. EPSS shall be capable of accepting load up to its full rating with the largest load step equal to the largest emergency load plus 15%.

FUEL SUPPLY SYSTEM

1. A regulated-flow fuel system supply shall be furnished to maintain constant rated speed regardless of load variations.
2. The fuel system shall include the following minimum equipment:
   a. Engine governor
   b. Fuel metering equipment
   c. Actuator
   d. Strainer
   e. Engine-driven fuel pump
   f. Relief valving
   g. Fuel filtration
   h. Fuel cutoff valving
   i. Fuel pressure instrumentation

FUEL TANK

1. An integral fuel tank shall be provided within the confines of the common steel base.
2. Tank shall be sized per NFPA requirements.
3. Tank shall have the capability to be connected to an external fuel tank.
4. All associated valves, piping and pumps shall be provided to interconnect the tank with the EPSS equipment.
5. Tank shall be equipped with a level gauge with low and high fuel level alarming.
6. Tank shall be double-walled with leak detection/alarming.
7. Fuel filling operations shall not affect the accuracy of fuel level indication system.
8. Tank shall be provided with the following minimum connections:
   a. Full-size fuel fill
   b. Full-size fuel return
   c. Screened vent

   d. Exterior fill
   e. Drain
   f. Two (2) level gauge connections
9. Above-ground storage tanks over 600 gallons which are used to store petroleum-based fluids shall be registered in the State of Colorado.

LUBRICATION SYSTEM

1. The EPSS lubrication system shall provide positive lubrication for all high-speed bearings and main gears. Pressure jets shall be provided for secondary gears. Remaining bearings and gears may be splash-lubricated.
2. Lubrication system shall include the following minimum equipment:
   a. Engine-driven oil pump
   b. System pressure regulator
   c. Engine block heater
   d. Lube oil heating
   e. Lube oil circulating pumping
   f. Full-flow filtration
   g. Heat exchanger
   h. Pressure and temperature monitoring
3. Lube oil heat exchanger shall be integral to the unit base and shall utilize engine coolant as the coolant medium.
4. DC motor-driven equipment shall be provided as required (e.g. startup fuel priming pump, etc.).
5. Provisions for removal of used engine and lube oil shall be provided.

AIR FILTRATION

1. Dry-type filters shall be provided for engine intake airflow.
2. Airflow monitoring shall be provided and shall include indication of filter restriction.
3. Air filtration shall have automatic louvers which open during equipment operation.

EXHAUST SYSTEM

1. The exhaust system shall include the following minimum equipment:
   a. Exhaust silencer
   b. Expansion joints
   c. Interconnecting duct work
   d. Exhaust piping
2. Exhaust system shall prevent ingress of moisture into the system.

GENERATOR

1. The generator shall be a synchronous unit rated for direct connection to the engine.
2. Generator shall include damper windings and shall conform to the applicable industry standards for synchronous, salient-pole machines.

3. The generator and exciter shall be provided with an open, drip-proof, fully-guarded, screened enclosure.
4. Generator shall have a rated capacity equal to, or greater than, the maximum engine overload capacity at the rated power factor load (see Appendix 2 for details).
5. Generator shall be able to operate at maximum capacity, continuously and at reduced loading during maximum enclosure ambient temperatures.
6. Generator shall be able to maintain voltage, current and frequency within the allowable tolerances for all connected loads.
7. Stator windings shall be form wound with vacuum pressure impregnation (VPI).
8. Field and stator winding shall be coated with fungus-resistant resin.
9. Generator total harmonic distortion (THD) shall be less than 5%.

GENERATOR INSULATION SYSTEM

1. The insulation system of field and stator shall be a minimum of Class F (155 °C hot spot). Based on the maximum ambient conditions and a 10 °C hot spot allowance, the temperature rise ratings (resistance method) shall not exceed the following:

SERVICDE DUTY	CLASS F INSULATION (155 °C hot spot)	CLASS H INSULATION (180 °C hot spot)
Standby	130 °C	150 °C
Prime	105 °C	125 °C
Continuous	80 °C	105 °C

GENERATOR EXCITATION SYSTEM

1. Generator/excitation system shall be capable of sustaining 300% of rated full-load current 10 seconds during fault current conditions.
2. Generator excitation system shall include an automatic voltage regulator (AVR) with three-phase sensing. AVR shall have over-excitation protection.
3. Generator voltage shall be able to be manually adjustable.

GENERATOR NEUTRAL GROUNDING

1. Generator shall be grounded via neutral grounding equipment (transformer, resistor, current transformers, etc.).

WIRING

1. EPSS internal wiring and raceway shall be factory installed and factory tested.
2. All internal wiring shall be installed in wiring gutters, conduit, or raceway.
3. All power supply circuits shall be protected via fuses or circuit breakers.
4. All control wiring shall be 600V, SIS, VW-1, XLPE, gray, switchboard wire.
5. Internal wiring shall have heat-shrink wire markers at both ends of conductors, labeled with wire termination information.
6. Minimum wire size shall be #10 AWG for current transformer circuits and #14 AWG for all other circuits.
7. Wiring shall be protected from contact with sharp edges with grommet material.
8. Flexible wire guards shall be installed for wiring which cross hinge points.

9. Terminal blocks shall be provided with a minimum of 20% spare terminals.
10. When compatible with Manufacturer's standard supply, all circuits shall be terminated with ring-type connectors.
11. All spare contacts shall be wired to terminal blocks.
12. Current transformer circuits shall be wired to shorting terminal blocks.

UNIT JUNCTION BOXES

1. EPSS units shall have the following separate unit junction boxes:
   a. Generator output terminals
   b. Auxiliary AC power
   c. Auxiliary DC power
   d. Instrumentation and control

PRIMARY CONNECTIONS

1. Generator terminal compartment shall be sized to accommodate primary connection stress cones as applicable.
2. Primary conductor vertical supports shall be provided at a minimum of 18 inch intervals.
3. Generator terminal compartment shall be sized to accept the size and number of conductors required to connect EPSS to Owner's system.

UNIT CONTROL AND PROTECTION

1. Integral unit control and protection panels shall be provided as part of the EPSS.
2. Panels shall be NEMA 12 with hinged fronts.
3. Unit control and protection panels shall be accessible from the exterior of the EPSS enclosure with weatherproof, transparent door sections which allow visual inspection of relays, alarms, etc.
4. Unit control and protection panels shall have anti-condensation heaters, as required.
5. A weatherproof emergency shutdown (ESD) mushroom switch shall be provided on the exterior of the EPSS enclosure in proximity to the personnel door. ESD shall have protective cover to prevent inadvertent operation.
6. See Appendix 2 and Appendix 4 for required EPSS protective relay requirements.

CURRENT TRANSFORMERS

1. Current transformers (CT) shall be provided per Appendix 2 for protective, monitoring and control functions.

VOLTAGE TRANSFORMERS

1. Voltage transformers (VT) shall be provided per Appendix 2 for protective, monitoring and control functions.
2. VTs shall be provided with current-limiting primary fuses

TEST SWITCHES

1. Test switches shall be installed for all protective relaying, metering, current and voltage inputs and relay outputs.
2. Test switches shall be ABB FT-1.
3. Current Transformer test switches shall be shorting type.
4. Test switches shall have black handles for current and voltage poles, red handles for trip poles.

GROUNDING

1. A continuous 2 inch-by ¼ inch (minimum) bare copper ground bus shall be provided for the entire length of the protection and control panels.
2. All associated equipment shall be connected to this ground bus.
3. A NEMA 2-hole, threaded bronze grounding pad shall be provided as part of the generator frame, adjacent to the main lead terminal housing.
4. Exterior NEMA 2-hole, threaded bronze grounding pads shall be provided on each end of the EPSS common frame.

POWER SUPPLIES

5. EPSS protection and metering equipment shall be fed via 125 VDC power supply.
6. EPSS auxiliary equipment shall be fed via Owner's single auxiliary AC power feed (see Appendix 2 for voltage/phase requirements).
7. Seller shall provide all auxiliary transformers, distribution panelboards, motor starters, contactors, circuitry, etc. to power all auxiliary EPSS loads.

BLACK START

1. EPSS shall be capable of starting, loading to full load and operating continuously without auxiliary power available.
2. All lube oil pumps, fuel pumps, and other motors required for black starting, shall be powered by the EPSS DC starting system.

EPSS CONTROL

1. EPSS shall include a governor and load controller capable of both automatic droop control and automatic isochronous frequency control.
2. Load control mode shall be locally and remotely selectable.
3. EPSS shall include automatic synchronization equipment to automatically raise/lower load and raise/lower voltage to permit synchronization with a live bus.
4. Following synchronization, the load controller shall ramp to a programmable, preset load setpoint.
5. EPSS shall also be capable of connecting to a dead bus in isochronous mode.
6. All equipment, software, software licenses, settings, temporary cabling, etc. shall be provided for setting and programming EPSS control systems.

EPSS CONTROL FEATURES

1. EPSS control system shall include the following minimum features:

a. Isochronous and Droop Control
b. Programmable preset default-loading setpoint – used when initially connecting the EPSS in droop control. When operating in isochronous control the load control setpoint shall automatically follow the isochronous operating load to allow for bumpless transfer when switching to droop control.
c. Automatic generator loading/unloading for bumpless load transfer.
d. Automatic synchronizing system which can be remotely or manually initiated. Automatic synchronizing system shall be able to select and synchronize the EPSS across its generator breaker or switchgear breaker. Automatic synchronizing system shall have capability for dead bus closing of the generator breaker.
e. Dead bus closing and live bus synchronizing.
f. Engine speed control.
g. EPSS black starting without auxiliary AC power.
h. Automatic and manual voltage control.
i. Automatic system to synchronize with utility following restoration of normal power.
j. Local and remote control interfaces

2. **Remote Control Functions** – EPSS control system shall accept the following remote control signals:

   a. START – EPSS shall perform the following upon closure of dry contact START command:
      i. EPSS shall start.
      ii. Live bus condition: EPSS shall synchronize to a live bus and ramp up in load to the preset loading value.
      iii. Dead bus condition: EPSS shall close its generator breaker and energize a dead bus.
   b. STOP – EPSS shall perform the following upon closure of dry contact STOP command:
      i. Droop control condition: EPSS shall unload, disconnect from the bus and perform normal shutdown.
      ii. Isochronous control condition: EPSS shall open its generator breaker and perform a normal shutdown
   c. RESTORE - EPSS shall perform the following upon closure of dry contact RESTORE command:
      i. Automatically synchronize across the bus main breaker and close that breaker when synchronized.
      ii. EPSS shall unload, disconnect from the bus and perform normal shutdown.
   d. ISOCHRONOUS MODE – EPSS shall operate in isochronous control upon closure of dry contact Isochronous Mode select command. EPSS shall operate in droop control when this contact is open.
   e. RAISE LOAD - EPSS shall perform the following upon closure of dry contact RAISE LOAD command:
      i. Droop control condition: EPSS shall increase load. Step change shall be programmable.
      ii. Isochronous control condition: EPSS shall increase speed. Step change shall be programmable.

f. LOWER LOAD - EPSS shall perform the following upon closure of dry contact RAISE LOAD command:
    i. Droop control condition: EPSS shall decrease load. Step change shall be programmable.
    ii. Isochronous control condition: EPSS shall decrease speed. Step change shall be programmable.

g. RAISE VOLTAGE - EPSS shall increase generator terminal voltage upon closure of dry contact RAISE LOAD command. Step change shall be programmable.

h. LOWER VOLTAGE - EPSS shall decrease generator terminal voltage upon closure of dry contact RAISE LOAD command. Step change shall be programmable.

i. PERMIT TO START – EPSS shall require a dry contact closure command to allow EPSS starting.

j. OPEN GENERATOR BREAKER – EPSS shall open its generator breaker.

3. **Remote Status/Alarms** – The following minimum EPSS remote status points shall be provided for connection to Owner's DCS system:

   a. READY FOR REMOTE START – A dry contact shall be provided which is closed when EPSS is ready to be started. Permissive logic for this contact closure shall include the Local/Remote switch is in "Remote" position.
   b. RUNNING – A closed dry contact shall be provided when EPSS is running.
   c. STOPPED – A dry closed contact shall be provided when EPSS is not running.
   d. EPSS TROUBLE – An open dry contact shall be provided when the EPSS detects trouble/errors with any EPSS equipment or system.
   e. PROTECTION TRIPPED – An open dry contact from the generator protective relaying shall be provided when the relaying trips.
   f. PROTECTION TROUBLE – An open dry contact from the generator protective relaying shall be provided for relay trouble outputs.
   g. GENERATOR BREAKER STATUS – Breaker position contacts shall be provided to verify breaker Open/Closed status.
   h. GEN BREAKRE PROTECTION TRIPPED – An open dry contact from the generator breaker protective relaying shall be provided when the relaying trips.

ALARMS

1. In addition to alarms and status indications required elsewhere in this specification, EPSS shall include the following minimum local alarms. All required remote status/alarms shall also be provided locally:

   a. Loss of AC power
   b. Loss of DC power
   c. Low battery voltage
   d. Battery charger trouble
   e. Governor trouble

f. Generator trouble
g. Excitation trouble
h. Low fuel level
i. High fuel level

STATUS/INDICATION

1. In addition to status indications required elsewhere in this specification, EPSS shall include the following minimum local status/indications. All required remote status/indication shall also be provided locally:

    a. Generator breaker position
    b. EPSS running status
    c. EPSS ready to load status
    d. Battery voltage
    e. Exhaust temperature
    f. Oil temperature
    g. Oil pressure
    h. Coolant temperature
    i. Hours of operation

HEATERS

1. EPSS shall be furnished with heaters to maintain the interior of the enclosure and it components above dew point for all ambient conditions. See Appendix 4 for site conditions.
2. Engine heater and control system shall be provided.
3. Heater rated voltage shall be a minimum of 1.5 times the applied voltage.
4. Heaters shall be supplied with all internal wiring, branch circuit protection and raceway.
5. Enclosure heater control shall be via multiple thermostats.
6. Enclosure heaters shall be interlocked such that heaters are de-energized while the unit is operating.

NAMEPLATES

1. Engraved nameplates shall be furnished on the outside of EPSS.
2. EPSS nameplates shall be stainless steel.
3. Nameplates shall indicate the following minimum information:
    a. Manufacturer's standard information
    b. Equipment description/name
    c. Equipment tag number
    d. EPSS equipment ratings
4. Engraved nameplates shall also be furnished for auxiliary devices and terminal blocks mounted inside EPSS enclosure, panels and compartments.
5. Nameplates shall be mounted using stainless steel, pan-head, self-tapping screws.

CATCHBASINS AND DRAINS

1. EPSS shall be provided with a single, valved, gravity-drain exit point.

TESTING

Testing requirements are defined in Appendix 6.

DELIVERABLES

Deliverable requirements are defined in Appendix 1.

PROPOSAL DATA REQUIREMENTS

Seller shall provide proposed equipment data in accordance with Appendix 2.

SITE CONDITIONS

Site conditions are defined in Appendix 4.

QUALITY ASSURANCE

QA/QC requirements are defined in Appendix 5.

PACKAGING STORAGE & SHIPPING

Packing, shipping storage requirements are defined in Appendix 7.

MATERIALS & WELDING

Additional materials and welding requirements are defined in Appendix 5.

PERFORMANCE GUARANTEES

Performance requirements are defined in Appendix 3

SOUND CONTROL REQUIREMENTS

EPSS equipment and enclosures shall be designed in accordance with the maximum allowable noise level requirements herein and in Appendix 2.

CLEANING, PAINTING & COATING

****
Fill in as required
****

SPARE PARTS

****
Fill in as required
****

APPENDICES TO SPECIFICATION

****
Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE MANUFACTURERS

APPENDIX 1

DELIVERABLES

****

The following is a list of minimum suggested deliverables and deliverable information. Revise per project requirements as required:

****

Manufacturer drawings:

1. Shipping layout drawings
2. Installation instructions/details including rigging information and equipment loadings
3. Dimensioned plan, elevation and detail drawings including engine details, generator details, auxiliary system details, weights, grounding details.
4. Bills of Material
5. Owner connection details
6. Nameplate schedule and details
7. EPSS one-line drawings
8. EPSS three-line drawings
9. Control and relaying/protective device schematics and wiring diagrams
10. Control panel layout drawings
11. Current transformer excitation curves
12. Panelboard schedules

Test data:

1. Factory test data/test report. See Appendix 6 for details.
2. Field test data/test report. See Appendix 6 for details.

Operation and Maintenance Manuals:

1. Operation and maintenance (O&M) manuals shall include the following minimum information:
    a. Installation instructions.
    b. Operating instructions.
    c. Maintenance instructions.
    d. Nameplate data.
    e. Assembly drawings.
    f. Bill of Material with vendor part numbers.
    g. Recommended spare parts list.
    h. Certified (final) test reports
    i. Storage and Handling instructions.
    j. Special tools required for installation, operation and/or maintenance.
    k. Warranty Information

Other:

1. EPSS control software, software licenses and control settings.

APPENDIX 1

DELIVERABLES

2. EPSS protective device software, software licenses and control settings.
3. EPSS protective device settings in native formats.

QA/QC:

Seller's QA/QC Inspection and Test Plan (ITP)

****
Include project-specific requirements for the following:
****

- Seller Deliverable Schedule
- Deliverable Format
- Deliverable Quantities

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

EMERGENCY POWER SUPPLY SYSTEM (EPSS) DATA SHEET

Seller shall provide the following minimum technical data applicable to the equipment in the proposed scope of supply.

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

EMERGENCY POWER SUPPLY SYSTEM (EPSS)	UNITS	REQUIREMENTS	SELLER RESPONSE
Manufacturer		Seller	
City & Country of Manufacture		Seller	
Service Duty		Standby	
Service Duty Load Factor	%	60	
GENERATOR:			
Real Power	kW	2250	
Apparent Power	kVA	2812	
Power Factor		0.8	
Synchronous Speed	RPM	1800	
Rated Nominal Voltage	kV	0.48	
Voltage Phases		3	
Phase Rotation		A, B, C	
Operating Frequency	Hz	60	
Insulation System		Seller	
Temperature rise	ºC	125	
Generator Enclosure		Seller	
Exciter type		Seller	
Voltage Regulation, no-load to full-load	%	+/-0.5%	
Frequency Regulation	%	+/-0.25%	
Total Harmonic Distortion	%	Less than 5%	

Generator cooling		Seller	
ENGINE:			
Configuration (block material, aspiration method, number of cylinders, etc.)		Seller	
Bore		Seller	
Stroke		Seller	
Displacement		Seller	
Battery capacity		Seller	
Starting voltage		Seller	
Air filter type		Seller	
Fuel filter		Seller	
Lube oil filter types		Seller	
Cooling system		Seller	
Emissions Compliance		EPA Tier II	
Fuel requirements:			
Max sulfur content		15 ppm	
Min Cetane index		40	
Max aromatic compound content	%	35	
Acoustical Requirements	dB	85	
Auxiliary Power Voltage/Phase		480V/3	
Protection and Control Voltage	VDC	125	
FINISH			
Color			

****

Coordinate fuel specifications, emission requirements, fuel storage, acoustic requirements, etc. with Xcel Environmental prior to finalizing spec. Insert additional requirements in this section and spec body

****

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

****

The following additional information shall also be included with proposals:

1. Seller variances or exceptions to the specification.
2. Itemization of proposed estimated materials.

****

APPENDIX 3

PERFORMANCE GUARANTEES

****
Typically, emissions guarantees are required for EPSS systems. Coordinate emission guarantee requirements with Xcel Environmental prior to finalizing spec.

Add any additional project-specific performance guarantees (e.g. generator electrical performance, fuel consumption, etc.) in this Appendix and spec body.

****

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

****
In addition to revising this spec to correspond to project-specific requirements, update all Appendix highlighted areas with project-specific data.
****

SITE CONDITIONS

LOCATION

Xcel Energy's Cherokee Station site is located in Adams County, CO at 6198 Franklin St.   Denver, CO 80216.

METEOROLOGICAL DATA

Table 1 below lists the major site conditions which are based on ambient weather conditions taken from several data references. The following abbreviations apply to this table:

DBT: Dry Bulb Temperature

MCWB: Mean coincident wet bulb for a given dry bulb temperature

AMSL: Above Mean Sea Level

APPENDIX 4

TABLE 1 – MAJOR SITE CONDITIONS

PARAMETER	DATA
Site Elevation	5131 feet AMSL
Site Ambient Conditions	
Record low dry bulb temperature: MCWB for record low DBT:	-29°F -29°F
99% winter design dry bulb temperature: MCWB for 99% winter design DBT:	-5°F -8°F
Average winter dry bulb temperature: MCWB for average winter DBT:	-35°F -29°F
Annual average dry bulb temperature: MCWB for annual average DBT:	50°F 39°F
Summer 1% dry bulb temperature: MCWB for summer design 1% DBT: (Comparable to ASHRAE cooling, 0.4% occurance)	95°F 70°F
Record high dry bulb temperature: MCWB for record high DBT:	105°F 72°F
Dry bulb temperature for ISO System Accrediation: MCWB for ISO System Accrediation DBT:	95°F 70°F
Relative Humidity Range	0% to 100%
Annual Average Percipitation	18 inches
Maximum 24 Hour Rainfall Total	3 inches
Annual Average Snowfall	60 inches
Maximum 24 Hour Snowfall Total	48 inches

APPENDIX 4

WIND LOADING

Wind loads shall be in accordance with the IBC. Basic wind design parameters are as follows:

DESCRIPTION	CHEROKEE	NOTES
Classification of Structure Category	III	Ref. ASCE 7-05, Section 1.5
Exposure	C	Ref. ASCE 7-05, Section 6.56
Wind Importance Factor	1.15	
Reference Wind Velocity, V	90 mph	3 sec. gust @ 33 ft. above ground. Ref. ASCE 7-05

SEISMIC CRITERIA

Structures shall be designed using the seismic criteria in the IBC as applicable to Colorado. Basic seismic parameters, per the IBC, are as follows:

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration at a short period (0.2 seconds), $S_s = 0.217g$.

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration a 1 second period), $S_s = 0.056g$.

Seismic Importance Factor, $I_E = 1.25$.

Based on the information presented in the Geotechnical Report, the project site has been assigned to Site Class D, to be verified by a site-specific geotechnical report.

APPENDIX 4

REFERENCE MATERIALS

The following drawings contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Control and Protection Schematic Diagrams
- Auxiliary equipment connection details.
- EPSS Load List

****
For each essential load to be connected to the EPSS add the following minimum information to the EPSS load list:
****

- o Load type (motor, static)
- o HP
- o Service Factor
- o Static kVA
- o Demand Factor
- o kW
- o kVA
- o kVAR
- o Full-load Current
- o Locked Rotor Current

APPENDIX 5

QA/QC (Including Inspection Test Plans)

****
Revise this Appendix accordingly per project-specific requirements.
****

QA/QC

INSPECTION AND TEST PLANS

Seller shall submit their standard Inspection and Test Plan (ITP) for approval in accordance with Appendix 1 requirements.

QA/QC INSPECTIONS/REPORTING

****
Determine frequency of Xcel inspections of Seller's facilities during fabrication, prior to delivery, etc. and add requirements to this section as required. Review Xcel Intranet QA/QC Toolbox for various tools and templates for the following, as project requirements dictate:

- Shop inspection reports
- Non-conformance reports
- Release for shipment, etc.

Add these documents to this Appendix as required.
****

WELDING

****
Discuss welding requirements with Xcel Quality during the spec development process and insert their most current requirements in this section.
****

APPENDIX 6

STARTUP, TESTING AND COMMISSIONING

****
The following are minimum suggested testing requirements. Revise per project requirements as required:
****

TESTING

Factory Testing:

1. Perform standard factory tests per Industry Standards referenced herein.
2. EPSS engine and generator shall completely factory assembled and tested to prove correct assembly and to verify ratings prior to shipment. The following minimum testing criteria apply:
    a. EPSS shall be operated at full-load for a minimum of 30 minutes.
    b. Vibration values shall be tested throughout the full-load test.
    c. Emission levels shall be tested throughout the full-load test.
    d. Noise levels shall be tested throughout the full-load test.
    e. Fuel consumption shall be tested throughout the full-load test.
    f. Control system operation modes, described herein, shall be tested.
    g. Point-to-point wiring verification shall be performed.
3. Submit test data/test reports in accordance with Appendix 1.

Shop Tests:

1. Perform standard shop tests in accordance with Industry Standards referenced herein.

****
Revise the following section per project-specific requirements. Minimum commissioning considerations are as follows:

****

COMMISSIONING

The following field commissioning services shall be provided by the Seller:

1. Furnishing of all required EPSS fluids including fuel, lube oil, coolant. EPSS fluids shall be filled after testing and shall be full as a pre-requisite for final acceptance.
2. Verification of all fluid levels.
3. Verification of proper EPSS installation.
4. Verification of all EPSS auxiliary system operation.
5. Test all alarms, safety shutdown devices for proper operation.

APPENDIX

STARTUP, TESTING AND COMMISSIONING

6. Verification of proper orientation and alignment of all EPSS components.
7. Verification absence of exhaust leaks, oil leaks, coolant leaks and excessive vibrations.
8. Performance of a 4-hour load test at full nameplate ratings using Owner's plant load. Record the following minimum values at 15 minute intervals:
   a. Service meter hours
   b. Voltage per phase
   c. Current per phase
   d. Frequency
   e. Power Factor
   f. VARS
   g. Engine coolant temperature
   h. Oil Pressure
   i. Fuel Pressure
   j. Ambient temperature
9. Protective relay testing
10. Full operational mode testing for each EPSS operation mode described herein.
11. EPSS electrical field testing per NETA guidelines.
12. Operation and maintenance training for Owner personnel.

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

PACKAGING, SHIPPING AND STORAGE

Seller shall prepare equipment for shipment following successful completion of factory testing and resolution of QA/QC non-conformances (see Appendix 5 for additional details.

Seller shall prepare equipment to withstand any possible damage or loss due to rough handling or exposure to weather during transit or extended outdoor storage (up to two (2) years).

Seller shall install all required covers to protect equipment from rain, hail, wind, dust, snow and environmental conditions detrimental to the equipment.

Equipment shall be adequately sealed and protected during shipment to prevent corrosion, foreign matter egress and freeze damage which could result from the presence of residual water.

Lifting points and centers of gravity shall be clearly marked on the shipped equipment.

Shipping structural bracing shall be installed as required to allow for field handling, skidding and hoisting.

Equipment supplied with space heaters shall have heater leads accessible without requiring disassembly of shipping containers.

Threaded outlets shall have plugs or caps installed prior to shipping.

Ancillary materials which are “shipped loose” shall be in separately boxed and re secured to the main equipment containers.

Seller shall provide the following minimum unloading/handling information:

- Shipping weight and dimensions of each article
- Pick points
- Rigging requirements
- Weight distribution
- Center of gravity
- Sensitivities
- Hazards

A QA/QC inspection certification, signed by the Seller shall be issued to the company prior to shipment. A copy of this certificate shall be included with the Bill of Lading.

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

Shipping documentation shall include the following minimum information:

- Company Destination (Plant, Unit)
- Company Agreement number
- Sellers order number
- Date shipped
- Shipping origin
- Company equipment tag information
- Seller's equipment identification information
- Shipment tracking information
- Shipment description
- Shipment quantity
- Gross weight
- Special handling requirements
- Identification of spare equipment
- Barcode, RFID, or similar material control information

Seller shall coordinate all deliveries with Company prior to shipment. Coordination shall include resolution of QA/QC non-conformances, delivery schedule, unloading/handling requirements, and storage requirements.

APPENDIX 8

ACCEPTABLE MANUFACTURERS

****
The following list contains the typically preferred manufacturers. Coordinate with Xcel Sourcing to determine final bid list:
****

Acceptable manufacturers are as follows:

- Caterpillar
- Cummins
- Detroit Diesel

MASTER SPECIFICTION
FOR
Isolated Phase Bus Duct

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
12-5-2014	1.0	New

ISOLATED PHASE BUS DUCT

GENERAL

DESCRIPTION

****
Insert project-specific description items (i.e. new construction project, replacement project, project location, etc.). Revise the following *example* as required:
****

The isolated phase bus duct shall be designed and constructed for use on an 18 kV, 3-phase, 60-hertz system.

One complete sectionalized assembly of a three phase, weatherproof, self-cooled, zero-flux design bus duct shall be required for connection from the generator main terminals to the generator step-up (GSU) transformer. Bus run taps shall be furnished for connection to the generator potential / surge equipment cubicle and generator excitation transformer for each turbine-generator package.

Bus duct provided under these Specifications shall include all fittings, bus-to-equipment terminations, supports, flexible connectors, accessories, connection hardware and any special tools required for a complete installation.

SUMMARY

Reference Drawings

The following drawings, included in Appendix 4, contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Bus Duct Layouts
- Transformer Connection Details
- Generator Connection Details
- Auxiliary equipment connection details.

Technical Proposal Documentation

See Appendix 2 for technical proposal requirements.

APPLICABLE CODES AND STANDARDS

- State and local codes, laws, ordinances, rules and regulations
- ANSI - American National Standards Institute

- ASTM - American Society for Testing and Materials
- ICEA - Insulated Cable Engineers Association
- IEEE - Institute of Electrical and Electronic Engineers
- NEMA - National Electrical Manufacturer's Association
- NFPA - National Fire Protection Association
- OSHA - Occupational, Health and Safety Administration
- UL Underwriter's Laboratories

In the event of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

DESIGN & CONSTRUCTION FEATURES

1. **Environmental**

   Isolated phase bus duct shall be manufactured to withstand site environmental conditions. See Appendix 4 for site specific environmental conditions.

2. **Ratings**

   Isolated phase bus duct ratings shall be as specified in Appendix 2 Data Sheets.

BUS CONSTRUCTION

1. Bus duct construction shall be high conductivity circular aluminum with welded joints and shall be in accordance with IEEE C37.23.

2. All bus conductor terminations shall have bolted connections. All bolted joints shall have silver-to-silver contact surfaces. Bolts shall be stainless steel.

3. Bus conductors shall be installed with wet-process porcelain insulating supports capable of withstanding the mechanical forces (compression, tension, and cantilever) imposed by short-circuit currents, and all other loading requirements.

4. The bus hot-spot and temperature rise ratings shall be greater than or equal to the worst-case hot-spot and temperature rise ratings of the equipment bushings connected to the bus.

5. Bus insulators shall be designed to allow bus thermal expansion.

6. Bus insulators shall be provided with externally removable, bolted access panels to allow maintenance/replacement of insulators without requiring bus disassembly.

7. See Appendix 5 for bus welding requirements.

ENCLOSURE CONSTRUCTION

****
This spec section is for a typical self-cooled bus duct system. Add project-specific forced-cooling requirements as applicable.
****

1. Bus duct enclosures shall be fabricated from high conductivity aluminum sheets formed into a circular shape with fully welded longitudinal seams.
2. Bus duct enclosures shall be zero-flux, continuous, and weatherproof for an indoor/outdoor installation.
3. Hardware for all fasteners used on the exterior portions of the duct shall be stainless steel.
4. Each phase conductor shall be installed in a weather-tight and dust-tight enclosure. The enclosure shall be electrically bonded to eliminate induced currents in the surrounding metallic structures.
5. Each bus and each electrical connection between bus enclosures shall provide a continuous path for currents equal to the maximum current ratings of the enclosed bus.
6. Contractor shall provide bus transition sections for connection of bus duct to the following equipment:

   ****
   Insert project-specific requirements for bus transition sections (new equipment, connection to existing transitions, etc.). Examples of bus connected equipment are as follows:
   ****

   a. Generator main terminals
   b. VT/surge cubicle terminals
   c. GSU transformer terminals
   d. UAT terminals
   e. Excitation transformer terminals
   f. Generator breaker terminals
   g. Interior-to-exterior transitions

7. Bus transition sections shall have externally removable, gasketed access panels which allow removal and connection of flexible bus connectors. Minimum access panel openings shall be two (2) feet by two (2) feet.
8. Bus shall be designed to permit removal of equipment bushings with a minimum of bus disassembly and without cutting/re-welding any part of the bus assembly.
9. Expansion joints shall be provided at all bus transition sections and at all fire stop isolation barriers to prevent mechanical stresses due to bus thermal expansion and equipment vibration.
10. Vapor isolation barriers or seal-off bushings shall be furnished at each equipment termination location, where required to provide an airtight seal.
11. Filtered drain plugs shall be provided for bus duct enclosure low points.
12. Bus duct enclosures and transition sections shall be primed and finish painted in accordance with the manufacturers’ standard.
13. Bus enclosure shorting plates shall be provided at all equipment transition sections.
14. Outdoor bus shall be constructed to allow for the effects of solar radiation heat

gain without the use of separate heat shields.

15. Sealing, 2-hour fire-stop isolation barriers shall be provided at the generator, building walls and at transformer containment walls.

16. See Appendix 5 for enclosure welding requirements

<u>CONDENSATION CONTROL</u>

1. Condensation control shall be via space heaters or pressurized air as specified in Appendix 2.

****

Choose either Space Heater of Pressurized Air section below depending on project requirements.

****

2. Space Heaters

a. Anit-condensation space heaters shall be located and thermally insulated to prevent surface damage or discoloration. Space heater capacity shall maintain the compartment and the bus duct internal temperature above the dew point temperature under all operating conditions.

b. Bus duct heater monitoring shall be provided at ground-level control panels. Heater control panels shall provide the following minimum equipment:

   i. Local indication of the status of bus duct heater operation
   ii. Local indication of heater faults.
   iii. One (1) Form C, common alarm relay for remote panel monitoring via Owner DCS.

c. Heaters shall be rated for 240 VAC and energized and sized for application at 120 VAC. Space heaters shall be controlled by an adjustable thermostat, factory set at the Manufacturer’s recommended set points. Space heaters shall be completely factory wired except for shipping split connections.

3. Positive Air System

a. A tap connection in each phase bus run shall be provided for connection to plant dry instrument air. The positive pressure air provisions are intended to pressurize the bus enclosure to prevent dust or moisture entering the bus enclosure.

b. One connection point for air supply and metering and one connection point for pressure monitoring shall be furnished in each phase bus enclosure. Connection points shall be 1/2 inch NPT; shipped with plugs. All air supply and metering connection points shall be at the top of enclosure.

c. Pressure regulating stations, including orifices, valves, and filters shall be provided to regulate the compressed air within pressure limits of the bus enclosures. Each phase bus enclosure run shall be equipped with a pressure relief valve to prevent bus damage in case of regulator device failure, exposing the duct to high supply pressure.

d. Pressure regulating stations shall also include the following minimum equipment:

   i. Airflow monitoring instrumentation

ii. Air pressure instrumentation
iii. Form C relay outputs for high pressure, low pressure and system fault. Relay outputs shall be used for remote DCS monitoring.

e. Manual valves shall be furnished with the pressure regulator system to allow manual purging of each phase bus enclosure.
f. Seal-off assemblies shall be furnished to prevent air leakage from the bus enclosure to all transition sections.

EQUIPMENT TERMINATIONS

1. Flexible connectors and bus duct termination enclosures/fittings shall be provided for bus-to-equipment terminations.
2. Flexible connectors, with non-magnetic bolts, shall be provided at all electrical equipment terminals and allow a minimum of 1-inch movement of any phase lead in any direction.
3. Removable, flexible, braided connectors shall be supplied to provide electrical insulation between bus duct and equipment, to isolate equipment vibration and to facilitate equipment testing and removal. Flexible connectors shall have a continuous current rating equal or greater than bus conductors.
4. The flexible connectors shall also serve as a disconnect means from the termination equipment and the bus conductors. Equipment shall be electrically isolated when the flexible connectors are removed.
5. Braided expansion links shall be installed at building penetrations on both the interior and exterior boundaries.

GROUNDING

1. A ground bus shall be furnished in parallel with each bus run to ensure all enclosures are grounded. Each ground bus shall be capable of carrying the rated bus short-circuit current.
2. The bus duct enclosure may serve as the ground bus provided it is constructed and connected such that it provides a continuous path for the maximum calculated short-circuit current.
3. Ground pads with standard NEMA 2-hole or 4-hole spacing shall be provided for all bus ground connections.
4. All bolted clamping cover assemblies shall be provided with ground straps as applicable.

INFRARED INSPECTION PANES

1. Infrared (IR) inspection viewing panes shall be installed to permit thermography inspection of all bus duct equipment connections, transitions and expansion joints. IR inspection viewing panes shall be oriented to allow viewing from ground level.
2. IR inspection viewing pane NEMA rating shall be equal to, or greater than, that of the enclosure in which it is being installed.
3. IR inspection viewing panes shall be NFPA 70E compliant.
4. IR inspection viewing panes shall be 3” minimum diameter and shall consist of reinforced polymeric optic material.

BUS DUCT SUPPORTS

1. Bus duct supports shall be rigid, self-supporting, galvanized steel beams. Supports shall be designed to withstand environmental loads (wind, snow, seismic, etc.), listed in Appendix 4, while bus duct is operating at design conditions and under fault conditions.
2. The vertical loadings imposed at the equipment connections shall not exceed the manufacturer's maximum loading.
3. A support structure with four (4) columns shall be furnished for all 90-degree horizontal bends of the three-phase bus duct. 2-column support structures shall be furnished for straight sections of the three-phase bus duct runs.
4. Supports shall be finished per the following requirements:
    a. Support structures shall be galvanized steel by the hot dip process in accordance with ASTM A123. Structures shall be galvanized both inside and out after all cutting; punching, welding and cleaning have been completed.
    b. Finished galvanized surfaces shall be uniform in color, appearance and texture and shall be free of roughness, lumps and runs.
    c. Support locations shall be in accordance with NEC working clearance requirements and shall be at least 3 feet from mechanical equipment to allow maintenance access.
    d. Support locations shall be reviewed with Company to ensure unobstructed clearance for doorways, forklift access, roadway access, personnel egress and headroom prior to final design and installation.

TESTING

Testing requirements are defined in Appendix 6.

DELIVERABLES

Deliverable requirements are defined in Appendix 1.

PROPOSAL DATA REQUIREMENTS

Seller shall provide proposed equipment data in accordance with Appendix 2.

SITE CONDITIONS

Site conditions are defined in Appendix 4.

QUALITY ASSURANCE

QA/QC requirements are defined in Appendix 5.

PACKAGING STORAGE & SHIPPING

Packing, shipping storage requirements are defined in Appendix 7.

MATERIALS & WELDING

Additional materials and welding requirements are defined in Appendix 5.

PERFORMANCE GUARANTEES

****
Fill in Appendix 3 as required
****

SOUND CONTROL REQUIREMENTS

****
Fill in as required
****

INSTRUMENTATION & CONTROL REQUIREMENTS

****
Fill in as required
****

CLEANING, PAINTING & COATING

****
Fill in as required
****

SPARE PARTS

****
Fill in as required
****

APPENDICES TO SPECIFICATION

****
Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE MANUFACTURERS

APPENDIX 1

DELIVERABLES

****
The following is a list of minimum suggested deliverables and deliverable information. Revise per project requirements as required:
****

Manufacturer drawings:

1. Bus duct plan and elevation drawings showing phasing arrangement, weights and detailed dimensions.
2. Bus duct connection details.
3. Schematics/wiring diagrams and P&ID showing connections for bus condensation control.
4. Bus duct support types, details, anchor bolt plan, and support locations.
5. Bus duct nameplate data.

Test data:

1. Factory and field test data/test report. See Appendix 6 for details.

Operation and Maintenance Manuals:

1. Operation and maintenance (O&M) manuals shall include the following minimum information:
   a. Installation instructions.
   b. Operating instructions.
   c. Maintenance instructions.
   d. Nameplate data.
   e. Assembly drawings.
   f. Bill of Material with vendor part numbers.
   g. Recommended spare parts list.
   h. Certified (final) test reports
   i. Storage and Handling instructions.
   j. Special tools required for installation, operation and/or maintenance.

QA/QC:

1. Seller's QA/QC Inspection and Test Plan (ITP).

****
Include project-specific requirements for the following:
****

- Seller Deliverable Schedule
- Deliverable Format
- Deliverable Quantities

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

ISOLATED PHASE BUS DUCT DATA SHEET

Seller shall provide the following minimum technical data applicable to the equipment in the proposed scope of supply.

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

ISOLATED PHASE BUS DUCT	UNITS	REQUIREMENTS	SELLER RESPONSE
Manufacturer		Seller	
City & Country of Manufacture		Seller	
Duty Cycle		Continuous	
Cooling		Self-Cooled	
ELECTRICAL PARAMETERS:			
Bus Conductor Material		Aluminum	
Enclosure Material		Aluminum	
Rated Nominal Voltage	kV	18	
Rated Maximum Voltage	kV	27	
Operating Frequency	Hz	60	
Rated Continuous Current at Max Ambient - Main Bus	A	7500	
Rated Momentary Current (167 ms) – Main Bus	kA	130	
Rated Momentary Current (max peak) – Main Bus	kA	219	
Rated Short-Time Current (1 sec) – Main Bus	kA	75	
Rated Continuous Current at Max Ambient - Tap Bus	A	1200	
Rated Momentary Current (167 ms) – Tap Bus	kA	235	
Rated Momentary Current (max peak) – Tap Bus	kA	396	
Rated Short-Time Current (1 sec) – Tap Bus	kA	130	
Rated Bus Temp Rise Above Max Ambient	°C	65	

Rated Enclosure Temp Rise Above Max Ambient	°C	40	
Rated Insulation Level (BIL)	kV	125	
Rated One Minute Dry Frequency Withstand	kV	60	
Total Electrical Loss at Rated Current	Watts/3-phase foot	Seller	
CONDENSATION CONTROL:			
Pressurized Air System			
Normal Operating Pressurized Air System Usage	scfm	Seller	
Max (startup) Operating Pressurized Air System Usage	scfm	Seller	
WEIGHTS AND DIMENSIONS:			
Bus Conductor Outside Diameter - Main Bus	inches	Seller	
Bus Conductor Outside Diameter - Tap Bus	inches	Seller	
Bus Conductor Wall Thickness - Main Bus	inches	Seller	
Bus Conductor Wall Thickness - Tap Bus	inches	Seller	
Enclosure Outside Diameter – Main Bus	inches	Seller	
Enclosure Outside Diameter – Tap Bus	inches	Seller	
Phase-to-Phase Spacing – Main Bus	inches	Seller	
Phase-to-Phase Spacing – Tap Bus	inches	Seller	
Bus Insulator Support Spacing	inches	Seller	
Bus Support Spacing	feet	Seller	
Total Weight per Single Phase Foot – Main Bus	pounds	Seller	
Total Weight per Single Phase Foot – Tap Bus	pounds	Seller	
FINISH			
Color		ANSI 70, Light Gray	

****
The following additional information shall also be included with proposals:

1. Seller variances or exceptions to the specification.
2. Itemization of proposed estimated materials.
3. Add/deduct pricing for bus duct cost per lineal foot, each type of bus duct fitting, flexible connectors, etc.

****

APPENDIX 3

PERFORMANCE GUARANTEES

****
Typically, isolated phase bus systems do not have performance guarantees associated with them. However, consider all project-specific requirements to determine the applicability of this Appendix.
****

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

****
In addition to revising this spec to correspond to project-specific requirements, update all Appendix highlighted areas with project-specific data.
****

SITE CONDITIONS

LOCATION

Xcel Energy's Cherokee Station site is located in Adams County, CO at 6198 Franklin St. Denver, CO 80216.

METEOROLOGICAL DATA

Table 1 below lists the major site conditions which are based on ambient weather conditions taken from several data references. The following abbreviations apply to this table:

DBT: Dry Bulb Temperature

MCWB: Mean coincident wet bulb for a given dry bulb temperature

AMSL: Above Mean Sea Level

APPENDIX 4

TABLE 1 – MAJOR SITE CONDITIONS

PARAMETER	DATA
Site Elevation	5131 feet AMSL
Site Ambient Conditions	
Record low dry bulb temperature: MCWB for record low DBT:	-29°F -29°F
99% winter design dry bulb temperature: MCWB for 99% winter design DBT:	-5°F -8°F
Average winter dry bulb temperature: MCWB for average winter DBT:	-35°F -29°F
Annual average dry bulb temperature: MCWB for annual average DBT:	50°F 39°F
Summer 1% dry bulb temperature: MCWB for summer design 1% DBT: (Comparable to ASHRAE cooling, 0.4% occurance)	95°F 70°F
Record high dry bulb temperature: MCWB for record high DBT:	105°F 72°F
Dry bulb temperature for ISO System Accrediation: MCWB for ISO System Accrediation DBT:	95°F 70°F
Relative Humidity Range	0% to 100%
Annual Average Percipitation	18 inches
Maximum 24 Hour Rainfall Total	3 inches
Annual Average Snowfall	60 inches
Maximum 24 Hour Snowfall Total	48 inches

APPENDIX 4

WIND LOADING

Wind loads shall be in accordance with the IBC. Basic wind design parameters are as follows:

DESCRIPTION	CHEROKEE	NOTES
Classification of Structure Category	III	Ref. ASCE 7-05, Section 1.5
Exposure	C	Ref. ASCE 7-05, Section 6.56
Wind Importance Factor	1.15	
Reference Wind Velocity, V	90 mph	3 sec. gust @ 33 ft. above ground. Ref. ASCE 7-05

SEISMIC CRITERIA

Structures shall be designed using the seismic criteria in the IBC as applicable to Colorado. Basic seismic parameters, per the IBC, are as follows:

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration at a short period (0.2 seconds), $S_s = 0.217g$.

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration a 1 second period), $S_s = 0.056g$.

Seismic Importance Factor, $I_E = 1.25$.

Based on the information presented in the Geotechnical Report, the project site has been assigned to Site Class D, to be verified by a site-specific geotechnical report.

APPENDIX 4

REFERENCE MATERIALS

The following drawings contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Bus Duct Layouts
- Transformer Connection Details
- Generator Connection Details
- Auxiliary equipment connection details.

APPENDIX 5

QA/QC (Including Inspection Test Plans)

****
Revise this Appendix accordingly per project-specific requirements.
****

QA/QC

INSPECTION AND TEST PLANS

Seller shall submit their standard Inspection and Test Plan (ITP) for approval in accordance with Appendix 1 requirements.

QA/QC INSPECTIONS/REPORTING

****
Determine frequency of Xcel inspections of Seller's facilities during fabrication, prior to delivery, etc. and add requirements to this section as required. Review Xcel Intranet QA/QC Toolbox for various tools and templates for the following, as project requirements dictate:

- Shop inspection reports
- Non-conformance reports
- Release for shipment, etc.

Add these documents to this Appendix as required.
****

WELDING

****
Discuss welding requirements with Xcel Quality during the spec development process and insert their most current requirements in this section.
****

APPENDIX 6

STARTUP, TESTING AND COMMISSIONING

****
The following are minimum suggested testing requirements. Revise per project requirements as required:
****

TESTING

Factory Testing:

1. Perform standard factory tests in accordance with IEEE C37.23.
2. Submit test data/test reports in accordance with Appendix 1.

Shop Tests:

1. Perform standard shop tests in accordance with IEEE standards.

****
Depending on project requirements, determine if factory field support is required to startup/commission iso-phase systems. Minimum commissioning considerations are as follows:

- Construction/installation inspections
- International Electrical Testing Association (NETA) standard field tests (e.g. bus high potential testing, etc.)
- Anti-condensation system/controls commissioning
- Forced-air cooling system/controls commissioning

****

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

PACKAGING, SHIPPING AND STORAGE

Seller shall prepare equipment for shipment following successful completion of factory testing and resolution of QA/QC non-conformances (see Appendix 5 for additional details.

Seller shall prepare equipment to withstand any possible damage or loss due to rough handling or exposure to weather during transit or extended outdoor storage (up to two (2) years).

Seller shall install all required covers to protect equipment from rain, hail, wind, dust, snow and environmental conditions detrimental to the equipment.

Equipment shall be adequately sealed and protected during shipment to prevent corrosion, foreign matter egress and freeze damage which could result from the presence of residual water.

Lifting points and centers of gravity shall be clearly marked on the shipped equipment.

Shipping structural bracing shall be installed as required to allow for field handling, skidding and hoisting.

Equipment supplied with space heaters shall have heater leads accessible without requiring disassembly of shipping containers.

Threaded outlets shall have plugs or caps installed prior to shipping.

Ancillary materials which are "shipped loose" shall be in separately boxed and re secured to the main equipment containers.

Seller shall provide the following minimum unloading/handling information:

- Shipping weight and dimensions of each article
- Pick points
- Rigging requirements
- Weight distribution
- Center of gravity
- Sensitivities
- Hazards

A QA/QC inspection certification, signed by the Seller shall be issued to the company prior to shipment. A copy of this certificate shall be included with the Bill of Lading.

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

Shipping documentation shall include the following minimum information:

- Company Destination (Plant, Unit)
- Company Agreement number
- Sellers order number
- Date shipped
- Shipping origin
- Company equipment tag information
- Seller's equipment identification information
- Shipment tracking information
- Shipment description
- Shipment quantity
- Gross weight
- Special handling requirements
- Identification of spare equipment
- Barcode, RFID, or similar material control information

Seller shall coordinate all deliveries with Company prior to shipment. Coordination shall include resolution of QA/QC non-conformances, delivery schedule, unloading/handling requirements, and storage requirements.

APPENDIX 8

ACCEPTABLE MANUFACTURERS

****
The following list contains the typically preferred manufacturers. Coordinate with Xcel Sourcing to determine final bid list:
****

Acceptable manufacturers are as follows:

- Calvert
- Delta-Unibus
- General Electric
- Technibus

MASTER SPECIFICTION
FOR
Low Voltage Motors

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
12-30-2014	1.0	New

LOW VOLTAGE MOTORS

****

In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

GENERAL

DESCRIPTION

****
Insert project-specific description items (i.e. new construction project, replacement project, project location, etc.)
****

SUMMARY

This specification details the requirements for low voltage (LV) AC motors. This specification does not cover valve, gate, elevator, machine tool, chemical feed, crane, submersible pump, HVAC, DC or other specialty motors.

Reference Drawings

The following drawings, included in Appendix 4, contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Schematic Diagrams
- Wiring Diagrams

****
For motor replacement projects, consult with Mechanical for existing driven equipment requirements and update this section with mechanical drawings as applicable.
****

Technical Proposal Documentation

See Appendix 2 for technical proposal requirements.

APPLICABLE CODES AND STANDARDS

- State and local codes, laws, ordinances, rules and regulations
- ABMA – American Bearing Manufacturers Association
- ANSI - American National Standards Institute
- ASTM - American Society for Testing and Materials
- ICEA - Insulated Cable Engineers Association
- IEEE - Institute of Electrical and Electronic Engineers

- NEMA - National Electrical Manufacturer's Association
- NFPA - National Fire Protection Association
- OSHA - Occupational, Health and Safety Administration
- UL Underwriter's Laboratories

In the event of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

DESIGN & CONSTRUCTION FEATURES

1. Design and Construction

a. Motor design and construction shall be coordinated with the driven equipment requirements and shall be suited for their intended use.
b. Motors for use with variable frequency drives (VFD) shall be VFD-rated and shall be able to maintain cooling requirements at the minimum design drive speeds.
c. Motors shall be rated for continuous duty for site conditions specified in Appendix 4.
d. All three-phase motors furnished under this specification shall be designed in accordance with IEEE 841.

2. Environmental

Motors shall be manufactured to withstand site environmental conditions. See Appendix 4 for site specific environmental conditions.

3. Ratings

Motors ratings shall be as specified in Appendix 2 Data Sheets.

MOTOR VOLTAGE RATINGS

Motor operating voltages shall be as follows:

MOTOR HP	NOMINAL SYSTEM VOLTAGE	MOTOR NAMEPLATE VOLTAGE	PHASE
Less than 0.75 HP	120	115	1
Greater-than-or-equal-to 0.75 HP and less-than-or-equal-to 250 HP	480	460	3

ENCLOSURES

1. All motors shall be self-ventilated.
2. Enclosures shall be cast iron or cast steel.
3. Enclosure parts, including frames, bearing brackets, fan covers, etc. shall be cast

iron, cast steel, sheet steel or steel plates.
4. Aluminum enclosures or enclosure parts are not permitted.
5. Fan-cooled motors shall have fans constructed from non-sparking fan material.
6. Motor rotation shall be permanently marked on motor enclosures.

TOTALLY ENCLOSED MOTORS

1. Totally enclosed, fan cooled (TEFC) motors shall have rotating shaft seals where available.
2. Drain holes shall be provided for TEFC motors.
3. TEFC motors shall have all exposed metal surfaces painted with a corrosion-resistant polyester coating.
4. TEFC motors shall have interior surfaces and the stator/rotor air gap surfaces protected with an alkyd enamel or polyester or epoxy coating.
5. TEFC motors shall meet NEMA requirements for a fully guarded machine.
6. Fastening hardware shall be heavy cadmium-plated steel or stainless steel.

INSULATION AND WINDINGS

1. All windings shall be copper.
2. Windings shall have Class F, non-hygroscopic insulation systems.
3. Insulation resistance, corrected to 40 °C, shall not be less than motor-rated kV+1 megohms for all windings.
4. Two-speed motors shall be furnished with two (2) separate windings. Single winding two-speed motors are not permitted.

ROTOR

1. Three-phase horsepower motors 250 HP and less shall have squirrel-cage copper rotors.

TEMPERATURE RISE

1. Winding temperature rise shall not exceed NEMA MG-1 requirements for a Class B insulation system.
2. Temperature rise shall be determined for motor operation at nameplate horsepower multiplied by the service factor and operation at maximum ambient temperature specified in Appendix 4.

SERVICE FACTOR

1. Motor service factor (SF) shall be 1.15 where available.

SPACE HEATERS

1. All motors 25 horsepower and larger shall have space heaters.
2. Heaters shall be rated for 240 VAC and energized and sized for application at 120 VAC.
3. Heaters shall be accessible via terminal housing which shall be separate from the motor power leads.

4. Heater leads shall be stranded copper with high temperature insulation.

TERMINAL HOUSING

1. Separate terminal housings shall be provided for motor power leads and accessory leads (heater leads, etc.) and shall be mounted to the motor frame.
2. Terminal housings shall be cast iron, stamped steel or fabricated steel.
3. Terminal housing gaskets shall be provided for housing access panels and between housings and motor frame.
4. Terminal housing shall be oversized and shall be capable of rotation in 90-degree steps.
5. Minimum motor lead terminal housing for 460V motors shall be 4-inches by 4-inches by 2-inches.
6. Minimum motor lead terminal housing for 115V motors shall be 3-inches by 3-inches by 2-inches

LEADS

1. All motor and accessory leads shall be permanently marked in accordance with NEMA MG-1.

GROUNDING

1. Motor ground provisions shall be furnished per NEMA MG-1.
2. Motors shall be furnished with provisions for connecting grounding conductors to the motor frame inside the motor lead terminal housing.

ANTI-FRICTION BEARINGS

1. Anti-friction bearings shall be provided in accordance with ABMA standards to have a minimum L-10 rating life of not less than 10,000 hours unless otherwise approved by the Owner.
2. Grease-lubricated radial bearings shall be double-shield type where available.
3. Motor bearing mountings shall prevent entrance of lubricant into the motor enclosure and prevent entrance of external contaminants into to the bearings.
4. Bearing mountings shall be provided with pipes and drain plugs.
5. Grease-lubricated bearing fittings shall provide access for external lubrication while motor is in service.
6. Pump motors shall be equipped with either external shaft slingers or seals to prevent liquid entry at motor bearings.
7. Grease-lubricated bearings shall be self-lubricating with external grease connections.
8. Bearings and bearing housings shall allow field disassembly for inspection and removal of rotor.

TORQUE CHARACTERISTICS

1. Motor torque characteristics shall be per NEMA MG-1.
2. Locked rotor kVA/HP for three-phase, 10 HP through 150 HP, shall not exceed 6.3 kVA/HP.

3. Locked rotor kVA/HP for three-phase, above 150 HP, shall not exceed 5.6 kVA/HP.

MOTOR EFFICIENCY

1. Three-phase motors shall be premium efficiency type motors.
2. Motor average nominal efficiency and power factor values shall meet NEMA standard requirements for “Energy Efficient”.

NAMEPLATES

1. Motor nameplates and attachment hardware shall be stainless steel.
2. Nameplates shall be stamped per NEMA requirements.

SPARE PARTS AND TOOLS

****
Fill in as required
****

TESTING

Testing requirements are defined in Appendix 6.

DELIVERABLES

Deliverable requirements are defined in Appendix 1.

PROPOSAL DATA REQUIREMENTS

Seller shall provide proposed equipment data in accordance with Appendix 2.

SITE CONDITIONS

Site conditions are defined in Appendix 4.

QUALITY ASSURANCE

QA/QC requirements are defined in Appendix 5.

PACKAGING STORAGE & SHIPPING

Packing, shipping storage requirements are defined in Appendix 7.

MATERIALS & WELDING

****
Fill in as required
****

PERFORMANCE GUARANTEES

****
Fill in Appendix 3 as required
****

SOUND CONTROL REQUIREMENTS

Sound levels shall be less than 85 dBA at three feet from motor boundary. Sound levels shall be determined in accordance with IEEE 85.

CLEANING, PAINTING & COATING

****
Fill in as required
****

APPENDICES TO SPECIFICATION

****
Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE MANUFACTURERS

APPENDIX 1

DELIVERABLES

****
The following is a list of minimum suggested deliverables and deliverable information. Revise per project requirements as required:
****

Manufacturer drawings:

1. Shipping layout drawings
2. Installation instructions/details including rigging information and equipment loadings
3. Nameplate schedule and details
4. Dimensioned motor outline drawings
5. Motor wiring diagrams
6. Motor data sheets

Test data:

1. Factory and field test data/test report. See Appendix 6 for details.

Operation and Maintenance Manuals:

1. Operation and maintenance (O&M) manuals shall include the following minimum information:
    a. Installation instructions.
    b. Operating instructions.
    c. Maintenance instructions.
    d. Nameplate data.
    e. Assembly drawings.
    f. Bill of Material with vendor part numbers
    g. Cut sheets and brochure data
    h. Recommended spare parts list
    i. Certified (final) test reports
    j. Storage and Handling instructions.
    k. Special tools required for installation, operation and/or maintenance
    l. Warranty information

APPENDIX 1

DELIVERABLES

QA/QC:

1. Seller's QA/QC Inspection and Test Plan (ITP)

****
Include project-specific requirements for the following:
****

- Seller Deliverable Schedule
- Deliverable Format
- Deliverable Quantities

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

LOW VOLTAGE MOTOR DATA SHEET

Seller shall provide the following minimum technical data applicable to the equipment in the proposed scope of supply.

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

LOW VOLTAGE MOTORS	UNITS	REQUIREMENTS	SELLER RESPONSE
120V MOTORS			
Motor Application			
Equipment Tag Number			
Manufacturer		Seller	
Model Number		Seller	
City & Country of Manufacture		Seller	
Motor Horsepower	HP		
Motor Voltage	V	120	
Phase		1	
Frequency	Hz	60	
Service Factor		1.15	
Full Load Speed	RPM		
NEMA Design Letter			
Insulation		Class F	
Temperature Rise (at 40 ºC)	ºC		
Duty Rating		Continuous	
Enclosure Type		TEFC	
NEMA Frame			
Full Load Current	A		
Locked Rotor Current	A		

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

LOW VOLTAGE MOTOR DATA SHEET

LOW VOLTAGE MOTORS	UNITS	REQUIREMENTS	SELLER RESPONSE
Locked Rotor kVA Letter			
Starting Method			
Overload Protection			
Belted or Direct-coupled			
Mounting			
Bearing Type			
Motor Weight			
460V MOTORS			
Motor Application			
Equipment Tag Number			
Manufacturer		Seller	
Model Number		Seller	
City & Country of Manufacture		Seller	
Motor Horsepower	HP		
Motor Voltage	V	460	
Phase		3	
Frequency	Hz	60	
Poles			
Service Factor		1.15	
Rotor Material/Type		Copper/Squirrel Cage	
Winding Material		Copper	
Full Load Speed	RPM		
NEMA Design Letter			
Insulation		Class F	
Temperature Rise (at 40 ^{o}C)	^{o}C		

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

LOW VOLTAGE MOTOR DATA SHEET

LOW VOLTAGE MOTORS	UNITS	REQUIREMENTS	SELLER RESPONSE
Duty Rating		Continuous	
Enclosure Type		TEFC	
IEEE 814 Rating		Yes	
NEMA Frame			
Full Load Current	A		
Locked Rotor Current	A		
Locked Rotor kVA Letter			
Starting Method			
Belted or Direct-coupled			
Mounting			
Bearing Type/Rating			
Motor Weight	lb		
Motor Full-Load Torque	lb-ft		
Motor Locked Rotor Torque	lb-ft		
Motor Nominal Efficiency (50% load)	%		
Motor Nominal Efficiency (75% load)	%		
Motor Nominal Efficiency (100% load)	%		
Space Heater Voltage	V		
Heater Quantity			
Heater Power Consumption (per heater)	W		
Minimum Starting Voltage	V		
Safe Stall Time (rated voltage, ambient temp)	sec		
Safe Stall Time (rated voltage, operating temp)	sec		
Safe Stall Time (80% voltage, ambient temp)	sec		
Safe Stall Time (80% voltage, operating temp)	sec		

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

LOW VOLTAGE MOTOR DATA SHEET

LOW VOLTAGE MOTORS	UNITS	REQUIREMENTS	SELLER RESPONSE
Combined Motor and Load Acceleration Time (100% voltage)	sec		
Rotor Inertia	$lb\text{-}ft^2$		
Load Inertia	$lb\text{-}ft^2$		
Motor Pull-up Torque	lb-ft		
Motor Breakdown Torque	lb-ft		
Motor X/R Ratio			
Locked Rotor Power Factor			

****
The following additional information shall also be included with proposals:

1. Seller variances or exceptions to the specification.
2. Itemization of proposed estimated materials.

****

APPENDIX 3

PERFORMANCE GUARANTEES

****
Insert project-specific performance guarantee requirements in this Appendix.
****

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

****
In addition to revising this spec to correspond to project-specific requirements, update all Appendix highlighted areas with project-specific data.
****

SITE CONDITIONS

LOCATION

Xcel Energy's Cherokee Station site is located in Adams County, CO at 6198 Franklin St. Denver, CO 80216.

METEOROLOGICAL DATA

Table 1 below lists the major site conditions which are based on ambient weather conditions taken from several data references. The following abbreviations apply to this table:

DBT: Dry Bulb Temperature

MCWB: Mean coincident wet bulb for a given dry bulb temperature

AMSL: Above Mean Sea Level

IBC: International Building Code

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

TABLE 1 – MAJOR SITE CONDITIONS

PARAMETER	DATA
Site Elevation	5131 feet AMSL
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Record low dry bulb temperature: MCWB for record low DBT:	-29°F -29°F
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Annual average dry bulb temperature: MCWB for annual average DBT:	50°F 39°F
Summer 1% dry bulb temperature: MCWB for summer design 1% DBT: (Comparable to ASHRAE cooling, 0.4% occurance)	95°F 70°F
Record high dry bulb temperature: MCWB for record high DBT:	105°F 72°F
Dry bulb temperature for ISO System Accrediation: MCWB for ISO System Accrediation DBT:	95°F 70°F
Relative Humidity Range	0% to 100%
Annual Average Percipitation	18 inches
Maximum 24 Hour Rainfall Total	3 inches
Annual Average Snowfall	60 inches
Maximum 24 Hour Snowfall Total	48 inches

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

WIND LOADING

Wind loads shall be in accordance with the IBC. Basic wind design parameters are as follows:

DESCRIPTION	CHEROKEE	NOTES
Classification of Structure Category	III	Ref. ASCE 7-05, Section 1.5
Exposure	C	Ref. ASCE 7-05, Section 6.56
Wind Importance Factor	1.15	
Reference Wind Velocity, V	90 mph	3 sec. gust @ 33 ft. above ground. Ref. ASCE 7-05

SEISMIC CRITERIA

Structures shall be designed using the seismic criteria in the IBC as applicable to Colorado. Basic seismic parameters, per the IBC, are as follows:

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration at a short period (0.2 seconds), $S_s = 0.217g$.

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration a 1 second period), $S_s = 0.056g$.

Seismic Importance Factor, $I_E = 1.25$.

Based on the information presented in the Geotechnical Report, the project site has been assigned to Site Class D, to be verified by a site-specific geotechnical report.

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

REFERENCE MATERIALS

The following drawings contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Schematic Diagrams
- Wiring Diagrams

****
For motor replacement projects, consult with Mechanical for existing driven equipment requirements and update this section with mechanical drawings as applicable.
****

APPENDIX 5

QA/QC (Including Inspection Test Plans)

****
Revise this Appendix accordingly per project-specific requirements.
****

QA/QC

INSPECTION AND TEST PLANS

Seller shall submit their standard Inspection and Test Plan (ITP) for approval in accordance with Appendix 1 requirements.

QA/QC INSPECTIONS/REPORTING

****
Determine frequency of Xcel inspections of Seller's facilities during fabrication, prior to delivery, etc. and add requirements to this section as required. Review Xcel Intranet QA/QC Toolbox for various tools and templates for the following, as project requirements dictate:

- Shop inspection reports
- Non-conformance reports
- Release for shipment, etc.

Add these documents to this Appendix as required.
****

APPENDIX 6

STARTUP, TESTING AND COMMISSIONING

****
The following are minimum suggested testing requirements. Revise per project requirements as required:
****

TESTING

Factory Testing:

1. Perform factory tests in accordance with IEEE/ANSI and NEMA standards.
2. Motor testing shall be performed with motor terminal housing installed on motor.
3. Factory tests shall include the following minimum tests:
   a. No-load running current
   b. No-load speed
   c. Insulation resistance
   d. Winding resistance
   e. Mechanical balance
   f. Locked rotor current
   g. Motor efficiency
4. Submit test data/test reports in accordance with Appendix 1.

Shop Tests:

1. Perform standard shop tests in accordance with NEMA and IEEE standards.

****
Depending on project requirements, determine the level of factory field support required for startup/commissioning.

****

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

PACKAGING, SHIPPING AND STORAGE

Seller shall prepare equipment for shipment following successful completion of factory testing and resolution of QA/QC non-conformances (see Appendix 5 for additional details.

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Seller shall install all required covers to protect equipment from rain, hail, wind, dust, snow and environmental conditions detrimental to the equipment.

Equipment shall be adequately sealed and protected during shipment to prevent corrosion, foreign matter egress and freeze damage which could result from the presence of residual water.

Lifting points and centers of gravity shall be clearly marked on the shipped equipment.

Shipping structural bracing shall be installed as required to allow for field handling, skidding and hoisting.

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Threaded outlets shall have plugs or caps installed prior to shipping.

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- Weight distribution
- Center of gravity
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- Hazards

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Shipping documentation shall include the following minimum information:

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- Sellers order number
- Date shipped
- Shipping origin
- Company equipment tag information
- Seller's equipment identification information
- Shipment tracking information
- Shipment description
- Shipment quantity
- Gross weight
- Special handling requirements
- Identification of spare equipment
- Barcode, RFID, or similar material control information

Seller shall coordinate all deliveries with Company prior to shipment. Coordination shall include resolution of QA/QC non-conformances, delivery schedule, unloading/handling requirements, and storage requirements.

APPENDIX 8

ACCEPTABLE MANUFACTURERS

****
The following list contains the typically preferred manufacturers. Coordinate with Xcel Sourcing to determine final bid list:
****

Acceptable manufacturers are as follows:

- Baldor
- General Electric
- Louis Allis
- Reliance
- Marathon
- Toshiba
- WEG

MASTER SPECIFICTION
FOR

Medium Voltage Motors

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
12-30-2014	1.0	New

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

GENERAL

DESCRIPTION

****
Insert project-specific description items (i.e. new construction project, replacement project, project location, etc.)
****

SUMMARY:

1. This specification describes the standards for motors that are applicable to design and construction for Xcel Energy's Energy Supply construction projects.

2. The specification describes alternating current, medium voltage induction motors. Excluded are low voltage motors (480 volts or smaller).

3. All equipment and materials shall be in accordance with applicable requirements of the Federal "Occupational Safety and Health Administration" Standards.

.

Reference Drawings

The following drawings, included in Appendix 4, contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Schematic Diagrams
- Wiring Diagrams

****
For motor replacement projects, consult with Mechanical for existing driven equipment requirements and update this section with mechanical drawings as applicable.
****

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A. State and local codes, laws, ordinances, rules and regulations
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C. ANSI - American National Standards Institute
D. ASTM - American Society for Testing and Materials
E. ICEA - Insulated Cable Engineers Association
F. IEEE - Institute of Electrical and Electronic Engineers
G. NEMA - National Electrical Manufacturer's Association
H. NFPA - National Fire Protection Association
I. OSHA - Occupational, Health and Safety Administration
J. UL Underwriter's Laboratories

In case of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

DESIGN & CONSTRUCTION FEATURES

1. Design and Construction

a. Motor design and construction shall be coordinated with the driven equipment requirements and shall be suited for their intended use.
b. Motors for use with variable frequency drives (VFD) shall be VFD-rated and shall be able to maintain cooling requirements at the minimum design drive speeds.
c. Motors shall be rated for continuous duty for site conditions specified in Appendix 4.
d. All three-phase motors furnished under this specification shall be designed in accordance with IEEE 841.

2. Environmental

a. Motors shall be manufactured to withstand site environmental conditions. See Appendix 4 for site specific environmental conditions.
b. Considerations shall be given to the exposure to solar heat in the areas of outdoor installation.

3. Ratings

a. Motors ratings shall be as specified in Appendix 2 Data Sheets.

MOTOR VOLTAGE RATINGS

1. Motor operating voltages, excluding motor-operated valves, shall be as follows:

Power (horsepower)	Nominal System Voltage	Motor Nameplate Voltage	Frequency (Hz)	Phases
Greater than 250 and less than 7500	4160	4000	60	3

ENCLOSURES

1. All medium voltage motors shall be provided with Weather-Protected II (WP II) enclosures. Enclosure parts for all motors (e.g., frames, bearing brackets, terminal housings, external fan covers) shall be made of cast iron, cast steel, sheet steel, or steel plates. Aluminum enclosure parts are not acceptable. All hardware shall be made of corrosion resistant material.

2. Removable washable impingement type air filters shall be furnished. A pressure differential device shall be provided at the air inlet of all motors furnished with air filters. The device shall be furnished with a snap-action sealed switch having normally open contacts which close on high-pressure differential. The switch shall have an adjustable setpoint which is accessible for calibration while the motor is in service. The initial setpoint shall be set at the factory and shall be set to prevent high motor temperatures due to clogged filters.

3. Motors located in areas classified as hazardous shall be furnished with enclosures certified for use in the classified area.

4. Except for two-pole motors, cooling fans, when provided, shall be bi-directional to allow for continuous motor operation in either a clockwise or counterclockwise direction. Specific cases where such a fan is impractical for mechanical reasons shall be brought to the attention of the Company.

5. Motors shall be designed to permit convenient access for drilling vertically through the motor feet for installation of tapered dowel pins after the motors are mounted with driven equipment. Where motor design requires angle drilling of dowel pinholes through the motor feet, the Contractor shall start the dowel pinholes at the required angle, and shall drill each hole to a depth not less than one-half the thickness of the motor feet. The tapered dowel pins shall be furnished by the Contractor.

6. Motor rotation shall be permanently marked on motor enclosures.

TOTALLY ENCLOSED MOTORS

1. Totally enclosed motors shall be furnished with drain holes and rotating shaft seals. Motors furnished with sliding type bearings shall have a rotating labyrinth shaft seal on the shaft extension end of the motor. Drain holes shall be provided with combination water drain-breather plugs.

2. External cooling fans for fan cooled motors shall be fabricated of brass, bronze, aluminum alloy containing not more than 0.2% copper, malleable iron, or plastic. All plastic fans shall be fabricated of a reinforced thermosetting plastic.

3. All exposed metal surfaces shall be protected with a corrosion resistant polyester paint or coating and shall have enclosure interior surfaces and the stator and rotor air gap surfaces protected with a corrosion-resistant alkyd enamel or with polyester or epoxy paint or coating. The stator air gap surfaces shall be protected with a vacuum pressure impregnation coating.

4. Bolts, nuts, screws, and other hardware items shall be corrosion-resistant or zinc dichromate treated metal.

INSULATION AND WINDINGS

1. All stator coils shall utilize copper conductors, shall be form-wound, and shall be insulated with mica based materials. All stator-winding materials shall have a Class F (155°C) thermal classification and shall utilize a vacuum pressure impregnation (VPI) system. After winding, the stator shall be subjected to two (2) complete VPI cycles. Following these two (2) cycles, the wound stator shall be coated with a solvent type epoxy varnish.

2. Motor insulation systems shall be rated for use in power plant applications utilizing either vacuum or SF6 bottles for an interrupting medium in either medium voltage switchgear or medium voltage controllers. The insulation system shall not require the installation of surge arresters or capacitors in either the switchgear or at the motor terminals.

3. All multi-turn form-wound stator coils shall have turn-to-turn insulation in accordance with IEEE Standard 522.

4. The temperature rise at rated output shall not exceed those for a Class B thermal insulation classification

ROTORS

1. All induction motors shall have squirrel-cage rotors. Rotors shall be sized to avoid overheating during acceleration of the motor and driven equipment. Rotors shall be copper or copper alloy cage material. All fabricated cage rotors shall include a swaging or wedging method during the installation of rotor bars to prevent rotor bar vibration.

2. All motor rotating components shall be dynamically balanced after mounting on the shaft. Motor vibration shall not exceed the peak-to-peak amplitude values listed in the following table. In addition, the magnitude of vibration values for twice the line frequency vibrations shall not exceed 0.0005 inches (0.013 mm).

3. The minimum clearance space required for removal of the rotor shall be indicated both in the proposal data and on the dimensional outline drawing.

TEMPERATURE RISE

1. Winding temperature rise shall not exceed NEMA MG-1 requirements for a Class B insulation system.

2. Temperature rise shall be determined for motor operation at nameplate horsepower multiplied by the service factor and operation at maximum ambient temperature specified in Appendix 4.

SERVICE FACTOR

1. Motor service factor (SF) shall be 1.15 where available.

SPACE HEATERS

1. Heaters shall be located and insulated so they do not damage motor components or finish. Space heaters shall be sized as required to maintain the motor internal temperature above the dew point when the motor is idle. Space heaters shall be easily removable on all modular frame construction. If space heaters are not removable and if the motor is not of modular frame construction, redundant space heaters of low watt density silicon rubber wrap-around type shall be wired to the accessory terminal housing.

2. Space heater leads shall be stranded copper cable with high temperature insulation and shall include terminal connectors.

3. Sheaths of metal-sheathed strip type space heaters shall be of a corrosion-resistant, non-oxidizing material and shall have a thickness of not less than 0.025 inch.

4. Heaters shall be rated for 240 VAC and energized and sized for application at 120 VAC.

TERMINAL HOUSING

1. An oversized terminal housing for power leads and a separate accessory terminal housing for accessory leads shall be furnished on all motors. All terminal housings shall be externally mounted on the motor frame enclosure. The terminal housing shall be able to be rotated in 90-degree steps to any vertical or horizontal orientation. Terminal housings for all motors shall be cast iron or sheet steel. Minimum protection requirements shall be equivalent to NEMA 4. All motor leads located in the housings shall be permanently marked for ease of identification. Provisions shall be provided within the power lead terminal box for attaching a grounding conductor.

2. A separate accessory terminal housing shall be provided for space heater leads, temperature detector leads, and other similar accessory equipment leads. It shall be complete with screw type terminal blocks for termination of such leads. Each terminal in the blocks shall be identified and marked for its respective leads. Accessory terminal housings shall be accessible from outside the motor.

3. Motor current transformers shall be mounted in the power lead terminal housing.

4. Motor power lead terminal housings shall be large enough to provide working space for the field fabrication of stress relief kits for shielded cable within the housing and to contain the stress relief kits after fabrication. Termination distance shall be defined as the inside dimension of the terminal box between the external conduit connection and either the centerline of the motor lead entrance or the bus bar terminal for connection of external power cable.

The motor terminal box minimum requirements shall be as follows:

Full Load Current at SF Load (Amps)	Termination Distance (Inches)	Conduit*Openings	Depth (Inches)	Width (Inches)
Less than 200 A	24	1-4 in.	18	27
Greater than 200 A Less than 400 A	30	2-4 in.	18	30
Greater than 400 A	30	As Approved by Company.	25	30

*Smaller conduit opening may be furnished if approved by the Company. If removable plate is supplied it shall have a space for connecting specific conduit and size.

LEADS

1. All leads, including motor power leads, space heater leads, and temperature detector leads, shall be wired into their respective terminal housings.

2. All motors shall have the direction of rotation marked by an arrow mounted visibly on the stator frame near the terminal housing or on the nameplate and the leads marked for phase sequence to correspond to the direction of rotation and supply voltage sequence.

3. Leads for dual voltage rated or for multispeed motors shall be easily connected or reconnected in the terminal housing for the operating voltage or for the specified speeds.

4. When current transformers for motor differential protection are required for single-speed motors, the motor phase leads shall be wired to the motor power lead terminal housing for connection for self balancing current type differential protection. Each current transformer shall encircle all power leads to the associated winding. The motor winding wye or delta connections shall be completed at the factory, leaving only three (3) leads, T1, T2, T3, for field connection in the power lead terminal housing. The wye or delta connection shall be completed in a manner that shall allow easy access to the end of each phase for field-testing.

5. Cable type leads shall be provided with compression type terminal connectors.

GROUNDING

1. Motor ground provisions shall be furnished per NEMA MG-1.

2. Motors shall be furnished with provisions for connecting grounding conductors to the motor frame inside the motor lead terminal housing.

3. External grounding pads shall be provided in at least two (2) locations (near mounting feet at opposite corners).

BEARINGS

1. The type of bearing furnished shall be as specified on the Medium Voltage Motor Data Sheet, Appendix 2. If Manufacturer standard is specified, the motor and driven equipment manufacturers shall determine the type of bearing to be furnished based upon the load, speed, and thrust conditions of the driven equipment.

2. Bearings shall be capable of operating for extended periods of time at any of the thrust loadings imposed by the specific piece of driven equipment during starting and normal operation without damage to the bearing, the motor frame, or other motor parts.

SLIDE TYPE BEARINGS

1. Sleeve bearings for horizontal motors shall be oil ring lubricated type. The bearings, end bells, and bearing housings shall be split type when available. Air gap measurement holes or other acceptable means shall be provided in each motor end enclosure for checking air gap of sleeve bearing motors.

2. Sleeve bearings on horizontal motors shall be designed and located centrally, with respect to running magnetic center, to prevent the rotor axial thrust from being continuously applied against either end of the bearing. The motors shall be capable of withstanding without damage the axial thrusts that are developed when the motor is initially energized.

3. Vertical motors with plate type thrust bearings shall have oil lubricated split sleeve guide bearings.

4. Bearing lubrication shall be furnished by an internal lubricant recirculation system. Oil reservoir capacity and ventilation of the bearing housing and oil reservoir shall maintain proper cooling of the oil and bearings.

ANTI-FRICTION BEARINGS

1. Antifriction bearings shall be designed and fabricated in accordance with ABMA standards to have an L-10 rating life of no less than the following under the load, speed, and thrust requirements: Direct-connected motors in continuous use: 100,000 hours unless otherwise approved by the Company.

2. Belt or chain-connected service: 42,500 hours.

3. Motors furnished with spherical roller thrust bearings shall be furnished with deep groove radial guide bearings. One guide bearing shall be locked to the shaft so that the guide bearing shall take upward thrust and to assure that the thrust bearing is always loaded. If spring-loading is furnished, the guide bearing shall not be preloaded during normal operation.

4. Stacked antifriction bearings are not acceptable.

5. Antifriction bearings shall be grease lubricated except where the specified speed and thrust require oil lubrication for the specified life. Grease lubricated bearings shall be self-lubricating and regreaseable.

MISCELLANEOUS BEARING REQUIREMENTS

1. All bearing mountings shall be designed to prevent the entrance of lubricant into the motor enclosure or dirt into the bearings and shall be provided with pipes and drain plugs.

2. Filler caps or grease fittings for lubrication shall be arranged for safe, easy addition of lubricant from the outside of the motor while the motor is in service.

3. Bearings and bearing housings shall be designed to permit disassembly in the field for inspection of the bearings or removal of the rotor.

4. All oil lubricated bearings shall be provided with oil level sight glasses marked for required oil level at motor running and standstill. Plastic sight windows or bottles shall be of a material not adversely affected by continuous exposure to sunlight.

5. Insulation shall be provided to prevent circulation of shaft current on bearings, on bearing temperature detectors, or on oil piping connections.

6. Bearing lubricants shall contain a corrosion inhibitor. The type and grade of lubricant shall be indicated on a nameplate attached to the motor frame or end shield adjacent to the lubricant filling device. The Contractor shall furnish all lubrication information required to assure proper equipment startup and subsequent bearing maintenance.

TORQUE CHARACTERISTICS

1. Breakaway, run-up/pull-up, and pull-out/breakdown torque shall at all times be at least 10% higher than the load-torque of the driven machine, at minimum specified starting voltage.

2. Motor torque in percent of rated full-load torque at rated voltage and frequency shall not be less than the standard torque valves specified in MEMA MG1.

3. Load-torque characteristics shall be furnished by the driven equipment Manufacturer; however, the responsibility for successful starting under the given conditions rests with the motor manufacturer

MOTOR EFFICIENCY

1. Three-phase motors shall be premium efficiency type motors.

2. Motor average nominal efficiency and power factor values shall meet NEMA standard requirements for “Energy Efficient”.

NAMEPLATES

1. All motor nameplate data shall conform to the requirements of NEMA MG 1. The following additional nameplate data shall be included:
    - a. Insulation system class designation.
    - b. Maximum ambient temperature for which motor is designed and temperature rise by resistance.
    - c. Starting capabilities at rated volts and at minimum starting voltage (may be a separate nameplate):
        1. Number of successive starts (coasting to a rest between starts) allowable after:
            - a. Motor initially at maximum specified ambient temperature.
            - b. Motor driving maximum expected operating load in the maximum specified ambient temperature and coasting to a stop.
        2. Cooling period required after completion of the preceding maximum number of starts before making an additional start with the motor in the following conditions:
            - a. Motor running driving maximum expected operating load in the maximum specified ambient temperature.
            - b. Motor running with the driven equipment uncoupled.
            - c. Motor at rest after being de-energized on reaching rated speed.
            - d. Direction of rotation and voltage sequence.
            - e. For dual voltage rated or multispeed motors, connection diagram for the specified voltage or the

specified speeds.

f. For motors with connections to an external lubricant re-circulating system, or with an integral forced lubrication system, oil pressure and oil flow required.

g. Type and grade of bearing lubricant, attached adjacent to lubricant filling devices.

h. Add motor weight.

i. For motors with current transformers for differential protection, connection diagram indicating motor lead terminal connections.

j. For motors with air filters, recommended set point for differential pressure device, attached on or near device enclosure.

k. All motor nameplates and attachment pins shall be corrosion-resistant metal.

OIL LUBRICATION SYSTEMS

1. If an external lubricant re-circulating system is provided, the Contractor shall furnish pipe taps for oil inlet and outlet connections in addition to the internal lubricant re-circulating system previously specified. Pipe taps for vertical motors shall be arranged to recirculate oil from the motor thrust bearing oil reservoir for cooling. The Contractor's lubrication system shall maintain proper lubrication and cooling of the bearings over the complete performance range of the external lubricant re-circulating system. The internal lubricant re-circulating system shall provide proper lubrication and cooling of the bearings during startup and coast-down with no oil flow from the external lubricant re- circulating system.

2. Where water cooling of bearing oil is required, the Contractor shall furnish pipe taps for the water inlet and outlet connections. The Contractor's lubrication system shall maintain proper cooling of the oil and bearings under the cooling water conditions specified.

SHAFTS

1. All shafts shall be solid. Each shaft shall be furnished with a corrosion-resistant treatment or shall be made of a corrosion-resistant material.

2. Motors furnished with sleeve bearings shall have permanent indicators indicating the motor magnetic center and end float limits when level and running at rated speed. A permanent, identified reference point shall be indicated or attached to the bearing housing or shaft seal. The markings shall be easily identifiable for use during motor installation.

3. For horizontal sleeve bearing motors, the rotor end float and coupling end play shall be in accordance with NEMA requirements. The distance from the magnetic center line mark to each end float limit mark shall be not less than 37.5% of the total rotor end float.

SOLE PLATES

1. Soleplate drawings shall be furnished indicating the size and location of the anchor bolts holding each soleplate to the concrete foundation and all mounting, alignment, and connection details and procedures. Motor mounting bolts shall be furnished with each soleplate. All foundation anchor bolts, washers, and nuts shall be furnished by others.

2. Soleplate anchor bolt cross-sectional area shall not be less than the cross-sectional area of the motor mounting bolts. Anchor bolt holes shall be shop drilled and shall be oversized 1/4 inch (6 mm) in diameter. The anchor bolts shall be located under the motor, and all projections, including washers and nuts, shall clear the motor and its appurtenances completely. Grout holes shall be provided in the central portion of each soleplate. Motor mounting holes shall be drilled and tapped.

CRITICAL SPEEDS

1. Motors shall be designed to keep torsional and rotational natural frequencies of vibration at least 25% above or below, preferably above, the motor rated speed ranges to avoid resonant vibration over the operating speed range of the equipment-motor unit.

VIBRATION TRANSDUCER MOUNTING

1. Two (2) provisions per bearing for non-contact Bently Nevada vibration probes shall be provided on the drive end and non-drive end of the motors.

TEMPERATURE DETECTORS

1. Temperature detectors shall be furnished ungrounded. A grounding terminal for each temperature detector shall be included with the detector lead terminals. The grounding terminals shall be provided with internal wiring to a common ground connection. The internal wiring shall be removable.

2. Resistance type temperature detectors shall be non-inductively wound, annealed after winding to ensure accuracy and stability, and insensitive to vibration and strain. Each detector shall be furnished with three (3) leads.

3. Winding temperature detectors and detector lead insulation class shall be the same as the stator coil insulation class. Detector leads shall be provided with protective brass interlocked spiral armor external to the slot.

BEARING PROTECTIVE DEVICES

1. A bearing temperature detector shall be furnished for each bearing of the motor. Each detector shall be complete with a detector head and holder assembly. The

detector temperature-sensitive tip shall be hermetically sealed.

2. When temperature detectors are to be applied on sleeve type bearings, the detector tip shall be held in close proximity with the outside diameter of the bearing babitt, not more than 1/8 inch from the shaft surface of the bearing. Where plate type (Kingsbury) thrust bearings are furnished, each detector tip shall be held in intimate contact with the shoe babbitt, not more than 1/8 inch from the runner surface of the shoe.

3. When temperature detectors are to be applied on antifriction type bearings, the detector tip shall be held on the outer race or in close proximity to the bearing metal.

4. When vibration monitoring is utilized with the anti-friction bearings, Robertshaw Model 376A Vibraswitches or Company-approved equivalent shall be mounted on the motor frame. The switches shall come complete with set point guard.

VARIATIONS FROM RATED VOLTAGE AND RATED FREQUENCY

1. Motors shall operate successfully under running conditions at rated load with a variation in the voltage or the frequency up to the following:
    a. Plus or minus 10% of rated voltage, with rated frequency.
    b. Plus or minus 5% of rated frequency with rated voltage.
    c. A combined variation in voltage and frequency of 10% (sum of absolute values) of the rated values, provided the frequency variation does not exceed plus or minus 5% of rated frequency.

SOUND CONTROL REQUIREMENTS

1. In no case shall the average no-load sound pressure level produced by the motor exceed 86 dBA free field at 3 feet.

2. In addition to the required overall sound pressure level, single frequency siren type to other noise, regardless of cause of source, shall not exceed levels which are irritating or which can produce damage to the human ear.

3. Sound reduction baffles, mufflers, and materials shall be contained within the motor enclosure.

INFRARED INSPECTION VIEWING PANES

1. Infrared (IR) inspection viewing panes shall be installed to permit thermography inspection of motor lead connections. IR inspection viewing panes shall be oriented to allow viewing from ground level.

2. IR inspection viewing pane NEMA rating shall be equal to, or greater than, that of the enclosure in which it is being installed.

3. IR inspection viewing panes shall be NFPA 70E compliant.

4. IR inspection viewing panes shall be 3” minimum diameter and shall consist of reinforced polymeric optic material.

SPARE PARTS AND TOOLS

Commissioning spares to be included/supplied with the equipment.

TESTING

Testing requirements are defined in Appendix 6.

DELIVERABLES

Deliverable requirements are defined in Appendix 1.

PROPOSAL DATA REQUIREMENTS

Seller shall provide proposed equipment data in accordance with Appendix 2.

SITE CONDITIONS

Site conditions are defined in Appendix 4.

QUALITY ASSURANCE

QA/QC requirements are defined in Appendix 5.

PACKAGING STORAGE & SHIPPING

Packing, shipping storage requirements are defined in Appendix 7.

SOUND CONTROL REQUIREMENTS

Sound levels shall be less than 85 dBA at three feet from motor boundary.
Sound levels shall be determined in accordance with IEEE 85.

MATERIALS & WELDING

****
Fill in as required
****

PERFORMANCE GUARANTEES

****
Fill in Appendix 3 as required
****

CLEANING, PAINTING & COATING

****
Fill in as required
****

APPENDICES TO SPECIFICATION

****
Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE MANUFACTURERS

APPENDIX 1

DELIVERABLES

****
The following is a list of minimum suggested deliverables and deliverable information. Revise per project requirements as required:
****

Manufacturer drawings:

1. Shipping layout drawings
2. Installation instructions/details including rigging information and equipment loadings
3. Nameplate schedule and details
4. Dimensioned motor outline drawings
5. Motor wiring diagrams
6. Motor data sheets

Test data:

1. Factory and field test data/test report. See Appendix 6 for details.

Operation and Maintenance Manuals:

1. Operation and maintenance (O&M) manuals shall include the following minimum information:
   a. Installation instructions.
   b. Operating instructions.
   c. Maintenance instructions.
   d. Nameplate data.
   e. Assembly drawings.
   f. Bill of Material with vendor part numbers
   g. Cut sheets and brochure data
   h. Recommended spare parts list
   i. Certified (final) test reports
   j. Storage and Handling instructions.
   k. Special tools required for installation, operation and/or maintenance
   l. Warranty information

APPENDIX 1

DELIVERABLES

QA/QC:

1. Seller's QA/QC Inspection and Test Plan (ITP)

****
Include project-specific requirements for the following:
****

- Seller Deliverable Schedule
- Deliverable Format
- Deliverable Quantities

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

MEDIUM VOLTAGE MOTOR DATA SHEET

Seller shall provide the following minimum technical data applicable to the equipment in the proposed scope of supply.

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

MEDIUM VOLTAGE MOTORS	UNITS	REQUIREMENTS	SELLER RESPONSE
Manufacturer			
City & Country of Manufacture			
Motor Voltage	kV		
Motor Frame Size			
Nameplate horsepower	HP		
Service Factor (SF)			
Frequency	Hz		
Poles			
NEMA design letter			
Insulation Class			
Duty Rating			
Enclosure type			
Mounting			
Rotor construction			
Rotor material			
Rotor weight	lb		
MEDIUM VOLTAGE MOTORS	UNITS	REQUIREMENTS	SELLER

			RESPONSE
Motor X/R ratio			
Temperature rise at service factor load	ºC		
Temperature rise at rated load	ºC		
Stator winding connection (Wye or Delta)			
Full load current at rated voltage	A		
Full load speed at rated voltage	RPM		
Locked rotor kVA/HP at rated voltage	kVA/HP		
Locked rotor current at rated voltage	A		
Locked rotor kVA letter			
Guaranteed efficiency at full load	%		
Guaranteed efficiency at 75% load	%		
Guaranteed efficiency at 50% load	%		
Efficiency test method	IEEE 112		
Power Factor basis (Test or Calculation)			
Torque at rated voltage:			
Starting torque	lb-ft		
Breakdown torque	lb-ft		
Full-load torque	lb-ft		
Acceleration time, including driven equipment:			
At rated voltage	sec		
At 85% voltage	sec		
MEDIUM VOLTAGE MOTORS	**UNITS**	**REQUIREMENTS**	**SELLER**

			RESPONSE
Safe stall time:			
Motor at SF load operating temperature	sec		
Motor at max ambient temperature	sec		
Consecutive Starts:			
Motor at SF load operating temperature			
Motor at max ambient temperature			
Cooling period at max number of consecutive starts:			
Motor operating at SF			
Motor operating w/driven equipment unloaded			
Down thrust rating:			
Continuous	lb		
Momentary	lb		
Up thrust rating			
Continuous	lb		
Momentary	lb		
Rotor inertia	lb-ft^2		
Thrust bearing type			
Thrust bearing lubrication (oil/grease)			
Lower guide bearing type			
Lower guide bearing lubrication (oil/ grease)			
Space heater rating, (watts/ volts/ phase)			
MEDIUM VOLTAGE MOTORS	**UNITS**	**REQUIREMENTS**	**SELLER**

			RESPONSE
Sound level	dBA		
Reed natural frequency	Hz		
Dimensions: bottom of flange to center of gravity	inches		
Overall dimensions including shaft extension	inches		
Shaft extension	inches		
Rotor removal clearance	inches		
Weight	lb		
Stator RTD type			
Stator RTD quantity			
Bearing Temperature device type			
Bearing Temperature device quantity			

****

The following additional information shall also be included with proposals:

1. Seller variances or exceptions to the specification.
2. Seller’s test report for electrically duplicate or prototype motor.
3. Seller’s motor efficiency test method description including assumptions and accuracy.
4. Typical motor outline drawing.
5. Motor speed torque at rated voltage.
6. Motor speed torque at 85% rated voltage.

****

APPENDIX 3

PERFORMANCE GUARANTEES

****
Insert project-specific performance guarantee requirements in this Appendix.
****

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

****
In addition to revising this spec to correspond to project-specific requirements, update all Appendix highlighted areas with project-specific data.
****

SITE CONDITIONS

LOCATION

Xcel Energy's Cherokee Station site is located in Adams County, CO at 6198 Franklin St.   Denver, CO 80216.

METEOROLOGICAL DATA

Table 1 below lists the major site conditions which are based on ambient weather conditions taken from several data references. The following abbreviations apply to this table:

DBT: Dry Bulb Temperature

MCWB: Mean coincident wet bulb for a given dry bulb temperature

AMSL: Above Mean Sea Level

IBC: International Building Code

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

TABLE 1 – MAJOR SITE CONDITIONS

PARAMETER	DATA
Site Elevation	5131 feet AMSL
Site Ambient Conditions	
Record low dry bulb temperature: MCWB for record low DBT:	-29°F -29°F
99% winter design dry bulb temperature: MCWB for 99% winter design DBT:	-5°F -8°F
Average winter dry bulb temperature: MCWB for average winter DBT:	-35°F -29°F
Annual average dry bulb temperature: MCWB for annual average DBT:	50°F 39°F
Summer 1% dry bulb temperature: MCWB for summer design 1% DBT: (Comparable to ASHRAE cooling, 0.4% occurance)	95°F 70°F
Record high dry bulb temperature: MCWB for record high DBT:	105°F 72°F
Dry bulb temperature for ISO System Accrediation: MCWB for ISO System Accrediation DBT:	95°F 70°F
Relative Humidity Range	0% to 100%
Annual Average Percipitation	18 inches
Maximum 24 Hour Rainfall Total	3 inches
Annual Average Snowfall	60 inches
Maximum 24 Hour Snowfall Total	48 inches

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

WIND LOADING

Wind loads shall be in accordance with the IBC. Basic wind design parameters are as follows:

DESCRIPTION	CHEROKEE	NOTES
Classification of Structure Category	III	Ref. ASCE 7-05, Section 1.5
Exposure	C	Ref. ASCE 7-05, Section 6.56
Wind Importance Factor	1.15	
Reference Wind Velocity, V	90 mph	3 sec. gust @ 33 ft. above ground. Ref. ASCE 7-05

SEISMIC CRITERIA

Structures shall be designed using the seismic criteria in the IBC as applicable to Colorado. Basic seismic parameters, per the IBC, are as follows:

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration at a short period (0.2 seconds), S_s = 0.217g.

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration a 1 second period), S_s = 0.056g.

Seismic Importance Factor, I_E = 1.25.

Based on the information presented in the Geotechnical Report, the project site has been assigned to Site Class D, to be verified by a site-specific geotechnical report.

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

REFERENCE MATERIALS

The following drawings contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Schematic Diagrams
- Wiring Diagrams

****
For motor replacement projects, consult with Mechanical for existing driven equipment requirements and update this section with mechanical drawings as applicable.
****

APPENDIX 5

QA/QC (Including Inspection Test Plans)

****
Revise this Appendix accordingly per project-specific requirements.
****

QA/QC

INSPECTION AND TEST PLANS

Seller shall submit their standard Inspection and Test Plan (ITP) for approval in accordance with Appendix 1 requirements.

QA/QC INSPECTIONS/REPORTING

****
Determine frequency of Xcel inspections of Seller's facilities during fabrication, prior to delivery, etc. and add requirements to this section as required. Review Xcel Intranet QA/QC Toolbox for various tools and templates for the following, as project requirements dictate:

- Shop inspection reports
- Non-conformance reports
- Release for shipment, etc.

Add these documents to this Appendix as required.
****

APPENDIX 6

STARTUP, TESTING AND COMMISSIONING

****
The following are minimum suggested testing requirements. Revise per project requirements as required:
****

TESTING

Factory Testing:

1. Perform factory tests in accordance with IEEE/ANSI and NEMA standards.
2. Motor testing shall be performed with motor terminal housing installed on motor.
3. Factory tests shall include the following minimum tests:
   a. No-load running current
   b. No-load speed
   c. Insulation resistance
   d. Winding resistance
   e. Mechanical balance
   f. Locked rotor current
   g. Motor efficiency
4. Submit test data/test reports in accordance with Appendix 1.

Shop Tests:

1. Perform standard shop tests in accordance with NEMA and IEEE standards.

****
Depending on project requirements, determine the level of factory field support required for startup/commissioning.

****

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

PACKAGING, SHIPPING AND STORAGE

Seller shall prepare equipment for shipment following successful completion of factory testing and resolution of QA/QC non-conformances (see Appendix 5 for additional details.

Seller shall prepare equipment to withstand any possible damage or loss due to rough handling or exposure to weather during transit or extended outdoor storage (up to two (2) years).

Seller shall install all required covers to protect equipment from rain, hail, wind, dust, snow and environmental conditions detrimental to the equipment.

Equipment shall be adequately sealed and protected during shipment to prevent corrosion, foreign matter egress and freeze damage which could result from the presence of residual water.

Lifting points and centers of gravity shall be clearly marked on the shipped equipment.

Shipping structural bracing shall be installed as required to allow for field handling, skidding and hoisting.

Equipment supplied with space heaters shall have heater leads accessible without requiring disassembly of shipping containers.

Threaded outlets shall have plugs or caps installed prior to shipping.

Ancillary materials which are “shipped loose” shall be in separately boxed and re secured to the main equipment containers.

Seller shall provide the following minimum unloading/handling information:

- Shipping weight and dimensions of each article
- Pick points
- Rigging requirements
- Weight distribution
- Center of gravity
- Sensitivities
- Hazards

A QA/QC inspection certification, signed by the Seller shall be issued to the company prior to shipment. A copy of this certificate shall be included with the Bill of Lading.

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

Shipping documentation shall include the following minimum information:

- Company Destination (Plant, Unit)
- Company Agreement number
- Sellers order number
- Date shipped
- Shipping origin
- Company equipment tag information
- Seller’s equipment identification information
- Shipment tracking information
- Shipment description
- Shipment quantity
- Gross weight
- Special handling requirements
- Identification of spare equipment
- Barcode, RFID, or similar material control information

Seller shall coordinate all deliveries with Company prior to shipment. Coordination shall include resolution of QA/QC non-conformances, delivery schedule, unloading/handling requirements, and storage requirements.

APPENDIX 8

ACCEPTABLE MANUFACTURERS

****
The following list contains the typically preferred manufacturers. Coordinate with Xcel Sourcing to determine final bid list:
****

Acceptable manufacturers are as follows:

- General Electric
- Louis Allis
- Seimens
- TECO Westinghouse
- Toshiba
- US Motors/Nidec
- WEG

MASTER SPECIFICTION
FOR

Metal-Clad Switchgear (MV)

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
3-4-2015	1.0	Enhancements; Required Format

METAL-CLAD SWITCHGEAR (MV)

****

In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

GENERAL

DESCRIPTION

****
Insert project-specific description items (i.e. new construction project, replacement project, project location, etc.)
****

SUMMARY

This specification details the requirements for medium voltage (MV) switchgear which is comprised of MV circuit breakers.

****
Note for MV switchgear replacement projects: Revise appropriate sections below, and Appendix 4, to include details regarding existing plant conditions that will affect switchgear design. Minimum existing plant condition items to consider:

- Existing space constraints
- Existing switchgear orientation
- Existing stub-up locations
- Existing bus duct connection points
- Arc Flash ductwork routing obstructions within existing space (if applicable)
- Breaker removal space impact of new gear dimensions

****

Reference Drawings

The following drawings, included in Appendix 4, contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Relaying/Protective Device Schematics
- Bus Duct Connection Info

Technical Proposal Documentation

See Appendix 2 for technical proposal requirements.

APPLICABLE CODES AND STANDARDS

- State and local codes, laws, ordinances, rules and regulations
- ANSI - American National Standards Institute
- ASTM - American Society for Testing and Materials
- ICEA - Insulated Cable Engineers Association
- IEEE - Institute of Electrical and Electronic Engineers
- NEMA - National Electrical Manufacturer's Association
- NFPA - National Fire Protection Association
- OSHA - Occupational, Health and Safety Administration
- UL Underwriter's Laboratories

In the event of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

DESIGN & CONSTRUCTION FEATURES

1. **Environmental**

   MV switchgear shall be manufactured to withstand site environmental conditions. See Appendix 4 for site specific environmental conditions.

2. **Ratings**

   MV switchgear ratings shall be as specified in Appendix 2 Data Sheets.

SWITCHGEAR CONSTRUCTION

1. Switchgear shall be metal-clad and mounted in one-high or two-high vertical sections fabricated of steel and assembled to provide rigid self-supporting, completely enclosed structures.
2. Switchgear shall include all gas ductwork required to exhaust arc flash gasses from the switchgear to building exterior.
3. Switchgear breakers shall be removable from the front.
4. All live parts shall be completely enclosed. Grounded removable steel barriers shall be provided between adjacent sections and solid removable metal barriers shall isolate the major primary sections of each circuit.
5. MV switchgear shall be provided with closed-door racking and closed-door remote racking.
6. Each breaker cubicle shall have individual back panels to allow rear access to associated cables etc. and shall be able to be opened without exposure to adjacent breaker live parts.
7. The switchgear shall be capable of extension from either end without modification to existing structural members.
8. If louvers are furnished as part of the switchgear enclosure they shall be provided with air filters.
9. The depth of cable entries shall allow for entrance, bending, and termination of power cables, including stress cones, and shall have a minimum of 24 inches of

clearance between the terminal pads and the cable entrance point to the cubicle.

10. Cable supports shall be provided every 24 inches to support cables for lugs not located near the cable entrance.
11. Switchgear sections shall allow top and bottom entry of power, control and instrumentation cables.

INFRARED INSPECTION PORTS

1. Infrared (IR) inspection ports shall be installed to permit thermography inspection of all line and load connections.
2. IR inspection port NEMA rating shall be equal to, or greater than, that of the enclosure in which it is installed.
3. IR inspection ports shall be NFPA 70E compliant.
4. IR inspection ports shall be 3 inch minimum diameter and shall consist of reinforced polymeric optic material.

SPACE HEATERS

1. Each vertical switchgear section shall be provided with thermostatically-controlled anti-condensation space heaters.
2. Heaters shall be rated for 240 VAC and energized and sized for application at 120 VAC.

GROUND BUS

1. A non-insulated, predrilled, copper bar ground bus shall extend the entire length of each switchgear lineup and to each cubicle.
2. Copper ground bar minimum size shall be 1/4 inch by 2 inches.

BUS CONSTRUCTION

1. Switchgear bussing shall consist of electrical grade high-conductivity copper bars, silver-plated at all contact surfaces and shall be designed to continuously carry rated design current.
2. Bussing shall be braced with rigid, tracking-resistant, fire-resistant, and moisture-resistant insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the momentary current rating of the largest circuit breaker in the assembly.
3. Bussing shall have fluidized bed epoxy, flame resistant, non-hygroscopic insulation with a continuous current rating. The bus bar insulation shall be flame resistant and shall be flame resistant in accordance with ANSI/IEEE standards.
4. Bus joints shall have insulated boots that can be easily removed and reinstalled to allow inspection of the joints.
5. Phase sequencing for power connections and main bus shall be left-to-right, top-to-bottom, front-to-back (phase A-B-C) when facing the front of the switchgear. All bussing shall have phase identification installed.

MV CIRCUIT BREAKERS

1. The switchgear shall be furnished with draw-out medium voltage power circuit

breakers. The power circuit breakers shall be vacuum type.

2. Each breaker shall have three (3) positions: operate, test, and disconnected. Breaker position shall be indicated on the breaker.
3. The power circuit breaker operating mechanism shall be fully mechanically and electrically trip-free in any position. The main contacts of the power circuit breakers shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.
4. Each breaker shall be furnished with a manual trip push button, which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.
5. Each circuit breaker shall be capable of being padlocked in the disconnected position.

SHUTTERS

1. Grounded automatic metal safety shutters shall be provided which isolate the primary connections in power circuit breaker or voltage transformer (VT) compartment when circuit breakers or VTs are withdrawn from the connected position.
2. Shutters shall automatically operate when the power circuit breaker or voltage transformer is racked in or out.

AUXILIARY SWITCHES

1. Breaker Draw-out Auxiliary Position Switches (52/a/b):
   a. Each power circuit breaker shall be furnished with breaker-mounted auxiliary position switches mounted on the breaker frame.
   b. The breaker-mounted auxiliary position switches shall provide breaker opened or closed indication only when the breaker is in the fully “in-service” and “test” position.
   c. A minimum of two (2) normally-open (“a”) and two (2) normally-closed (“b”) contacts shall be furnished for Company’s use in addition to those required by the Seller’s design.
2. Breaker Stationary Position Switches (52S/a/b):
   a. Each breaker shall be furnished with stationary auxiliary position switches mounted in the breaker cell compartment.
   b. The breaker stationary auxiliary position switches shall provide breaker opened or closed indication only when the breaker is in the fully “in-service” position. When the breaker is not in the “in-service” position (e.g. in the “test” position or “disconnected” positions) the breaker stationary auxiliary position switches shall indicate the breaker is open at all times.
   c. A minimum of two (2) normally-open (“a”) and two (2) normally-closed (“b”) contacts shall be furnished for Company’s use in addition to those required by the Seller’s design.
3. Breaker Truck Position Switches (52H):
   a. Each breaker shall be furnished with truck position switches mounted in the breaker cell compartment. Each switch shall be field convertible to be either normally open or normally-closed.
   b. The breaker truck position switches shall provide breaker “in-service”/“not in-service” indication. The switches shall indicate that the breaker is “in-

service" only when the breaker is fully racked in to the "in-service" position.

c. A minimum of two (2) normally-open ("a") and two (2) normally-closed ("b") contacts shall be furnished for Company's future use in addition to those required by the Seller's design.

INSTRUMENTATION AND CONTROL

1. MV switchgear and motor controllers shall be controlled and monitored by Owner's Distributed Control System (DCS).
2. Interposing relays shall be provided for interfacing with the DCS controls as required. Seller shall coordinate with Owner regarding DCS I/O requirements to determine the necessity and type(s) of interposing relays.

INSTRUMENT AND CONTROL WIRING

1. Instrumentation and control (I&C) wiring shall be stranded Type SIS, VW-1, extra flexible, insulated to 600 V with XLPE or EPR insulation.
2. The wiring shall have the following minimum sizes:
   a. Current Transformer circuits: 10 AWG
   b. Power circuits 12 AWG
   c. All other I&C circuits: 14 AWG
3. I&C wiring shall be installed and tested at the factory.
4. I&C wiring shall be installed in wiring gutters or conduit and secured with nylon ties.
5. I&C wiring shall be protected from contact with sharp edges with grommets.
6. Flexible wire guards shall be installed for wiring which cross hinge points.
7. Heat-shrinkable wire markers shall be installed at each end of each wire. Wire markers shall identify the wire's respective termination points.

TERMINAL BLOCKS

1. All terminal blocks shall be one-piece UL94-VO material terminal blocks with strap-screw connectors and a minimum rating of 600 V, 30 amperes.
2. All current transformer circuits shall be wired to shorting-type terminal blocks.
3. All terminal blocks and terminals on terminal blocks shall have legible machine lettering.
4. No more than two (2) wires shall be terminated at any one (1) terminal point.
5. One (1) side of each terminal block used for external connections shall be reserved solely for external connections.
6. Current transformer circuits shall be wired to shorting terminal blocks

TERMINATIONS

1. Terminal blocks shall be provided with a minimum of 20% spare terminals.
2. When compatible with Manufacturer's standard supply, all circuits shall be terminated with ring-type connectors.
3. All spare contacts shall be wired to terminal blocks.

CONTROL POWER

1. A common 125 VDC bus shall be wired throughout each switchgear lineup to provide power for breaker control, charging motor, protective relaying, and other auxiliary components.
2. The common 125 VDC bus shall have one (1) supply point in each switchgear lineup. A single, visible break disconnecting device shall be provided to disconnect both the closing and tripping circuits.
3. Breaker close and trip circuits shall be fused separately in each breaker cubicle. Control or protective devices that are common to more than one (1) breaker shall be fused on separately fused circuits. Minimum trip circuit fuse rating shall be 30 A.
4. Breaker close circuit power shall be sub-fused from the trip circuit power supply.

PROTECTIVE RELAYING AND METERING

1. Seller shall furnish and install protective relaying and metering as shown in Appendix 4 reference drawings.
2. Relaying and metering test switches shall be provided for all trip, current transformer (CT) and voltage transformer (VT) circuits. See Appendix 4 drawings for additional requirements. Test switches shall be ABB FT-1 or States Type FMS. Test switches shall have black handles for current and voltage poles, red handles for trip poles.
3. Control switches shall be furnished and installed for each breaker. The switches shall be configured such that the breakers cannot be closed with the breakers racked in to the “in-service” position.
4. Lock-out relays (LOR) shall be manual reset Electroswitch Series 24, lighted target nameplate with (2) LEDs and mechanical trip target.
5. Breaker position indicating lights shall be provided for each breaker adjacent to their respective control switches. Indicating lights shall be long-life LED type with push-to-test feature. Red lights shall indicate breaker in CLOSED position green lights shall indicate breaker in OPEN position.
6. Coil monitoring relays shall be furnished and installed. Relays shall be flush-mounted on the cubicle door front such that coil healthy indicating light is visible.
7. Optical arc flash detection relays shall be installed in all medium voltage switchgear cubicles. Optical relays shall coordinate with protective devices specified herein and are intended to reduce personnel arc flash hazard levels.
8. Metering shall be provided in accordance with Appendix 4 drawings.
9. Switchgear metering shall be factory calibrated have factory installed parameter settings.

CURRENT TRANSFORMERS

1. Current transformer (CT) shall be designed to allow maintenance or replacement of the CTs without damage. CTs shall be mechanically braced to withstand rated breakers/contactor short circuit currents.
2. Current transformer mechanical and thermal limits shall be coordinated with the momentary and short time ratings of their associated breakers/contactors.
3. All spare breakers and equipped spaces shall be furnished with multi-ratio

current transformers as shown on Appendix 4 drawings.

4. Unless otherwise specified, CT polarity marks shall be toward the breaker.

VOLTAGE TRANSFORMERS

1. Voltage transformers (VT) shall be mounted on draw-out type removable units which isolate and ground the potential circuits when the unit is in the fully withdrawn position.
2. Each VT shall be provided with current limiting primary fuses. Secondary fusing shall be fast-acting type and selected to fully coordinate with the primary fuses for a fault on the secondary control circuits.

NAMEPLATES

1. Engraved nameplates shall be furnished on the outside of each switchgear lineup and individual switchgear section.
2. Switchgear nameplates shall be 1/16 inch laminated phenolic resin with white background and black core. Nameplates shall indicate the following minimum information:
   a. Equipment description/name
   b. Equipment tag number
   c. NEMA equipment ratings
3. Engraved nameplates shall also be furnished for auxiliary devices and terminal blocks mounted inside compartments.
4. Nameplates shall be mounted using stainless pan-head self-tapping screws.

SPARE PARTS AND TOOLS

1. Each switchgear lineup shall be furnished with the following minimum spare parts, maintenance and operating equipment:
   a. One (1) portable lift truck for breaker installation and removal.
   b. One (1) ground and test device.
   c. Manual lever or crank for moving the breaker elements into and out of the operating position.
   d. Manual spring charging handle for circuit breaker.
   e. Remote racking device.
   f. Remote test station for testing the circuit breaker outside the cubicle and in the test position.
   g. Special tools required for operation or maintenance.
   h. Test modules, test devices, test equipment, software, and software licenses for testing and setting relays and associated protective devices.
   i. Provide 50% spare set of fuses for each size and type of fuse furnished and 10% spare set of indicating lights and lenses.

TESTING

Testing requirements are defined in Appendix 6.

DELIVERABLES

Deliverable requirements are defined in Appendix 1.

PROPOSAL DATA REQUIREMENTS

Seller shall provide proposed equipment data in accordance with Appendix 2.

SITE CONDITIONS

Site conditions are defined in Appendix 4.

QUALITY ASSURANCE

QA/QC requirements are defined in Appendix 5.

PACKAGING STORAGE & SHIPPING

Packing, shipping storage requirements are defined in Appendix 7.

MATERIALS & WELDING

****
Fill in as required
****

PERFORMANCE GUARANTEES

****
Fill in Appendix 3 as required
****

SOUND CONTROL REQUIREMENTS

****
Fill in as required
****

CLEANING, PAINTING & COATING

****
Fill in as required
****

APPENDICES TO SPECIFICATION

****

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE MANUFACTURERS

APPENDIX 1

DELIVERABLES

****
The following is a list of minimum suggested deliverables and deliverable information. Revise per project requirements as required:
****

Manufacturer drawings:

1. Shipping layout drawings
2. Installation instructions/details including rigging information and equipment loadings
3. Dimensioned switchgear lineup (overall and cubicle) plan, elevation and detail drawings including cubicle cross sections, bus arrangements, weights, grounding details.
4. Switchgear Bill of Material
5. Bus duct connection details
6. Arc flash ductwork plan, elevation and detail drawings
7. Nameplate schedule and details
8. Switchgear one-line drawings
9. Switchgear three-line drawings
10. Control and relaying/protective device schematics and wiring diagrams
11. Current transformer excitation curves

Test data:

1. Factory and field test data/test report. See Appendix 6 for details.

Operation and Maintenance Manuals:

1. Operation and maintenance (O&M) manuals shall include the following minimum information:
    a. Installation instructions.
    b. Operating instructions.
    c. Maintenance instructions.
    d. Nameplate data.
    e. Assembly drawings.
    f. Bill of Material with vendor part numbers
    g. Cut sheets and brochure data for all transformer auxiliary equipment including relay manufacturer's O&M information
    h. Recommended spare parts list
    i. Certified (final) test reports
    j. Storage and Handling instructions.
    k. Special tools required for installation, operation and/or maintenance
    l. Warranty information

APPENDIX 1

DELIVERABLES

QA/QC:

1. Seller's QA/QC Inspection and Test Plan (ITP)

****
Include project-specific requirements for the following:
****

- Seller Deliverable Schedule
- Deliverable Format
- Deliverable Quantities

APPENDIX 2

PROPOSAL DATA REQUIREMENTS

METAL-CLAD SWITCHGEAR (MV) DATA SHEET

Seller shall provide the following minimum technical data applicable to the equipment in the proposed scope of supply.

****
In addition to revising this spec to correspond to project-specific requirements, update all highlighted areas with project-specific data.
****

METAL-CLAD SWITCHGEAR (MV)	UNITS	REQUIREMENTS	SELLER RESPONSE
Manufacturer		Seller	
City & Country of Manufacture		Seller	
MV BREAKER SWITCHGEAR			
Bus Conductor Material		Copper with silver-plated contact surfaces	
Switchgear Configuration		3-Phase, 3W, Low-Impedance Gnd	
Switchgear Bus Rating	A	4000	
Rated Nominal Voltage	kV	4.16	
Rated Maximum Voltage	kV	4.76	
Operating Frequency	Hz	60	
Insulation Level (Frequency)	kV, RMS	19	
Insulation Level (Impulse)	kV, Crest	60	
Rated Short Circuit and Short Time Current (@ rated max kV)	kA, RMS	50	
Max Symmetrical Interrupting Capability	kA, RMS	50	
Rated Interrupting Time	cycles	5	
Rated Permissible Tripping Delay	seconds	2	
Installation Location		Indoors	
Enclosure NEMA type		Type 1	

Switchgear Type		Metal-Clad	
Arc-Resistance Type		Type 1	
Breaker Type		Vacuum, Draw-out	
Control Voltage	VDC	125	

****

The following additional information shall also be included with proposals:

1. Seller variances or exceptions to the specification.
2. Itemization of proposed estimated materials.
3. Add/deduct pricing for breaker type/rating, contactor type/rating, etc.
4. Recommended spare parts list with pricing.

****

APPENDIX 3

PERFORMANCE GUARANTEES

****
Typically, switchgear systems do not have performance guarantees associated with them. However, consider all project-specific requirements to determine the applicability of this Appendix.
****

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

****
In addition to revising this spec to correspond to project-specific requirements, update all Appendix highlighted areas with project-specific data.
****

SITE CONDITIONS

LOCATION

Xcel Energy's Cherokee Station site is located in Adams County, CO at 6198 Franklin St. Denver, CO 80216.

METEOROLOGICAL DATA

Table 1 below lists the major site conditions which are based on ambient weather conditions taken from several data references. The following abbreviations apply to this table:

DBT: Dry Bulb Temperature

MCWB: Mean coincident wet bulb for a given dry bulb temperature

AMSL: Above Mean Sea Level

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

TABLE 1 – MAJOR SITE CONDITIONS

PARAMETER	DATA
Site Elevation	5131 feet AMSL
Site Ambient Conditions	
Record low dry bulb temperature: MCWB for record low DBT:	-29°F -29°F
99% winter design dry bulb temperature: MCWB for 99% winter design DBT:	-5°F -8°F
Average winter dry bulb temperature: MCWB for average winter DBT:	-35°F -29°F
Annual average dry bulb temperature: MCWB for annual average DBT:	50°F 39°F
Summer 1% dry bulb temperature: MCWB for summer design 1% DBT: (Comparable to ASHRAE cooling, 0.4% occurance)	95°F 70°F
Record high dry bulb temperature: MCWB for record high DBT:	105°F 72°F
Dry bulb temperature for ISO System Accrediation: MCWB for ISO System Accrediation DBT:	95°F 70°F
Relative Humidity Range	0% to 100%
Annual Average Percipitation	18 inches
Maximum 24 Hour Rainfall Total	3 inches
Annual Average Snowfall	60 inches
Maximum 24 Hour Snowfall Total	48 inches

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

WIND LOADING

Wind loads shall be in accordance with the IBC. Basic wind design parameters are as follows:

DESCRIPTION	CHEROKEE	NOTES
Classification of Structure Category	III	Ref. ASCE 7-05, Section 1.5
Exposure	C	Ref. ASCE 7-05, Section 6.56
Wind Importance Factor	1.15	
Reference Wind Velocity, V	90 mph	3 sec. gust @ 33 ft. above ground. Ref. ASCE 7-05

SEISMIC CRITERIA

Structures shall be designed using the seismic criteria in the IBC as applicable to Colorado. Basic seismic parameters, per the IBC, are as follows:

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration at a short period (0.2 seconds), $S_s = 0.217g$.

Mapped Maximum Considered Earthquake (MCE), 5% damped, spectral response acceleration a 1 second period), $S_s = 0.056g$.

Seismic Importance Factor, $I_E = 1.25$.

Based on the information presented in the Geotechnical Report, the project site has been assigned to Site Class D, to be verified by a site-specific geotechnical report.

APPENDIX 4

SITE CONDITIONS AND REFERENCE MATERIALS

REFERENCE MATERIALS

The following drawings contain additional scope requirements as part of this specification:

- General Arrangements
- One-Line Diagrams
- Three-Line Diagrams
- Control and Relaying/Protective Device Schematic Diagrams
- Bus Duct Layouts Connection Info

APPENDIX 5

QA/QC (Including Inspection Test Plans)

****
Revise this Appendix accordingly per project-specific requirements.
****

QA/QC

INSPECTION AND TEST PLANS

Seller shall submit their standard Inspection and Test Plan (ITP) for approval in accordance with Appendix 1 requirements.

QA/QC INSPECTIONS/REPORTING

****
Determine frequency of Xcel inspections of Seller's facilities during fabrication, prior to delivery, etc. and add requirements to this section as required. Review Xcel Intranet QA/QC Toolbox for various tools and templates for the following, as project requirements dictate:

- Shop inspection reports
- Non-conformance reports
- Release for shipment, etc.

Add these documents to this Appendix as required.
****

APPENDIX 6

STARTUP, TESTING AND COMMISSIONING

****
The following are minimum suggested testing requirements. Revise per project requirements as required:
****

TESTING

Factory Testing:

1. Perform factory tests in accordance with IEEE/ANSI and NEMA standards.
2. Factory tests shall include the following minimum tests:
   a. Bus high potential and insulation resistance
   b. Voltage withstand
   c. Point-to-point wiring checks
   d. Relay injection testing
   e. Standard breaker tests
   f. Standard contactor tests
   g. CT and VT ratio, excitation and polarity tests
   h. Shutter operational tests
3. Submit test data/test reports in accordance with Appendix 1.

Shop Tests:

1. Perform standard shop tests in accordance with IEEE standards.

****
Depending on project requirements, determine the level of factory field support required for startup/commissioning. Minimum commissioning considerations are as follows:

- Construction/installation inspections
- International Electrical Testing Association (NETA) standard field tests (e.g. bus high potential testing, megger, etc.)
- Breaker operation testing

****

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

PACKAGING, SHIPPING AND STORAGE

Seller shall prepare equipment for shipment following successful completion of factory testing and resolution of QA/QC non-conformances (see Appendix 5 for additional details.

Seller shall prepare equipment to withstand any possible damage or loss due to rough handling or exposure to weather during transit or extended outdoor storage (up to two (2) years).

Seller shall install all required covers to protect equipment from rain, hail, wind, dust, snow and environmental conditions detrimental to the equipment.

Equipment shall be adequately sealed and protected during shipment to prevent corrosion, foreign matter egress and freeze damage which could result from the presence of residual water.

Lifting points and centers of gravity shall be clearly marked on the shipped equipment.

Shipping structural bracing shall be installed as required to allow for field handling, skidding and hoisting.

Equipment supplied with space heaters shall have heater leads accessible without requiring disassembly of shipping containers.

Threaded outlets shall have plugs or caps installed prior to shipping.

Ancillary materials which are “shipped loose” shall be in separately boxed and re secured to the main equipment containers.

Seller shall provide the following minimum unloading/handling information:

- Shipping weight and dimensions of each article
- Pick points
- Rigging requirements
- Weight distribution
- Center of gravity
- Sensitivities
- Hazards

A QA/QC inspection certification, signed by the Seller shall be issued to the company prior to shipment. A copy of this certificate shall be included with the Bill of Lading.

APPENDIX 7

PACKAGING, SHIPPING AND STORAGE

Shipping documentation shall include the following minimum information:

- Company Destination (Plant, Unit)
- Company Agreement number
- Sellers order number
- Date shipped
- Shipping origin
- Company equipment tag information
- Seller’s equipment identification information
- Shipment tracking information
- Shipment description
- Shipment quantity
- Gross weight
- Special handling requirements
- Identification of spare equipment
- Barcode, RFID, or similar material control information

Seller shall coordinate all deliveries with Company prior to shipment. Coordination shall include resolution of QA/QC non-conformances, delivery schedule, unloading/handling requirements, and storage requirements.

APPENDIX 8

ACCEPTABLE MANUFACTURERS

****
The following list contains the typically preferred manufacturers. Coordinate with Xcel Sourcing to determine final bid list:
****

Acceptable manufacturers are as follows:

- ABB
- Eaton
- Powell
- Siemens
- Square-D

TECHNICAL SPECIFICATION

4160 VOLT NON-SEGREGATED PHASE BUS DUCT

Prepared by:
NAME OF A/E FIRM ENGINEERING PROJECT

Rev.	Date	Issued for	Prepared By	Technical Approval	Project Approval

4160 VOLT NON-SEGREGATED PHASE BUS DUCT

TABLE OF CONTENTS

EXHIBIT A

TABLE OF CONTENTS (CONTINUED)

EXHIBIT A

4160 VOLT NON-SEGREGATED PHASE BUS DUCT

PART 1 SCOPE

1.01 GENERAL

A. Description

1. The 4160 V non-segregated phase bus duct shall be designed and constructed for use on a 4160 V, 3-phase, 60 hertz, 3 wire, resistance grounded (2.4 ohm) system.

2. All indoor and outdoor bus duct, including fittings, bus duct supports, and conductor flexible connectors shall be furnished in accordance to these Specifications.

3. One 4160 V bus duct shall be required from each auxiliary power transformer secondary flange connection of each unit auxiliary power transformer.

B. Bus Duct Layout

1. Refer to site layout and powerhouse layout drawings for location and orientation of powerhouse and auxiliary power transformer equipment.

2. The following estimated bus duct lengths, number of supports, and fittings may be used for bidding purposes (per bus duct run).

   a. Outdoor bus duct length/run -

   b. Indoor bus duct length/run -

   c. Fittings (quantity) -

   d. Outdoor supports(quantity)/run -

3. Include separate additional add/deduct pricing in proposal for elbows and a cost per foot of bus for final price adjustments.

C. Reference Drawings

The following drawings are being submitted as part of this specification:

Bus Layout

One-Line Diagram

Site Layout

Aux Transformer Outline

5kV Non-Seg Bus Auxiliary Transformer

D. Technical Proposal Documentation

1. The following information shall be included with the bid proposal:

e. Any variances or exceptions which the Manufacturer has to this and referenced specifications.

f. Attached data sheets to be filled out as completely as possible.

g. Estimated materials.

h. Manufacturer's sales literature pertinent to proposed equipment.

E. Approved Manufacturers

Delta-Unibus

Calvert

Cutler-Hammer

ABB

1.02 WORK TO BE PROVIDED BY SELLER

FILL IN AS REQUIRED

1.03 WORK TO BE PROVIDED BY PURCHASER

FILL IN AS REQUIRED

PART 2 CODES, STANDARDS & REGULATIONS

A. State and local codes, laws, ordinances, rules and regulations

B. ANSI - American National Standards Institute

C. ASTM - American Society for Testing and Materials

D. ICEA - Insulated Cable Engineers Association

E. IEEE - Institute of Electrical and Electronic Engineers

F. NEMA - National Electrical Manufacturer's Association

G. NFPA - National Fire Protection Association

H. OSHA - Occupational, Health and Safety Administration

I. UL Underwriter's Laboratories

In case of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

PART 3 TECHNICAL REQUIREMENTS

3.01 PERFORMANCE REQUIREMENTS & GUARANTEES

FILL IN AS REQUIRED

3.02 DESIGN & CONSTRUCTION FEATURES

A. Environmental

1. The following ambient and site conditions shall be used in the designed of all furnished equipment.

a. Site Location

b. Site Elevation, Feet (above mean sea level)

c. Atmospheric Pressure (psia)

d. Maximum Design Temperature, degrees F

e. Minimum Design Temperature, degrees F

f. Design Wind Speed, per ANSI C2 (MPH)

g. Snow Load (pounds per square foot)

h. Seismic Zone (UBC)

i. Electrical Classification

2. Considerations shall be given to the exposure to solar heat in the areas of outdoor installation.

B. RATINGS

1. Bus duct shall be furnished with the following voltage ratings:

a. Nominal voltage: 4.16 kV rms

b. Rated maximum voltage: 4.76 kV rms

c. Rated power frequency dry 1 minute withstand voltage: 19 kV rms

d. Rated impulse withstand voltage: 60 kV peak

2. Bus duct shall be furnished with the following current and short circuit ratings:

a. Continuous rated current: 2,000 amps rms

b. Short-circuit withstand, asymmetrical (10 cycle rating): 65,000 amps rms or greater

C. BUS CONSTRUCTION

1. Bus duct construction shall be in accordance to ANSI standard C37.23; and other applicable requirements of Codes and Standards stated in these Specifications.

2. Bus duct shall be furnished as a complete assembly of rigidly

supported conductors, housed in a 3-phase enclosure without barriers between the phase conductors.

3. The bus conductors shall be copper or aluminum alloy and shall be designed to carry rated continuous current without exceeding temperature rise requirements specified in IEEE and NEMA standards. The current carrying capacity shall be based on actual service conditions including skin and proximity effects, and the effects of the bus insulation, the bus duct enclosure, and the ambient temperature.

4. The bus shall be installed with rigid, non-tracking, fire-resistant, and nonhygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the momentary current.

5. All bus conductor connections shall be completed by bolting. These connections shall be silver-plated for copper bus and tin-plated for aluminum. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through the ambient temperature range from 20°F to 100°F. Expansion joints shall be furnished where required.

6. Except at bolted terminations and connection points, all phase conductors in bus duct shall have a “Noryl” or equal sleeve type insulating material. All bolted joints; expansion joints; and bus connections, factory or field; and connections between the bus conductors and transformer terminals shall be insulated with removable boots. Removable boots shall be designed to overlap permanent insulation on each conductor in the connection insulated by the boot. The length of overlap on each conductor shall not be less than 2 inches at expansion joints, and not less than 1 inch at other connections. The insulation rating of bus, joint, connection, and termination insulation shall be not less than the voltage rating of the equipment.

7. Taps or connections shall be provided, as required, to accommodate auxiliary equipment such as lightning and surge protection, generator controls, metering and relaying, and current and potential transformers.

8. Removable covers shall be provided to permit access to the interior of the enclosure.

D. BUS ENCLOSURE

1. Indoor sections of bus duct shall be furnished with non-ventilated dust-tight enclosures. Outdoor sections of bus duct shall be furnished with non-ventilated weatherproof enclosures.

2. The bus enclosures shall be fabricated from aluminum not less than 1/8 inch thick.

3. Wall flanges and airtight vapor barriers shall be furnished at each transition from indoor to outdoor bus duct. In addition, a fire barrier, with 2 hour rating, shall be provided when penetrating firewalls.

4. After fabrication, all metal work of the enclosures shall be thoroughly cleaned and any steel work shall be phosphorized, or equivalent, and shall be painted with gray ANSI 61, or equivalent, gray paint.

E. SPACE HEATERS

2. Outdoor bus duct sections shall be furnished with space heaters to prevent condensation of moisture within the bus duct.

3. The heaters shall be located and thermally insulated such that no painted surface or bus insulation shall be damaged or discolored. Space heater capacity shall be as required to maintain the compartment and the bus duct internal temperature above the dew point. Voltage normally applied to the space heaters will be 120 V.

4. Space heater voltage rating shall be 240 V. Space heaters shall be controlled by an adjustable thermostat, factory set at manufacturer's recommended setpoints.

F. GROUND BUS

1. A ground bus shall be furnished which will electrically connect together all equipment connected to the bus duct. The ground bus shall be capable of carrying rated bus short-circuit current.

2. If the bus duct enclosure is so constructed and connected that it provides a continuous path for ground current equal in magnitude and duration to that specified in Subsection 2.2B, it may serve as the ground bus. If the enclosure is used as the ground bus, a tooth type lock washer shall be furnished under each bolt head and each nut at connections between sections of bus duct. Bolts, nuts, and

lock washers shall be stainless steel.

3. Provisions shall be made at each transition from indoor to outdoor bus duct to connect the enclosure to the station grounding system.

G. OUTDOOR BUS DUCT SUPPORTS

1. Supports shall be designed for the Seismic Zone and wind speeds as specified in Subsection 2.1. Support spans shall be 12 feet or less.

2. Finish

   a. Supports shall be galvanized steel in accordance with ASTM A36.

   b. Structures shall be galvanized by the hot dip process in accordance with ASTM A-123 except that all shapes shall receive 3.0 ounces of zinc per square foot of surface area. Structures are to be galvanized both inside and out after all cutting, punching, welding and cleaning have been completed.

   c. Finished galvanized surfaces must be uniform in color, appearance and texture and must be free of excessive roughness, pimples, lumpiness and runs.

3. Each support shall have a standard NEMA (2 hole) ground pad located at its base.

4. Manufacturer shall consider equipment maintenance access when locating supports. Support locations shall be at least 3 feet from equipment to allow room for equipment maintenance.

H. INDOOR BUS SUPPORTS

1. Indoor supports shall be galvanized steel and designed for hanging supports from building overhead steel. Support spans shall be 12 feet or less.

I. EQUIPMENT TERMINATIONS

1. Manufacturer shall furnish all flexible connectors and bus termination fittings for equipment terminations, for the termination of the busbars to the transformers and switchgear.

3.03 SEISMIC REQUIREMENTS

FILL IN AS REQUIRED

3.04 SOUND CONTROL REQUIREMENTS

FILL IN AS REQUIRED

3.05 ELECTRICAL REQUIREMENTS

FILL IN AS REQUIRED

3.06 INSTRUMENTATION & CONTROL REQUIREMENTS

FILL IN AS REQUIRED

3.07 MATERIALS & WELDING

FILL IN AS REQUIRED

3.08 CLEANING, PAINTING & COATING

FILL IN AS REQUIRED

3.09 PACKAGING & SHIPPING

FILL IN AS REQUIRED

3.10 STORAGE & HANDLING PROCEDURES

FILL IN AS REQUIRED

3.11 SPARE PARTS

FILL IN AS REQUIRED

3.12 QUALITY ASSURANCE

FILL IN AS REQUIRED

PART 4 TESTING

4.01 MATERIAL TESTING & INSPECTION

A. Factory Tests

1. Perform standard factory tests in accordance to ANSI C37.23.

2. Include certified test reports in instruction books.

4.02 SHOP TESTS

FILL IN AS REQUIRED

4.03 FIELD TESTING

FILL IN AS REQUIRED

PART 5 INSTALLATION

A. Contractor shall install bus duct and outdoor supports in accordance to Manufacturer's instructions and drawings.

B. Install power wiring to bus duct space heater circuits from 120/208 volt distribution panel.

PART 6 SELLER'S DATA SUBMISSION SCHEDULE

6.01 GENERAL

FILL IN AS REQUIRED

6.02 DRAWINGS

A. SUBMITTALS

Submit approval drawings, final drawings, instruction books, and technical proposal per Section 01300.1.6 FACTORY TESTS

1. Perform standard factory tests in accordance to ANSI C37.23.

2. Include certified test reports in instruction books.

B. Approved Drawings

1. Shop approval drawings shall include at least the following drawings:

   a. Bus duct layout and arrangement showing phasing arrangement, weight, and detailed dimensions.

   b. Bus duct support details, anchor bolt plan, and support locations.

   c. Bus duct ratings

   d. Schematics and wiring diagrams showing customer connections for bus duct heaters.

   e. Bus duct connection details

C. Final Drawings and Manuals

1. Submit final “as-built” drawings and manuals.

2. The instruction books shall include, but not limited to:

   a. Complete service and repair manuals

   b. Complete parts list with vendor part numbers and a recommended spare parts list.

   c. Bill of materials

   d. Certified test reports

   e. Storage and Handling instructions

   f. Installation instruction

   g. Complete information for tightening of all electrical connections secured with bolts or studs shall be included on erection and assembly drawings. The information furnished shall include torque wrench settings or complete details of other tightening procedures recommended for bus joints and connector attachments.

D. TECHNICAL PROPOSAL DOCUMENTATION

1. The following information shall be included with the bid proposal:

a. Any variances or exceptions which the Manufacturer has to this and referenced Specifications.

b. Attached data sheets to be filled out as completely as possible.

c. Estimated materials

d. Manufacturer's sales literature pertinent to proposed equipment.

6.03 DATA SUBMISSION SCHEDULE

FILL IN AS REQUIRED

EXHIBIT B

PART 7 TECHNICAL DATA

7.01 SITE DATA

FILL IN AS REQUIRED

7.02 TECHNICAL DATA BY PURCHASER

FILL IN AS REQUIRED

7.03 TECHNICAL DATA BY SELLER

FILL IN AS REQUIRED

APPENDICES

NONSEGREGATED BUS DUCT DATA SHEET

Manufacturer shall provide the following data applicable to the equipment in the proposed scope of supply.

Manufacturer/Model Number	______________ / ______________
Bus insulation	______________
Bus continuous rating	______________
Nominal voltage rating, kV rms	______________
Rated maximum voltage, kV rms	______________
Rated power frequency dry 1 minute	______________
Withstand voltage, kV rms	______________
Rated impulse withstand voltage, kV rms	______________
Rated low frequency withstand voltage, kV rms	______________
Size / rating of ground bus	______________
Rated momentary asym current, amperes rms (10 cycle rating)	______________

Exceptions to Specification:

____

____

____

____

MASTER SPECIFICTION
FOR
GENERATOR STEP-UP (GSU) TRANSFORMER

Revision _0_
Date 20131212

Responsible Technical Specialist ___________________

Author: John J Howard Jr	Revision No.:	Specification Approval:

GENERATOR STEP-UP (GSU) TRANSFORMER

GENERAL

Scope of Work

1. Seller shall design, test and deliver _____, < 3 >-phase, 60 Hz, oil-filled GSU transformer(s). Transformers shall be equipped with a high voltage no-load tap changer. Transformer MVA ratings shall be as specified in Appendix 2 Data Sheets. Maximum winding temperature (hot spot) rise shall not exceed < 80 > ºC and maximum liquid oil temperature rise shall not exceed < 65 > ºC when the generator is running at the maximum gross MW output, 24 hours, at the specified altitude in the specified location. The high voltage neutral shall be brought out and grounded through a bushing.
2. Seller shall be responsible for the following:
   a. Design, testing and delivery of GSU transformers as specified herein
   b. Delivery of transformer oil
   c. Field assembly
   d. Oil drying and vacuum oil filling
   e. GSU field testing
   f. GSU operation and maintenance training for site personnel
3. Company shall be responsible for the following:
   a. GSU foundation(s)
   b. GSU unloading and setting
   c. GSU electrical connections (primary, secondary, and control voltages)
   d. GSU grounding connections
4. Seller shall allow Company personnel access to its factory during transformer assembly and for witness testing. Seller shall provide transformer manufacturing schedule and updates to the schedule to the Company. Travel costs for Company personnel for site factory visits are the responsibility of the Company.

Specifier – Add discussion of options and criteria that must be addressed

---

B. Bus Duct Layout

1. *Refer to site layout and powerhouse layout drawings for location and orientation of powerhouse and auxiliary power transformer equipment.*
2. *The following estimated bus duct lengths, number of supports, and fittings may be used for bidding purposes (per bus duct run).*

Outdoor bus duct length/run
Indoor bus duct length/run
Fittings (quantity)
Outdoor supports(quantity)/run

3. *Include separate additional add/deduct pricing in proposal for elbows and a cost per foot of bus for final price adjustments.*

C. Reference Information
See Attachment 4

D. Technical Proposal Documentation
See Attachment 1

E. Approved Manufacturers
See Attachment 8

SUMMARY: Seller shall provide _____ Generator Step-Up (GSU) transformer**( )** for the _____ Plant located in _____.

APPLICABLE CODES AND STANDARDS

A. State and local codes, laws, ordinances, rules and regulations
B. ANSI - American National Standards Institute
C. ASTM - American Society for Testing and Materials
D. ICEA - Insulated Cable Engineers Association
E. IEEE - Institute of Electrical and Electronic Engineers
F. NEMA - National Electrical Manufacturer's Association
G. NFPA - National Fire Protection Association
H. OSHA - Occupational, Health and Safety Administration
I. UL Underwriter's Laboratories

In case of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

PERFORMANCE REQUIREMENTS & GUARANTEES
See Appendix 3

DESIGN & CONSTRUCTION FEATURES

A. Environmental
1. The following ambient and site conditions shall be used in the designed of all furnished equipment.
See Appendix 4
2. Considerations shall be given to the exposure to solar heat in the areas of outdoor installation.
3. The generator step-up (GSU) transformers shall be rated **< 65 >** ^{o}C rise to limit temperature to a maximum rise above

temperature ranges indicated in Appendix 4 Site Conditions. Winding and hot spot temperature rise shall be per ANSI Standards. Transformer cooling class shall be in accordance with Appendix 2 Data Sheets.

B. RATINGS

1. Transformer ratings shall be as specified in Appendix 2 Data Sheets.
2. Nameplate information shall be per the ANSI-C57.12.00 requirements.
3. Low Voltage (X) Primary: 3-phase, 60 Hz, **< delta >** connected.
4. High Voltage (H) Secondary: **< Grounded-Wye >** connected.
5. Taps: **< Two (2) 2.5% >** full capacity taps above nominal rated high voltage, **< Two (2) 2.5% >** full capacity taps below nominal rated high voltage, arranged for de-energized operation.
6. Vector Relationship: High voltage **< leading >** low voltage by **< 30 >** degrees.
7. Winding BIL rating: as specified in Appendix 2 Data Sheets.
8. Transformer impedance shall be measured per ANSI C57.12.90. Impedance tolerance shall be per ANSI standard. The zero sequence impedance shall be equal to or less than the positive sequence impedance.
9. Sound Levels shall be in accordance with NEMA TR1 Table O-2.

C. SHORT CIRCUIT & OVER-VOLTAGE CAPACITY

1. The transformer shall be capable of withstanding, without damage, the mechanical and thermal stresses caused by short circuits on the external terminals of any winding or windings, with 105% rated voltage maintained across the terminals of any other winding connected to an energy source for two seconds.
2. The transformer will be directly connected to the generator in such a way that it may be subjected to load rejection conditions which result in an abnormally high voltage from the generator. Therefore, the transformer shall be designed to withstand, as a minimum, the resulting voltage stresses with 1.4 times rated voltage for 5 seconds, applied at the transformer terminals.
3. The transformer shall be capable of operating at 100% duty cycle at 10% above rated voltage at full load and 15% above rated voltage at no load.
4. The transformer shall be capable of being back-fed from the **< ___ >** kV switchyard to serve auxiliary

loads while the generator is disconnected.

D. LOSSES
1. The transformer kW losses as a percentage of the base rating shall be evaluated based on no load losses, load losses at maximum nameplate rating, and cooling equipment power requirements at nameplate rating.
2. The loss evaluation factors shall be as follows: No Load (core losses): $2,000/kW; Load (copper losses): $2,000/kW; Cooling System (fan losses): $2,000/kW.
3. If Seller's actual losses at full load are higher than their guaranteed losses, the difference shall be deducted from the order price at a rate of $2,000 /kW.

E. HIGH VOLTAGE BUSHINGS
1. High voltage bushings shall be cover mounted, oil-filled, porcelain-clad, with liquid level indicators, the voltage class and BIL shall be as specified in Appendix 2 Data Sheets. Draw lead connections with silver plated threaded studs are preferred.
2. Transformer high voltage bushing terminals shall be designed and constructed for connection to an overhead line via NEMA four-hole flat pads.
3. Each high voltage bushing shall have bushing current transformers as specified in Appendix 2 Data Sheets.
4. The transformer design shall not utilize reduced clearance capabilities specific only to one (1) bushing manufacturer. The transformer design shall allow for interchangeability of all approved manufacturer’s bushings in accordance with ANSI C57.19.00.

F. LOW VOLTAGE BUSHINGS
1. Low voltage phase bushings shall be oil-filled, porcelain-clad as specified in Appendix 2 Data Sheets.
2. Low voltage bushings shall be designed for connection to **< iso-phase bus >**.
3. Low voltage bushings shall be rated for connection to the **< <u>bus</u> >** operating at 105°C.
4. Each low voltage bushing shall have current transformers as specified in Appendix 2 Data Sheets.
5. Three (3) IEEE C62.11 station-class, metal oxide surge arrestors shall be provided (one for each high voltage phase). Surge arrestors shall be manufactured by General Electric, Cooper Industries, Ohio Brass, or ABB.

G. SURGE ARRESTERS
1. Three (3) IEEE C62.11 station-class, metal oxide surge arrestors shall be provided (one for each high voltage phase). Surge arrestors shall be manufactured by General Electric, Cooper Industries, Ohio Brass, or ABB.

2. A copper ground loop connecting the three surge arresters to two (2) separate ground pads at separate corners of the tank shall be furnished. Arrester rating shall be as specified in Appendix 2 Data Sheets.
3. Surge arrester line terminals shall be tin-plated.

H. NEUTRAL BUSHING
1. The high voltage neutral bushing shall be equipped with a current transformer as specified in Appendix 2 Data Sheets.
2. The Seller shall furnish an appropriately sized, permanently installed copper ground bus. This bus shall be connected to a grounding pad located on the transformer cover adjacent to the neutral bushing, and shall be routed down the side of the transformer to a second grounding pad located 6 inches from the bottom of the transformer base. Each grounding pad shall have four (4) ½-inch tapped holes located on 1 ¾-inch centers. The Seller shall furnish a removable, semi-rigid or flexible connection between the cover mounted grounding pad and the neutral bushing.

I. GROUNDS
1. Tank Grounds: Two (2) stainless steel, NEMA four-hole ground plates on opposite corners, one (1) stainless steel, NEMA four-hole ground plate located on the top of the transformer near the H0/X0/Y0 bushing(s), and stainless steel, NEMA two-hole hole ground plates adjacent to each core ground bushing.
2. Core Ground: The core ground shall be brought through the tank wall using a bushing of appropriate ampacity. Ground connection shall be made to a NEMA drilled and tapped, copper faced, steel ground pad located near the bushing. The transformer core ground connection shall be accessible from a manhole without removing any oil from the transformer tank or climbing into the tank. Bushings shall have a protective cover with a permanent non-rusting metal nameplate with the words “CORE GROUND ACCESS” engraved with 1/2” letters into the nameplate.
3. Grounding Brackets: Two (2) grounding brackets for portable grounds shall be provided per high and low voltage side of the transformer for a total of four (4) grounding brackets. The brackets shall be made of copper or stainless steel and shall be brazed if copper or welded if stainless-steel to the tank near each corner on both the high and low voltage sides. Appropriate procedures for brazing copper or welding stainless steel to the tank shall be used to ensure both good electrical conductivity and mechanical strength. The brackets shall not be painted. Grounding brackets shall be in accordance with Exhibit D, Personal Protective

Grounding Bracket Detail.

4. High Voltage Grounding Brackets: Three high voltage porcelain insulators shall be provided with provisions for grounding the transformer. Steel supporting brackets shall be supplied that extend from the high voltage side of the transformer and support the (3) insulators and (3) surge arrestors. Insulators shall be located furthest from the high voltage bushing and adjacent to the surge arrestor. Insulators shall be supplied with a copper bracket extending from the insulator. Copper bracket and insulator shall be of suitable for use in attaching Company-supplied grounding balls and grounding cables (for connecting safety grounds between the high voltage line source, and ground).

J. CORE & COILS

1. Cores and coils shall be braced to withstand short-circuit forces limited only by the transformer impedance without damage or displacement of the coil on the core under conditions described in this Specification, and to withstand normal moving and handling without the use of special shipping braces.
2. Transformer coils shall be copper. The coils shall be insulated from the core and from each other with sufficient insulation to withstand the standard impulse and low frequency tests for transformers of the designed voltage class. Insulation materials shall be asbestos-free.
3. Rectangular windings are not acceptable for main or tap windings.
4. Transformer windings shall be designed to be free-buckling and shall not rely on winding tubes for short circuit strength.
5. Core and coil assembly and all other internal components shall be dried by vapor-phase process to assure proper dryness of the insulation material.
6. The core legs shall have a solid support from the bottom to the top clamp to prevent sideways deformation and bulging of the outermost laminations. The core shall be adequately braced to the core clamping structure, so that it cannot move in any direction. The windings shall be tight to prevent sideways movements. The core and coil assembly and other internal components shall be supported by permanent bracing to the interior of the tank.

K. OIL PRESERVATION SYSTEM

1. The oil preservation system shall be a sealed conservator with flexible bladder to prevent contact with the atmosphere and allow expansion and contraction of the oil volume as the temperature changes. The conservator shall have a capacity between highest and lowest levels that are

adequate for full range of oil temperature. All conservator alarm contacts shall be wired to the main control cabinet

2. The system shall include a Buchholz gas detector relay and a sampling valve located at ground level. Access opening shall be provided at the conservator for cleaning and inspection purposes. A working platform with access ladder shall be provided for inspection and maintenance of the conservator and associated Buchholz relay. The relay shall be located in the piping between the main tank and the conservator.
3. All tanks and enclosures subject to operating pressures of the oil preservation system shall be designed to withstand 125% of the maximum operating pressures. In addition, the transformer tank and equipment shall be designed with sufficient bracing and strength to permit full vacuum filling with insulating liquid.

L. COOLING EQUIPMENT

1. Integrally mounted equipment shall be furnished to provide the cooling capacity necessary to maintain the transformer rating. Temperature control shall be provided by an assembly of devices arranged and designed to automatically vary the transformer cooling equipment capacity in steps proportional to transformer load and temperature.
2. Cooling fan motors shall be 480V, 3-phase, 60 Hz. Motors shall be totally enclosed, non-ventilated, with sealed, pre-lubricated ball bearings with bearing wear indicator, and rated for all-weather outdoor operation. Non-metallic bearings for fan motors are not acceptable.
3. Controls
4. The transformer cooling equipment control shall be via Electronic Temperature Monitor (ETM). The ETM shall monitor winding hot spot temperature and top oil temperature. The ETM shall be mounted onto the outside of the transformer in a self-contained corrosion and weatherproof enclosure.
5. The transformer cooling equipment control system shall utilize control contacts furnished on the winding temperature indicator. Where multiple thermal relays are provided, thermal relay temperature control contacts shall be wired for parallel control of the cooling equipment
6. Controls shall be provided for manually alternating the cooling fan operation sequence. Manual control switches shall be provided in the control cabinet to allow testing and maintenance of the cooling fans.
7. Cooling equipment shall be interruptible by an 86 (Lockout relay) type device such as an 86T, 86U or by fire detection.

8. Suitable alarm actuating devices with form C contacts shall be provided to indicate failure of any or all motors and loss of power.
9. Transformer cooling equipment shall be designed and arranged to allow individual radiators to be removed from the transformer without removing the transformer from service, draining oil from any other transformer component, or loss of oil past valve with 5 psi positive pressure on main tank.
10. Manually operated shutoff valves shall be provided, as required, for cooling equipment removal. All shutoff valves shall be bolted-flange mounted, and shall have provisions for padlocking in the open or closed position.
11. Each removable radiator shall be furnished with vent and drain valves for evacuation and oil filling.
12. The design of the radiators shall accommodate significant amounts of dust/ash particles in the air, and shall operate without clogging. Integrally mounted equipment shall be furnished to provide the cooling capacity necessary to maintain the transformer rating.
13. Spare flanges shall be installed for the tank on the addition of future radiators.

M. TRANSFORMER BANK

1. All tanks, bases, radiators, covers, junction boxes when required, and any other attached compartments shall be fabricated from steel of sufficient strength to withstand normal service stresses and vacuum filling without distortion or damage to any part. The base shall be extra heavy (3/4-inch minimum thickness) and suitable for rolling or skidding in any direction.
2. All joints in transformer tanks, radiators, bases, etc., shall be made gas-tight and oil-tight by welding, except that the connections between oil coolers, pumps, and tanks shall be provided with gasketed, bolted flanges. All covers shall be welded in place.
3. Transformers shall be equipped with welded cover lifting lugs, jack bosses (located not less than 16 inches above the base and shall provide a minimum unobstructed jack clearance of 6 inches from tank wall or other obstruction), pulling eyes, skids, and jacking pads to accommodate rollers.
4. The tank finish color shall be **< ANSI Z55.1 No. 70, grey >**. Seller’s surface preparation, painting procedures and materials used shall be submitted with bid proposal for Company review. Products containing lead are not acceptable.
5. All interiors and exteriors of tanks, enclosures, cabinets and

other metal parts which are not galvanized, stainless steel or of corrosion resistant material and are exposed to oil and weather shall be thoroughly cleaned and painted as required

6. The interior color of the transformer tank and control cabinet(s) shall be white and shall be fully capable of withstanding transformer operating conditions without degradation such as chipping, cracking, or peeling.
7. The top of the transformer tank shall be covered with skid resistant paint, which is the same color as the exterior tank walls.
8. Tank side seams and the connection point of the tank sides to the tank bottom shall be welded both inside and outside.
9. A minimum of two (2) 24-inch diameter manholes shall be provided on top of the transformer tank. One (1) of the required manhole covers shall include a 1-inch threaded nipple and a flanged vacuum fitting for a connection of a 4-inch diameter vacuum hose. The 4-inch (nominal) vacuum fitting shall have eight (8) 3/4-inch diameter bolt holes, equally spaced on a 7 1/2-inch diameter bolt circle. The vacuum-fitting flange shall be mounted sufficiently high off of the manhole cover to allow for easy access for removing and replacing bolts and nuts.
10. All piping connections for Owner use shall be American standard threads or flanges.
11. Gaskets and gasketed joints shall be designed so that the gasket shall not be exposed to the weather or standing water, and shall be provided with mechanical stops to prevent crushing.

N. WIRING

1. All wire shall be stranded, tinned copper conductor with 600V flame-retardant, cross-linked synthetic polymer insulation, type XHHW or equal. The minimum wire size for control and alarm functions shall be stranded No. 14 AWG. The minimum wire size for motor circuits, power circuits, and CT circuits shall be No. 12 AWG.
2. Wiring shall not be spliced or tapped. All interconnections shall be made and identified with wire markers at equipment terminals or terminal blocks.
3. All control wiring, including CT circuits, shall be terminated with non insulating, seamless barrel ring tongue lugs (Burndy type YAV HYLUG is preferred)
4. All CT secondary leads shall be terminated to short-circuiting type terminal blocks located in the control cabinet. CT terminal blocks shall be 6 point, shorting type 600V, 30A class minimum, Marathon type 1506, GE type EB-27, or Penn union type 606.

5. All CT secondary leads shall be brought to terminal blocks mounted in a junction box outside the transformer tank. CT terminal blocks shall be 6 point, shorting type 600V, 30A class minimum, Marathon type 1506, GE type EB-27, or Penn union type 606.
6. Control terminal blocks shall be 12-point, 600V, 30A class minimum, Marathon type 1512, GE type EB-25, or Buchanan type 2B112.
7. DC power Blocks shall be 600V class GE type EB-1 or equivalent.
8. Terminals shall be labeled with white terminal identification marking strips. Terminal blocks shall be mounted on the sides or back walls of the transformer control cabinet, and shall be easily accessible with normal tools.
9. Rigid galvanized steel conduit shall be used for all power, control, and alarm external wiring. When the wiring terminates at an externally tank-mounted power, control, or alarm device, rigid conduit shall be provided to a suitable location near the device. Wiring may be routed through tank support channels as an alternate to rigid conduit.
10. Liquid-tight, flexible, metal conduit may be provided from a point near the device to the device itself.
11. Associated terminal blocks shall be grouped together to facilitate the use of multi-conductor cables for interconnecting equipment. Common voltage rated control and power terminal blocks shall be grouped together (i.e. 480VAC terminal blocks and wiring physically separated from 120VAC or 125VDC control terminal blocks and wiring; 120VAC control terminal blocks and wiring physically separated from 125VDC control terminal blocks and wiring). A minimum of 10% spare terminal blocks shall be provided, and shall be grouped and reserved for Company's use only.
12. The transformer control cabinet shall be designed such that all exposed 480VAC points of contact are contained in a separate compartment with a dead front metal door or panel. Physical separation of 480VAC from lower voltage (DCS contact indication, 120VAC, or 125VDC) control circuits shall be maintained.
13. Plastic self-locking tie wraps shall not be an acceptable material for lead support.
14. All conduit, cable, and fittings shall be weatherproof, and securely fastened to the transformer at regular intervals. Rubber covered cable is acceptable for fans and gauges, and external wiring runs of less than 4 feet, however, its use shall be limited.
15. No more than two (2) wires are permitted to terminate at a

given terminal.

M. AUXILIARY EQUIPMENT & ACCESSORIES

1. Each transformer shall be equipped with a high voltage, de-energized tap changer with an external operating mechanism located on the side of the transformer tank. The tap changer handle shall have provisions for padlocking in any position, and shall provide visible indication of the tap position without unlocking.
2. A single weatherproof control cabinet shall be provided for all external conduit/cable connections, control components. The cabinet shall be accessible from ground level, and shall be sized large enough to house all forced air-cooling equipment control components.
    a. The control cabinet shall be supplied with thermostatically controlled space heaters to prevent condensation. Space heaters shall be rated 240 VAC, but shall be sized for a normal operating voltage of 120 VAC. Space heater circuits shall be individually protected with molded case circuit breakers. Molded case circuit breakers shall be manufactured by General Electric, Square D, or Cutler-Hammer.
    b. The cabinet shall include vertically hinged doors arranged to permit ready access to the cabinet from the ground level. A locking device shall be provided to hold the doors in the fully open position. Should design of cabinets be such that door width is in excess of 30 inches, double doors shall be provided and the doors shall be hinged for center opening. Hinge material shall be stainless steel.
    c. Doors shall have three-point latches for the closed position and shall include provisions for attaching padlocks. Bolts or screws to secure the door shall not be used.
    d. The top of the control cabinet shall not be more than 7 feet above the bottom of the tank. The bottom of the control cabinet shall be located a minimum of 2.5 feet above the bottom of the tank.
    e. A removable, gasketed plate, minimum size 12 inches by 16 inches, shall be provided in the bottom of the control cabinet to permit field drilling and installation of control system conduits. The Contractor shall not place the plate directly under any device within the control cabinet that would encumber the pulling of control conductors into the cabinet.
    f. Each auxiliary equipment branch circuit shall be

protected by an individual molded case circuit breaker properly coordinated with the Control Power Transformer (CPT) breakers. Molded case circuit breakers shall be manufactured by General Electric, Square D, or Cutler-Hammer.

g. The control cabinet shall be provided with a 120 VAC, duplex (3-wire) with ground fault interruption (GFI) receptacle and switched cabinet light, wired to a 20 amp, molded case circuit breaker. The circuit breaker line side shall be wired to control cabinet terminal blocks. Molded case circuit breakers shall be manufactured by General Electric, Square D, or Cutler-Hammer.

h. The control cabinet shall be equipped with a Seekirk Inc. Model B1002BNC-S33 annunciator (125 VDC, feed thru, LED, NC contacts (open to alarm)). Two (2) form C contacts rated for operation at 125 VDC shall be provided for a common output alarm. The normally closed contacts shall be wired in series and wired out to a terminal block in the control cabinet.

i. The control voltage for the annunciator, transformer protective relays and associated equipment shall be 125 VDC.

j. The control cabinet shall be equipped with a “Loss of DC Alarm Voltage” alarm relay, with alarm and trip contacts wired to a terminal block in the cabinet.

k. All control relays shall have enclosed, dust tight contacts.

l. All devices and terminal blocks mounted in the control cabinet shall be clearly labeled with a designation. This label shall be located on or near the device and be affixed in such a manner that they will not become detached during the life of the transformer (Dymo Tape or similar embossed plastic tapes are not acceptable).

m. A metal oxide arrestor (MOV) surge suppressor shall be mounted across the 125 VDC supply terminal within the control cabinet. The MOV shall be rated for a minimum of 10 kA, 200 joules capability with a maximum peak discharge voltage of 500V.

n. All control devices, controllers, and control systems and assemblies shall be in accordance with NEMA ICS 1 and 2 and shall meet the requirements of this Standard.

o. For each transformer, an automatic voltage seeking transfer switch shall be provided to supply power to the transformer auxiliary equipment. Two (2) sources of nominal 480V, 3-phase, 3-wire, 60 Hz power to feed this switch will be provided. The automatic transfer equipment shall be of sufficient capacity to transfer the total cooling equipment, control circuit, and space heater load from the normal source to the standby source upon failure of the normal source voltage. Voltage failure relays shall be installed in order to monitor normal and standby source voltages. Each relay shall provide a contact closure on loss of voltage. The contacts shall be wired to terminal blocks in the control cabinet. Control power for the transfer controls shall be 120 VAC.

p. Alarm Requirements. The following minimum alarm points shall be provided:
  1. Top Oil Temperature – (26Q).
  2. Winding Temperature – Monitor One Winding (49T)
  3. Liquid Level Indicator – Main Tank/Conservator – Normal High (71Q-1(MT)/HA)
  4. Liquid Level Indicator – Main Tank/Conservator – Normal Low (71Q-1(MT)/LA)
  5. Liquid Level Indicator – Main Tank/Conservator – Emergency Low (71Q-3(MT)/LT)
  6. Transformer Gas Detection – Buchholz Relay (71GD(MT))
  7. Pressure Relief Device – Main Tank (63P-1(MT))
  8. AC Supply – Loss of Main AC Supply (27-1)
  9. Stage 1 Cooling – Loss of AC (27-2)
  10. Stage 2 Cooling – Loss of AC (27-3)
  11. Loss of Cooling Control Voltage – AC (27-4)
  12. Loss of DC Control Voltage – DC (27-6)

q. Tank cover pressure relief devices shall be supplied for each oil-filled compartment. Each device shall be equipped with form C alarm contacts, a manual reset, and mechanically operated flag, to indicate that the relief device has operated. Released oil shall be directed away from all control cabinets or where personnel may be standing. Alarm contacts shall be wired to terminal blocks in the control cabinet. Pressure relief device shall be Qualitrol 213 series.

r. Liquid level indicators (main tank and all other oil filled compartments) shall be provided with all alarm contacts wired to terminal blocks located in control cabinets:

1. The main tank shall either have a single, magnetic-type level indicator with two (2) low level and one (1) high level alarm contacts or two (2) separate, magnetic-type level indicators. All contacts shall be Form “C” contacts.
2. All other oil filled compartments shall have single indicators with Form “C” contacts at the lowest level considered safe for continued operation of the transformer and wired to terminal blocks in the main control cabinet.
3. All liquid level indicators shall be readable from ground level.

s. An Electronic Temperature Monitor (ETM) shall be provided.
1. The ETM shall monitor winding hot spot temperature and main tank top oil temperature.
2. A minimum of six (6) form C dry contact outputs [with auxiliary interposing relays as needed to accommodate a 125 VDC contact make/break rating for four (4) of the six (6) contacts (output contacts used for first and second stage temperature alarm levels on each of the top oil and hot spot winding temperatures), with the other contacts used for controlling the cooling system (responsive to the simulated winding hottest spot temperature)].
3. Form C alarm and trip contacts shall be wired out and terminated to terminal blocks in the transformer main control cabinet.
4. The ETM shall be mounted adjacent to or within the transformers main control cabinet, at an approximate height of 5 feet above the base of the transformer for easy viewing from ground level.
5. Source to the ETM shall be from a 125 VDC input power supply. On loss of DC, all stages of fans shall be triggered to energize.
6. A minimum of two (2) 0 to 1 mA DC analog (corresponding to 0 to 200°C) SCADA outputs for both top oil temperature and hot spot winding temperature.
7. Weather-tight NEMA 3R or better enclosure with outdoor-rated display and controls accessible without opening the enclosure’s

front door. A switch or operator accessible front panel menu for manual control of the system. Basic Temperature error (including probe) to be less than 1°C.

8. RS232/485 digital interface and MS Windows-based programming software for setup and monitoring from a PC.
9. Acceptable ETM manufacturers/models are as follows:

Manufacturer	**Model Number**
Weschler Instruments	Transformer Advantage CT - Electronic
Qualitrol	509-100 Series – Electronic

t. Transformers shall be equipped with the following valves and fittings:
   1. A combination drain and lower filter valve shall be provided to drain the oil as completely as possible but to at least within 1 inch of the bottom of the main tank and for outlet to the filtering means. The drain valve shall be 2 inches with a built-in 3/8-inch sampling device.
   2. Lower filter press valve with malleable iron pipe plug.
   3. A 1 ½-inch upper filter press valve with malleable iron pipe plug.
   4. Standard 4-inch bolted round pipe flange with gasketed cover plate for attaching the Company's vacuum valve and hose. The flange shall be located on the corner farthest from the upper filter press valve to insure that oil does not enter the Company's vacuum system.
   5. A shut-off valve shall be provided on each end of the connection piping to the main tank.

u. Transformer shall be equipped with a gas detector relay with seal in coil, mounted in the control cabinet. Gas detector relay shall be a EMB Buchholz Type BF80-10, twin float relay DR80, Model 09-236 with form C contacts wired out to a seal-in relay panel (Qualitrol model 909-200-01 AC/DC Seal-In relay). Seal-in relay panel to be mounted in the control cabinet.

v. Transformer shall be equipped with a GE Hydran M-2 dissolved gas-in-oil intelligent monitor/transmitter.

w. Transformer shall be equipped with the following fall protection devices:

1. Brackets for mounting of 2-inch diameter pipes for use as safety rails shall be provided at the top of the transformer. Design and fabricate brackets to meet OSHA-required lateral loads at the top of the safety rail. Brackets shall be spaced a maximum of 4 feet apart, with one on each corner of the transformer.
2. A weld-on base shall be provided near the center of the transformer top. It will be used for attaching a 4-foot Company-supplied tether pole to meet OSHA 29 CFR 1926.502(d). The base shall be designed to support a horizontal force of 10,800 lbs at the top of a 4’ tether pole. The area above the base should be clear of obstructions as to facilitate attachment of the Company- supplied tether pole.
3. Unique Concepts Ltd. weld-on base, Part Number 10816, shall be installed by the Seller for attachment of a portable fall arrest system provided by the Company. Weld-on bases shall be installed on the transformer cover within three (3) inches of each manhole.

x. Nameplates: All nameplates shall be inked and engraved stainless steel. At least four (4) bolts or rivets shall attach nameplates. Mounting holes shall be provided with rubber grommets or equivalent to decrease vibration noise. Nameplate shall be located to be accessible and readable from grade level with no other equipment blocking or otherwise limiting view of the nameplate

1. A temperature relay nameplate shall be supplied and shall give the recommended temperatures at which the first set of cooling equipment shall be started, the second set of cooling equipment shall be started, and the temperature at which an alarm shall be actuated. All of these shall be calculated on the basis of operation at 65°C winding temperature rise. This information shall also be provided on the wiring diagram. The nameplate shall be mounted on or near to the temperature indicator(s)
2. De-energized tap changer nameplates shall be provided and shall include make and model information. These nameplates shall be

mounted next to the main nameplate or the information may be incorporated into the main nameplate.

N. INSULATING LIQUID

1. Insulating oil shall be Type II and shall meet ANSI C57.106 requirements. It shall be free of PCB's, chemically stable, free from acidity or other corrosive ingredients, and shall contain a suitable oxidation inhibitor. Maximum oxidation inhibitor content shall be 0.3% by weight and transformer nameplates shall indicate that the oil is inhibited. The oil shall contain less than 30 ppm water when tested in accordance with the procedures of ASTM D1533-88 (Karl Fischer method). The dielectric strength of the oil shall be at least 30 kV when tested in accordance with the procedures of ASTM D877-87, or 20 kV when tested in accordance with the procedures of ASTM D1816-84A using a 0.04-inch gap.

SOUND CONTROL REQUIREMENTS

Specifier Note: Additional information required

ELECTRICAL REQUIREMENTS

Specifier Note: Additional information required

INSTRUMENTATION & CONTROL REQUIREMENTS

Specifier Note: Additional information required

MATERIALS & WELDING

Specifier Note: Additional information required

CLEANING, PAINTING & COATING

Specifier Note: Additional information required

PACKAGING & SHIPPING

See Appendix 7

STORAGE & HANDLING PROCEDURES

See Appendix 7

SPARE PARTS

Commissioning spares to be included/supplied with the equipment.

QUALITY ASSURANCE

See Appendix 5

TESTING

See Appendix 5

SELLER'S DATA SUBMISSION SCHEDULE

See Appendix 2

APPENDICES

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES
   A. The Seller shall furnish Manufacturer's approval drawings (**< <u>Two (2)</u> >** full-size hard copies and **< <u>one (1)</u> >** AutoCAD File each), consisting of the following minimum documents:
      1. Manufacturer's approval drawing schedule (submitted with proposal)
      2. Transformer installation instructions/details including unloading rigging information and equipment loadings
      3. Transformer dimensioned outline drawings (English dimension units)
      4. Transformer nameplate drawings
      5. Current transformer saturation curves
      6. Control panel schematics and wiring diagrams
      7. Final test reports.
   B. Seller shall furnish **< <u>three (3)</u> >** Operations & Maintenance (O&M) manuals. In addition to all required information required to operate and maintain furnished equipment O&M manuals shall contain Manufacturer's cut sheets and brochure data for all furnished ancillary equipment (control panel, annunciator, monitoring equipment, fans, etc.).
   C. Seller shall furnish warranty information for all equipment supplied.
   D. Seller shall submit completed "SELLER DATA" as outlined in Appendix 2 Data Sheets. Seller Data shall be submitted with proposal.

2. PROPOSAL DATA REQUIREMENTS

DATA SHEETS

GENERATOR STEP UP TRANSFORMER	**UNITS**	**REQUIREMENTS**	**SELLER RESPONSE**
Manufacturer		Seller	
City & Country of Manufacture		Seller	
Duty Cycle		Continuous	
ELECTRICAL PARAMETERS:			
Capacity	MVA		
Capacity with one section of the cooling inoperative	MVA	Seller	
Temperature Rise	ºC	**65**	
Type of Cooling			
Phase Displacement		**High Voltage leads Low Voltage by 30 º**	
Frequency	Hz	60	
Connection - High Voltage Winding		**Wye**	
Connection - Low Voltage Winding		**Delta**	
Voltage Rating - High Voltage Winding	kV		
Voltage Rating - Low Voltage Winding	kV		
No Load Tap Voltages (Full Capacity Taps) – High Voltage Winding	kV	**-____% to +____% @ ____ % Steps**	
No Load Tap Voltages (Full Capacity Taps) - Low Voltage Winding	kV	None	
BIL - High Voltage Winding	kV		
BIL - Low Voltage Winding	kV		
BIL - High Voltage Winding at Neutral Point	kV		
No Load Loss at - 100% of Rated Voltage	kW	Seller	

No Load Loss at - 105% of Rated Voltage	kW	Seller	
No Load Loss at – 110% of Rated Voltage	kW	Seller	
Load Loss at 100% of Rated Voltage, 100% ONAN Loading Of Transformer	kW	Seller	
Load Loss at 100% of Rated Voltage, 100% ONAF Loading Of Transformer	kW	Seller	
Total Cooling System Losses (@ max ONAF Loading).	kW	Seller	
Total Loss (No Load + Load) at 100% of Rated ONAN Loading Of transformer, 100% Voltage.	kW	Seller	
Total Loss (No Load + Load + Cooling) at 100% of Rated max ONAF Loading of transformer, 100% Voltage.	kW	Seller	
Impedance at Rated Capacity (at ONAN rating)	%		
Reactance at Rated Capacity	%	Seller	
Resistance at Rated Capacity	%	Seller	
X/R Ratio		Seller	
Maximum Overvoltage Excitation Capability at Full Load in % of Rated Voltage	%	ANSI	
Exciting Current in % of Full Load Current at Rated Voltage and Frequency	%	Seller	
Three Phase Capacitance to Ground H.V. Side Only	pF	Seller	
MATERIALS			
Color		**ANSI Z55.1 Color 70, Light Gray**	
Tank		Plate steel	
H.V. Windings		Copper	
L.V. Windings		Copper	
Fall Protection Brackets (for railing on top of transformer)		Yes	
Fall Protection Tether Pole Base		Yes	

Fall Arrest Brackets near each Manhole		Yes	
NOISE DATA			
Audible Sound Level @ 100% Load	dBA	NEMA TR1	
Audible Sound Level @ No Load	dBA	NEMA TR1	
APPROXIMATE WEIGHTS			
Core and coils	lb	Seller	
Tank and Fittings	lb	Seller	
Oil	lb	Seller	
Shipping Weight (without oil)	lb	Seller	
APPROXIMATE DIMENSIONS			
Overall height	in	Seller	
Width	in	Seller	
Depth	in	Seller	
Untanking	in	Seller	
Minimum Clearance of Jacking Lugs to base	in	16	
COOLING			
Quantity of Fans		Seller	
Rated Voltage	V	480	
OIL PRESERVATION SYSTEM			
Conservator Tank System		Yes	
High/Low Pressure Gauges & Alarm Contacts		Yes	
Minimum Positive Pressure	PSIG	0.5	
Maximum Positive Pressure	PSIG	5	
Maintenance-Free Dehydrating Breather (High Voltage Supply model 1030-012K)		Yes	

CONTROL CABINET			
Enclosure type	NEMA	4X	
Heater Voltage	VAC	120	
Heater Wattage	Watts	Seller	
Alarm Annunciator		Seekirk (per spec)	
INSTRUMENTATION / ALARMS			
Electronic Temperature Management (ETM) for cooling fan control, High temperature alarms, Hot Spot Winding Temperature (49T), and Top Oil Temperature (26Q)		Qualitrol ETM 509-100 Or Weschler Instruments Transformer Advantage CT – Electronic	
Pressure/Vacuum gage (63P) & bleeder device.		Yes	
Oil Level Indicator (71Q-HA) for Main tank and conservator tank.		Yes	
Oil Level Indicator (71Q-LA) for Main tank and conservator tank		Yes	
Oil Level Indicator (71Q-LT) for Main tank and conservator tank		Yes	
Transformer Gas Detection Relay (Buchholz) (71GD)		Yes	
Combustible Gas Monitor (GE Hydran M-2)		Yes	
Pressure Relief Device (63P-1) w/ trip contact and alarm contact		Yes	
Loss of Main AC Supply (27-1)		Yes	
Stage 1 Cooling – Loss of AC (27-2)		Yes	
Stage 2 Cooling – Loss of AC (27-3)		Yes	
Loss of cooling control voltage – AC (27-4)		Yes	
Loss of DC control voltage (27-5)		Yes	
TERMINAL BUSHINGS			

Manufacturer - High Voltage		ABB	
Manufacturer - Low Voltage		ABB	
Manufacturer - High Voltage Neutral		ABB	
Type/Style - High Voltage		Oil-Filled/Porcelain	
Type/Style - Low Voltage		Oil-Filled/Porcelain	
Type/Style - High Voltage Neutral		Oil-Filled/Porcelain	
Arrangement of Bushings – High Voltage (Sidewall or Cover).		Cover	
Arrangement of Bushings – Low Voltage (Sidewall or Cover).		Cover	
Arrangement of Bushings – High Voltage Neutral (Sidewall or Cover).		Cover	
Creepage Distance - High Voltage	In	Seller	
Creepage Distance - Low Voltage	In	Seller	
Creepage Distance - High Voltage Neutral	In	Seller	
Rated Voltage - High Voltage	kV		
Rated Voltage - Low Voltage	kV		
Rated Voltage - High Voltage Neutral	kV		
Rated Amps - High Voltage	Amps		
Rated Amps - Low Voltage	Amps		
Rated Amps - High Voltage Neutral	Amps		
BIL - High Voltage	kV		
BIL - Low Voltage	kV		
BIL - High Voltage Neutral	kV		
Terminal Bushings Shipped Loose		Yes	
Core Ground Bushing		Yes	
BUSHING CURRENT TRANSFORMERS			
High Voltage Bushing CT Quantity/Bushing			
High Voltage Bushing CT Ratio			
High Voltage Bushing CT Accuracy		**_____ @ C800, _____ @ 0.3-B1.8**	

High Voltage Bushing CT Burden		Seller	
Low Voltage Bushing CT Quantity/Bushing			
Low Voltage Bushing CT Ratio			
Low Voltage Bushing CT Accuracy		**_____ @ C800, _____ @ 0.3-B1.8**	
Low Voltage Bushing CT Burden		Seller	
High Voltage Neutral Bushing CT Quantity/Bushing		1	
High Voltage Neutral Bushing CT Ratio			
High Voltage Neutral Bushing CT Accuracy		C800	
High Voltage Neutral Bushing CT Burden		Seller	
HV SURGE ARRESTERS			
Manufacturer/Model No		ABB, Cooper, GE or Ohio Brass	
Type		Porcelain/MOV	
Rating	kV rms		
Maximum Continuous Voltage Capability, MCOV	kV rms		
GROUND PROVISIONS			
Tank Grounds – Two, NEMA 4-Hole		Yes	
Core Ground – with Bushing / Cover / Ground Pad		Yes	
HO Ground Bus / Pad		Yes	
Surge Arrestor Grounding Cable		Yes	
Grounding Brackets – Four brackets / side of Transformer		Yes	
(3) High Voltage Insulators with Grounding Brackets		Yes	
TERMINAL CONNECTIONS			
High Voltage		**Open Air**	

Low Voltage		**Iso-Phase**	

3. PERFORMANCE GUARANTEES

4. SITE CONDITIONS AND REFERENCE MATERIALS

1.0 Summary

1.1. This Schedule outlines the Site conditions used for the design of all equipment covered under this contract.

2.0 Location

2.1. Xcel Energy's xxxxxx Station site is located xxxxxxxxx.

2.2. The property consists of approximately xxx acres.

2.3. Existing plant site consists of xxxxxx generating units.

3.0 Ambient Design Criteria

3.1. Meteorology

3.1.1. Local meteorological data with long periods of record for xxxxxx is available. Xxxxx data is used for design wet-bulb temperature, dry-bulb temperature, wind, and other design criteria. Contractor is responsible for verifying Meteorological data by obtaining the most recent information available.

3.1.1.1. Temperature and Humidity

- Maximum Summer Extreme Temperature xx°F
- Minimum Winter Extreme Temperature xx°F
- Summer Design Dry Bulb Temperature xx°F
- Summer Design Wet Bulb Temperature xx°F
- Winter Design Dry Bulb Temperature xx°F
- Average Annual Dry Bulb Temperature xx°F
- Average Annual Wet Bulb Temperature xx°F

3.1.1.2. Indoor Temperatures

- Indoor temperatures can be expected to range from xx°F to xx°F.

3.1.1.3. Precipitation and Snow

- Annual precipitation in the site vicinity is expected to average about xx inches. Annual snowfall in the plant vicinity averages about xx inches.
- The snow load for xxxxxx is xx lb/ft2.

3.2. Barometric Pressure

3.2.1. The standard barometric pressure adjusted to the site elevation of xxxxx feet is xx psia..

American National Standards Institute (ANSI/IEEE)

A. C57.12.00 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

B. C57.12.70 Terminal Markings and Connections for Distribution and Power Transformers
C. C57.12.90 Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
D. C57.13 Requirements for Instrument Transformers
E. C57.19.00 General Requirements and Test Procedure for Outdoor Power apparatus Bushings
F. C57.93 Guide for Installation of Liquid Immersed Power Transformers
G. C57.115 Guide For Loading Mineral-Oil-Immersed Power Transformers, Rated in Excess of 100 MVA (65oC Winding Rise)
H. C57.116 Guide for Transformers Directly Connected to Generators
I. C62.1 Surge Arresters for Alternating-Current Power Circuits
J. C62.11 Standard for Metal-Oxide Surge Arresters for AC Power Circuits
K. C57.106 Guide for Acceptance and Maintenance of Insulating Oil in Equipment

National Electrical Manufacturers Association (NEMA)
A. LA 1 Surge Arresters
B. TR 1 Transformers, Regulators and Reactors
C. 107 Methods of Measurement of Radio Influence Voltage of High-voltage Apparatus

American Society for Testing and Materials (ASTM)
A. D117 Guide to test Methods and Specifications for Electrical Insulating Oils of Petroleum Origin
B. D3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus

NFPA 70 Latest edition of the National Electrical Code.
ANSI C2 National Electrical Safety Code (NESC).

5. QA/QC (Including Inspection Test Plans)
    1. Transformers shall be tested in accordance with ANSI/IEEE C57.12.00 and ANSI/IEEE C57.12.90.
    2. The following tests shall be performed and certified by the Seller for each transformer:
        a. Resistance measurements on all windings. The test report shall indicate how windings were connected, either series or parallel.
        b. Ratio tests on the rated voltage connection and on all tap connections.
        c. Polarity and phase relation test on the rated voltage connection.
        d. No load loss and exciting current at rated frequency and voltage and at maximum raise and lower tap position.
        e. No load loss and exciting current at rated frequency at 90% rated voltage (0.9 p.u.).
        f. No load loss and exciting current at rated frequency at 110% rated voltage (1.10 p.u.).
        g. Auxiliary losses shall be verified by actual test measurements.
        h. Impedance volts at rated current and at maximum raise and lower tap positions.
        i. Load loss at rated current and at maximum raise and lower tap positions.
        j. Temperature rise test made at the transformer self-cooled KVA rating at rated current.
        k. Applied voltage test.
        l. Induced voltage test for Class II power transformers with radio influence voltage (RIV) for partial discharge measurement.
        m. Impulse tests. The neutral current method of fault detection shall be employed and oscillographic or digital records of all impulse tests shall be furnished with the test report.
        n. Core insulation resistance test.
        o. Sweep Frequency Response Analysis. For use in creating a baseline response analysis.
        p. Transformer noise frequency spectrum analysis (under no load and full load conditions).
        q. Insulation power factor test.
    3. The certified test report shall indicate all impedance values (positive, negative, and zero sequence); oil test reports, which include all tests indicated in ANSI C57.106.
    4. Copies of all factory power factor tests or equivalents shall

be furnished with the certified test reports. Certified test reports shall be prepared and submitted to the Company following completion of the testing and prior to transformer shipment.

6. STARTUP, TESTING, AND COMMISSIONING

7. PACKAGING, SHIPPING, AND STORAGE
    A. Transformers shall be shipped under positive dry air pressure.
    B. Seller shall install and ship impact recorders on rail cars transporting the transformers. The impact recorders shall be installed at the factory to provide a permanent record of the magnitude of axial, transverse, and vertical forces to which the transformer was subjected while in transit (via truck, rail, and/or shipping vessel).
    C. The transformer shall be designed to withstand transportation-related mechanical loadings generated by impacts, swaying, yawing, fatigue and vibration. The minimum design limits for impact loading with respect to the transformer shall be: 5 g longitudinal, 3 g vertical and 1 g transverse directions. The transformer shall be designed to allow transportation via rail and truck, (and via sea vessel as applicable).

8. ACCEPTABLE SUPPLIERS

Complete technical requirements as required for the identified topic.

EXHIBIT A

GENERATOR STEP-UP (GSU) TRANSFORMER

SCOPE OF WORK AND TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

1. SCOPE OF WORK

1.1 SUMMARY

1.1.1 Seller shall provide _____ Generator Step-Up (GSU) transformer**(s)** for the _____ Plant located in _____.

1.2 SCOPE OF WORK

1.2.1 Seller shall design, test and deliver _____, **< 3 >**-phase, 60 Hz, oil-filled GSU transformer**(s)**. Transformers shall be equipped with a high voltage no-load tap changer. Transformer MVA ratings shall be as specified in Exhibit B Data Sheets. Maximum winding temperature (hot spot) rise shall not exceed **< 80 >** ºC and maximum liquid oil temperature rise shall not exceed **< 65 > º**C when the generator is running at the maximum gross MW output, 24 hours, at the specified altitude in the specified location. The high voltage neutral shall be brought out and grounded through a bushing.

1.2.2 **Seller shall be responsible for the following**:

A. Design, testing and delivery of GSU transformers as specified herein

B. Delivery of transformer oil

C. Field assembly

D. Oil drying and vacuum oil filling

E. GSU field testing

F. GSU operation and maintenance training for site personnel.

1.2.3 **Company shall be responsible for the following**:

A. GSU foundation(s)

B. GSU unloading and setting

C. GSU electrical connections (primary, secondary and control voltages)

D. GSU grounding connections

1.2.4 Seller shall allow Company personnel access to its factory during transformer assembly and for witness testing. Seller shall provide transformer manufacturing schedule and updates to the schedule to the Company. Travel costs for Company personnel for site factory visits are the responsibility of the Company.

1.3 REFERENCES

1.3.1. American National Standards Institute (ANSI/IEEE)

A. C57.12.00 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

B. C57.12.70 Terminal Markings and Connections for Distribution and Power Transformers

C. C57.12.90 Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers

D. C57.13 Requirements for Instrument Transformers

E. C57.19.00 General Requirements and Test Procedure for Outdoor Power apparatus Bushings

F. C57.93 Guide for Installation of Liquid Immersed Power Transformers

G. C57.115 Guide For Loading Mineral-Oil-Immersed Power Transformers, Rated in Excess of 100 MVA (65oC Winding Rise)

H. C57.116 Guide for Transformers Directly Connected to Generators

I. C62.1 Surge Arresters for Alternating-Current Power Circuits

J. C62.11 Standard for Metal-Oxide Surge Arresters for AC Power Circuits

K. C57.106 Guide for Acceptance and Maintenance of Insulating Oil in Equipment

1.3.2. National Electrical Manufacturers Association (NEMA)

A. LA 1 Surge Arresters

B. TR 1 Transformers, Regulators and Reactors

C. 107 Methods of Measurement of Radio Influence Voltage of High-voltage Apparatus

1.3.3. American Society for Testing and Materials (ASTM)

A. D117 Guide to test Methods and Specifications for Electrical Insulating Oils of Petroleum Origin

B. D3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus

1.3.4. NFPA 70 Latest edition of the National Electrical Code.

1.3.5. ANSI C2 National Electrical Safety Code (NESC).

1.4 CODES AND STANDARDS

1.4.1 In addition to the codes and standards of ANSI, ASTM, IEEE, NEMA, and NFPA, as referenced herein, all GSU materials and devices shall be in accordance with the applicable requirements of the Federal "Occupational Safety and Health Administration" (OSHA) Standards.

1.4.2. In case of conflict between the requirements of the specified codes and standards, the following hierarchy shall take precedence: Mandatory governmental regulations, codes and standards, this Specification and referenced industry codes and standards.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1. Transformers shall be shipped under positive dry air pressure.

1.5.2. Seller shall install and ship impact recorders on rail cars transporting the transformers. The impact recorders shall be installed at the factory to provide a permanent record of the magnitude of axial, transverse, and vertical forces to which the transformer was subjected while in transit (via truck, rail, and/or shipping vessel).

1.5.3. The transformer shall be designed to withstand transportation-related mechanical loadings generated by impacts, swaying, yawing, fatigue and vibration. The minimum design limits for impact loading with respect to the transformer shall be: 5 g longitudinal, 3 g vertical and 1 g transverse directions. The transformer shall be designed to allow transportation via rail and truck, (and via sea vessel as applicable).

1.6 MAINTENANCE MATERIALS

1.6.1 The Seller shall furnish **< two (2) >** of each special tool required to operate and maintain the transformer.

1.6.2. The Seller shall furnish **< one (1) >** additional complete set of gaskets for all items removed for shipment and all items, which are normally removed for inspection during installation or maintenance.

1.7 SUBMITTALS

1.7.1 The Seller shall furnish Manufacturer's approval drawings (**< Two (2) >** full-size hard copies and **< one (1) >** AutoCAD File each), consisting of the following minimum documents:

A. Manufacturer's approval drawing schedule (submitted with proposal)

B. Transformer installation instructions/details including unloading rigging information and equipment loadings

C. Transformer dimensioned outline drawings (English dimension units)

D. Transformer nameplate drawings

E. Current transformer saturation curves

F. Control panel schematics and wiring diagrams

G. Final test reports.

1.7.2 Seller shall furnish **< three (3) >** Operations & Maintenance (O&M) manuals. In addition to all required information required to operate and maintain furnished equipment O&M manuals shall contain Manufacturer's cut sheets and brochure data for all furnished ancillary equipment (control panel, annunciator, monitoring equipment, fans, etc.).

1.7.3 Seller shall furnish warranty information for all equipment supplied.

1.7.4 Seller shall submit completed "SELLER DATA" as outlined in Exhibit B Data Sheets. Seller Data shall be submitted with proposal.

2. TECHNICAL SPECIFICATIONS

2.1 COOLING CLASS AND TEMPERATURE RISE

The generator step-up (GSU) transformers shall be rated **< 65 >** ^{o}C rise to limit temperature to a maximum rise above temperature ranges indicated in Exhibit E Site Conditions. Winding and hot spot temperature rise shall be per ANSI Standards. Transformer cooling class shall be in accordance with Exhibit B Data Sheets.

2.2 SITE CONDITIONS

Site conditions shall be as specified in Exhibit E Site Conditions.

2.3 RATINGS

2.3.1. Generator Step-up Power Transformer

H. Transformer ratings shall be as specified in Exhibit B Data Sheets.

I. Nameplate information shall be per the ANSI-C57.12.00 requirements.

J. Low Voltage (X) Primary: 3-phase, 60 Hz, **< delta >** connected.

K. High Voltage (H) Secondary: **< Grounded-Wye >** connected.

L. Taps: **< Two (2) 2.5% >** full capacity taps above nominal rated high voltage, **< Two (2) 2.5% >** full capacity taps below nominal rated high voltage, arranged for de-energized operation.

M. Vector Relationship: High voltage **< leading >** low voltage by **< 30 >** degrees.

N. Winding BIL rating: as specified in Exhibit B Data Sheets.

O. Transformer impedance shall be measured per ANSI C57.12.90. Impedance tolerance shall be per ANSI standard. The zero sequence impedance shall be equal to or less than the positive sequence impedance.

P. Sound Levels shall be in accordance with NEMA TR1 Table O-2.

2.4 DESIGN FEATURES AND CONSTRUCTION

2.4.1 Short Circuit & Over-Voltage Capacity

A. The transformer shall be capable of withstanding, without damage, the mechanical and thermal stresses caused by short circuits on the external terminals of any winding or windings, with 105% rated voltage maintained across the terminals of any other winding connected to an energy source for two seconds.

B. The transformer will be directly connected to the generator in such a way that it may be subjected to load rejection conditions which result in an abnormally high voltage from the generator. Therefore, the transformer shall be designed to withstand, as a minimum, the resulting voltage stresses with 1.4 times rated voltage for 5 seconds, applied at the transformer terminals.

C. The transformer shall be capable of operating at 100% duty cycle at 10% above rated voltage at full load and 15% above rated voltage at no load.

D. The transformer shall be capable of being back-fed from the **< ___ >** kV switchyard to serve auxiliary loads while the generator is disconnected.

2.4.2 Losses

A. The transformer kW losses as a percentage of the base rating shall be evaluated based on no load losses, load losses at maximum nameplate rating, and cooling equipment power requirements at nameplate rating.

B. The loss evaluation factors shall be as follows: No Load (core losses): $2,000/kW; Load (copper losses): $2,000/kW; Cooling System (fan losses): $2,000/kW.

C. If Seller's actual losses at full load are higher than their guaranteed losses, the difference shall be deducted from the order price at a rate of $2,000 /kW.

2.4.3 High Voltage Bushings

A. High voltage bushings shall be cover mounted, oil-filled, porcelain-clad, with liquid level indicators, the voltage class and BIL shall be as specified in Exhibit B Data Sheets. Draw lead connections with silver plated threaded studs are preferred.

B. Transformer high voltage bushing terminals shall be designed and constructed for connection to an overhead line via NEMA four-hole flat pads.

C. Each high voltage bushing shall have bushing current transformers as specified in Exhibit B Data Sheets.

D. The transformer design shall not utilize reduced clearance capabilities specific only to one (1) bushing manufacturer. The transformer design shall allow for interchangeability of all approved manufacturer's bushings in accordance with ANSI C57.19.00.

2.4.4 Low Voltage Bushings

A. Low voltage phase bushings shall be oil-filled, porcelain-clad as specified in Exhibit B Data Sheets.

B. Low voltage bushings shall be designed for connection to **< iso-phase bus >**.

C. Low voltage bushings shall be rated for connection to the **< bus >** operating at 105°C.

D. Each low voltage bushing shall have current transformers as specified in Exhibit B Data Sheets.

E. Three (3) IEEE C62.11 station-class, metal oxide surge arrestors shall be provided (one for each high voltage phase). Surge arrestors shall be manufactured by General Electric, Cooper Industries, Ohio Brass, or ABB

2.4.5 Surge Arresters

A. Three (3) IEEE C62.11 station-class, metal oxide surge arrestors shall be provided (one for each high voltage phase). Surge arrestors shall be manufactured by General Electric, Cooper Industries, Ohio Brass, or ABB.

B. A copper ground loop connecting the three surge arresters to two (2) separate ground pads at separate corners of the tank shall be furnished. Arrester rating shall be as specified in Exhibit B Data Sheets.

C. Surge arrester line terminals shall be tin-plated.

2.4.6 Neutral Bushing

A. The high voltage neutral bushing shall be equipped with a current transformer as specified in Exhibit B Data Sheets.

B. The Seller shall furnish an appropriately sized, permanently installed copper ground bus. This bus shall be connected to a grounding pad located on the transformer cover adjacent to the neutral bushing, and shall be routed down the side of the transformer to a second grounding pad located 6 inches from the bottom of the transformer base. Each grounding pad shall have four (4) ½-inch tapped holes located on 1 ¾-inch centers. The Seller shall furnish a removable, semi-rigid or flexible connection between the cover mounted grounding pad and the neutral bushing.

2.4.7 Grounds

A. Tank Grounds: Two (2) stainless steel, NEMA four-hole ground plates on opposite corners, one (1) stainless steel, NEMA four-hole ground plate located on the top of the transformer near the H0/X0/Y0 bushing(s), and stainless steel, NEMA two-hole hole ground plates adjacent to each core ground bushing.

B. Core Ground: The core ground shall be brought through the tank wall using a bushing of appropriate ampacity. Ground connection shall be made to a NEMA drilled and tapped, copper faced, steel ground pad located near the bushing. The transformer core ground connection shall be accessible from a manhole without removing any oil from the transformer tank or climbing into the tank. Bushings shall have a protective cover with a permanent non-rusting metal nameplate with the words “CORE GROUND ACCESS” engraved with 1/2” letters into the nameplate.

C. Grounding Brackets: Two (2) grounding brackets for portable grounds shall be provided per high and low voltage side of the transformer for a total of four (4) grounding brackets. The brackets shall be made of copper or stainless steel and shall be brazed if copper or welded if stainless steel to the tank near each corner on both the high and low voltage sides. Appropriate procedures for brazing copper or welding stainless steel to the tank shall be used to ensure both good electrical conductivity and mechanical strength. The brackets shall not be painted. Grounding brackets shall be in accordance with Exhibit D, Personal Protective Grounding Bracket Detail.

D. High Voltage Grounding Brackets: Three high voltage porcelain insulators shall be provided with provisions for grounding the transformer. Steel supporting brackets shall be supplied that extend from the high voltage side of the transformer and support the (3) insulators and (3) surge arrestors. Insulators shall be located furthest from the high voltage bushing and adjacent to the surge arrestor. Insulators shall be supplied with a copper bracket extending from the insulator. Copper bracket and insulator shall be of suitable for use in attaching Company-supplied grounding balls and grounding cables (for connecting safety grounds between the high voltage line source, and ground).

2.4.8 Core and Coils

A. Cores and coils shall be braced to withstand short-circuit forces limited only by the transformer impedance without damage or displacement of the coil on the core under conditions described in this Specification, and to withstand normal moving and handling without the use of special shipping braces.

B. Transformer coils shall be copper. The coils shall be insulated from the core and from each other with sufficient insulation to withstand the standard impulse and low frequency tests for transformers of the designed voltage class. Insulation materials shall be asbestos-free.

C. Rectangular windings are not acceptable for main or tap windings.

D. Transformer windings shall be designed to be free-buckling and shall not rely on winding tubes for short circuit strength.

E. Core and coil assembly and all other internal components shall be dried by vapor-phase process to assure proper dryness of the insulation material.

F. The core legs shall have a solid support from the bottom to the top clamp to prevent sideways deformation and bulging of the outermost laminations. The core shall be adequately braced to the core clamping structure, so that it cannot move in any direction. The windings shall be tight to prevent sideways movements. The core and coil assembly and other internal components shall be supported by permanent bracing to the interior of the tank.

2.4.9 Oil Preservation System

A. The oil preservation system shall be a sealed conservator with flexible bladder to prevent contact with the atmosphere and allow expansion and contraction of the oil volume as the temperature changes. The conservator shall have a capacity between highest and lowest levels that are adequate for full range of oil temperature. All conservator alarm contacts shall be wired to the main control cabinet

B. The system shall include a Buchholz gas detector relay and a sampling valve located at ground level. Access opening shall be provided at the conservator for cleaning and inspection purposes. A working platform with access ladder shall be provided for inspection and maintenance of the conservator and associated Buchholz relay. The relay shall be located in the piping between the main tank and the conservator.

C. All tanks and enclosures subject to operating pressures of the oil preservation system shall be designed to withstand 125% of the maximum operating pressures. In addition, the transformer tank and equipment shall be designed with sufficient bracing and strength to permit full vacuum filling with insulating liquid.

2.4.10 Cooling Equipment

A. Integrally mounted equipment shall be furnished to provide the cooling capacity necessary to maintain the transformer rating. Temperature control shall be provided by an assembly of devices arranged and designed to automatically vary the transformer cooling equipment capacity in steps proportional to transformer load and temperature.

B. Cooling fan motors shall be 480V, 3-phase, 60 Hz. Motors shall be totally enclosed, non-ventilated, with sealed, pre-lubricated ball bearings with bearing wear indicator, and rated for all-weather outdoor operation. Non-metallic bearings for fan motors are not acceptable.

C. Controls

D. The transformer cooling equipment control shall be via Electronic Temperature Monitor (ETM). The ETM shall monitor winding hot spot temperature and top oil temperature. The ETM shall be mounted onto the outside of the transformer in a self-contained corrosion and weatherproof enclosure.

E. The transformer cooling equipment control system shall utilize control contacts furnished on the winding temperature indicator. Where multiple thermal relays are provided, thermal relay temperature control contacts shall be wired for parallel control of the cooling equipment

F. Controls shall be provided for manually alternating the cooling fan operation sequence. Manual control switches shall be provided in the control cabinet to allow testing and maintenance of the cooling fans.

G. Cooling equipment shall be interruptible by an 86 (Lockout relay) type device such as an 86T, 86U or by fire detection.

H. Suitable alarm actuating devices with form C contacts shall be provided to indicate failure of any or all motors and loss of power.

I. Transformer cooling equipment shall be designed and arranged to allow individual radiators to be removed from the transformer without removing the transformer from service, draining oil from any other transformer component, or loss of oil past valve with 5 psi positive pressure on main tank.

J. Manually operated shutoff valves shall be provided, as required, for cooling equipment removal. All shutoff valves shall be bolted-flange mounted, and shall have provisions for padlocking in the open or closed position.

K. Each removable radiator shall be furnished with vent and drain valves for evacuation and oil filling.

L. The design of the radiators shall accommodate significant amounts of dust/ash particles in the air, and shall operate without clogging. Integrally mounted equipment shall be furnished to provide the cooling capacity necessary to maintain the transformer rating.

M. Spare flanges shall be installed for the tank on the addition of future radiators.

2.4.11 Transformer Tank

A. All tanks, bases, radiators, covers, junction boxes when required, and any other attached compartments shall be fabricated from steel of sufficient strength to withstand normal service stresses and vacuum filling without distortion or damage to any part. The base shall be extra heavy (3/4-inch minimum thickness) and suitable for rolling or skidding in any direction.

B. All joints in transformer tanks, radiators, bases, etc., shall be made gas-tight and oil-tight by welding, except that the connections between oil coolers, pumps, and tanks shall be provided with gasketed, bolted flanges. All covers shall be welded in place.

C. Transformers shall be equipped with welded cover lifting lugs, jack bosses (located not less than 16 inches above the base and shall provide a minimum unobstructed jack clearance of 6 inches from tank wall or other obstruction), pulling eyes, skids, and jacking pads to accommodate rollers.

D. The tank finish color shall be **< ANSI Z55.1 No. 70, grey >**. Seller's surface preparation, painting procedures and materials used shall be submitted with bid proposal for Company review. Products containing lead are not acceptable.

E. All interiors and exteriors of tanks, enclosures, cabinets and other metal parts which are not galvanized, stainless steel or of corrosion resistant material and are exposed to oil and weather shall be thoroughly cleaned and painted as required

F. The interior color of the transformer tank and control cabinet(s) shall be white and shall be fully capable of withstanding transformer operating conditions without degradation such as chipping, cracking, or peeling.

G. The top of the transformer tank shall be covered with skid resistant paint, which is the same color as the exterior tank walls.

H. Tank side seams and the connection point of the tank sides to the tank bottom shall be welded both inside and outside.

I. A minimum of two (2) 24-inch diameter manholes shall be provided on top of the transformer tank. One (1) of the required manhole covers shall include a 1-inch threaded nipple and a flanged vacuum fitting for a connection of a 4-inch diameter vacuum hose. The 4-inch (nominal) vacuum fitting shall have eight (8) 3/4-inch diameter bolt holes, equally spaced on a 7 1/2-inch diameter bolt circle. The vacuum-fitting flange shall be mounted sufficiently high off of the manhole cover to allow for easy access for removing and replacing bolts and nuts.

J. All piping connections for Owner use shall be American standard threads or flanges.

K. Gaskets and gasketed joints shall be designed so that the gasket shall not be exposed to the weather or standing water, and shall be provided with mechanical stops to prevent crushing.

2.4.12 Wiring

A. All wire shall be stranded, tinned copper conductor with 600V flame-retardant, cross-linked synthetic polymer insulation, type XHHW or equal. The minimum wire size for control and alarm functions shall be stranded No. 14 AWG. The minimum wire size for motor circuits, power circuits, and CT circuits shall be No. 12 AWG.

B. Wiring shall not be spliced or tapped. All interconnections shall be made and identified with wire markers at equipment terminals or terminal blocks.

C. All control wiring, including CT circuits, shall be terminated with non insulating, seamless barrel ring tongue lugs (Burndy type YAV HYLUG is preferred)

D. All CT secondary leads shall be terminated to short-circuiting type terminal blocks located in the control cabinet. CT terminal blocks shall be 6 point, shorting type 600V, 30A class minimum, Marathon type 1506, GE type EB-27, or Penn union type 606.

E. All CT secondary leads shall be brought to terminal blocks mounted in a junction box outside the transformer tank. CT terminal blocks shall be 6 point, shorting type 600V, 30A class minimum, Marathon type 1506, GE type EB-27, or Penn union type 606.

F. Control terminal blocks shall be 12-point, 600V, 30A class minimum, Marathon type 1512, GE type EB-25, or Buchanan type 2B112.

G. DC power Blocks shall be 600V class GE type EB-1 or equivalent.

H. Terminals shall be labeled with white terminal identification marking strips. Terminal blocks shall be mounted on the sides or back walls of the transformer control cabinet, and shall be easily accessible with normal tools.

I. Rigid galvanized steel conduit shall be used for all power, control, and alarm external wiring. When the wiring terminates at an externally tank-mounted power, control, or alarm device, rigid conduit shall be provided to a suitable location near the device. Wiring may be routed through tank support channels as an alternate to rigid conduit.

J. Liquid-tight, flexible, metal conduit may be provided from a point near the device to the device itself.

K. Associated terminal blocks shall be grouped together to facilitate the use of multi-conductor cables for interconnecting equipment. Common voltage rated control and power terminal blocks shall be grouped together (i.e. 480VAC terminal blocks and wiring physically separated from 120VAC or 125VDC control terminal blocks and wiring; 120VAC control terminal blocks and wiring physically separated from 125VDC control terminal blocks and wiring). A minimum of 10% spare terminal blocks shall be provided, and shall be grouped and reserved for Company's use only.

L. The transformer control cabinet shall be designed such that all exposed 480VAC points of contact are contained in a separate compartment with a dead front metal door or panel. Physical separation of 480VAC from lower voltage (DCS contact indication, 120VAC, or 125VDC) control circuits shall be maintained.

M. Plastic self-locking tie wraps shall not be an acceptable material for lead support.

N. All conduit, cable, and fittings shall be weatherproof, and securely fastened to the transformer at regular intervals. Rubber covered cable is acceptable for fans and gauges, and external wiring runs of less than 4 feet, however, its use shall be limited.

O. No more than two (2) wires are permitted to terminate at a given terminal.

2.5 AUXILIARY EQUIPMENT & ACCESSORIES

2.5.1 Each transformer shall be equipped with a high voltage, de-energized tap changer with an external operating mechanism located on the side of the transformer tank. The tap changer handle shall have provisions for padlocking in any position, and shall provide visible indication of the tap position without unlocking.

2.5.2 A single weatherproof control cabinet shall be provided for all external conduit/cable connections, control components. The cabinet shall be accessible from ground level, and shall be sized large enough to house all forced air-cooling equipment control components.

A. The control cabinet shall be supplied with thermostatically controlled space heaters to prevent condensation. Space heaters shall be rated 240 VAC, but shall be sized for a normal operating voltage of 120 VAC. Space heater circuits shall be individually protected with molded case circuit breakers. Molded case circuit breakers shall be manufactured by General Electric, Square D, or Cutler-Hammer.

B. The cabinet shall include vertically hinged doors arranged to permit ready access to the cabinet from the ground level. A locking device shall be provided to hold the doors in the fully open position. Should design of cabinets be such that door width is in excess of 30 inches, double doors shall be provided and the doors shall be hinged for center opening. Hinge material shall be stainless steel.

C. Doors shall have three-point latches for the closed position and shall include provisions for attaching padlocks. Bolts or screws to secure the door shall not be used.

D. The top of the control cabinet shall not be more than 7 feet above the bottom of the tank. The bottom of the control cabinet shall be located a minimum of 2.5 feet above the bottom of the tank.

E. A removable, gasketed plate, minimum size 12 inches by 16 inches, shall be provided in the bottom of the control cabinet to permit field drilling and installation of control system conduits. The Contractor shall not place the plate directly under any device within the control cabinet that would encumber the pulling of control conductors into the cabinet.

F. Each auxiliary equipment branch circuit shall be protected by an individual molded case circuit breaker properly coordinated with the Control Power Transformer (CPT) breakers. Molded case circuit breakers shall be manufactured by General Electric, Square D, or Cutler-Hammer.

G. The control cabinet shall be provided with a 120 VAC, duplex (3-wire) with ground fault interruption (GFI) receptacle and switched cabinet light, wired to a 20 amp, molded case circuit breaker. The circuit breaker line side shall be wired to control cabinet terminal blocks. Molded case circuit breakers shall be manufactured by General Electric, Square D, or Cutler-Hammer.

H. The control cabinet shall be equipped with a Seekirk Inc. Model B1002BNC-S33 annunciator (125 VDC, feed thru, LED, NC contacts (open to alarm)). Two (2) form C contacts rated for operation at 125 VDC shall be provided for a common output alarm. The normally closed contacts shall be wired in series and wired out to a terminal block in the control cabinet.

I. The control voltage for the annunciator, transformer protective relays and associated equipment shall be 125 VDC.

J. The control cabinet shall be equipped with a “Loss of DC Alarm Voltage” alarm relay, with alarm and trip contacts wired to a terminal block in the cabinet.

K. All control relays shall have enclosed, dust tight contacts.

L. All devices and terminal blocks mounted in the control cabinet shall be clearly labeled with a designation. This label shall be located on or near the device and be affixed in such a manner that they will not become detached during the life of the transformer (Dymo Tape or similar embossed plastic tapes are not acceptable).

M. A metal oxide arrestor (MOV) surge suppressor shall be mounted across the 125 VDC supply terminal within the control cabinet. The MOV shall be rated for a minimum of 10 kA, 200 joules capability with a maximum peak discharge voltage of 500V.

N. All control devices, controllers, and control systems and assemblies shall be in accordance with NEMA ICS 1 and 2 and shall meet the requirements of this Standard.

O. For each transformer, an automatic voltage seeking transfer switch shall be provided to supply power to the transformer auxiliary equipment. Two (2) sources of nominal 480V, 3-phase, 3-wire, 60 Hz power to feed this switch will be provided. The automatic transfer equipment shall be of sufficient capacity to transfer the total cooling equipment, control circuit, and space heater load from the normal source to the standby source upon failure of the normal source voltage. Voltage failure relays shall be installed in order to monitor normal and standby source voltages. Each relay shall provide a contact closure on loss of voltage. The contacts shall be wired to terminal blocks in the control cabinet. Control power for the transfer controls shall be 120 VAC.

P. Alarm Requirements. The following minimum alarm points shall be provided:

1. Top Oil Temperature – (26Q).
2. Winding Temperature – Monitor One Winding (49T)
3. Liquid Level Indicator – Main Tank/Conservator – Normal High (71Q-1(MT)/HA)
4. Liquid Level Indicator – Main Tank/Conservator – Normal Low (71Q-1(MT)/LA)
5. Liquid Level Indicator – Main Tank/Conservator – Emergency Low (71Q-3(MT)/LT)
6. Transformer Gas Detection – Buchholz Relay (71GD(MT))
7. Pressure Relief Device – Main Tank (63P-1(MT))
8. AC Supply – Loss of Main AC Supply (27-1)
9. Stage 1 Cooling – Loss of AC (27-2)
10. Stage 2 Cooling – Loss of AC (27-3)
11. Loss of Cooling Control Voltage – AC (27-4)
12. Loss of DC Control Voltage – DC (27-6)

Q. Tank cover pressure relief devices shall be supplied for each oil-filled compartment. Each device shall be equipped with form C alarm contacts, a manual reset, and mechanically operated flag, to indicate that the relief device has operated. Released oil shall be directed away from all control cabinets or where personnel may be standing. Alarm contacts shall be wired to terminal blocks in the control cabinet. Pressure relief device shall be Qualitrol 213 series.

R. Liquid level indicators (main tank and all other oil filled compartments) shall be provided with all alarm contacts wired to terminal blocks located in control cabinets:

1. The main tank shall either have a single, magnetic-type level indicator with two (2) low level and one (1) high level alarm contacts or two (2) separate, magnetic-type level indicators. All contacts shall be Form “C” contacts.
2. All other oil filled compartments shall have single indicators with Form “C” contacts at the lowest level considered safe for continued operation of the transformer and wired to terminal blocks in the main control cabinet.

3. All liquid level indicators shall be readable from ground level.

S. An Electronic Temperature Monitor (ETM) shall be provided.

1. The ETM shall monitor winding hot spot temperature and main tank top oil temperature.

2. A minimum of six (6) form C dry contact outputs [with auxiliary interposing relays as needed to accommodate a 125 VDC contact make/break rating for four (4) of the six (6) contacts (output contacts used for first and second stage temperature alarm levels on each of the top oil and hot spot winding temperatures), with the other contacts used for controlling the cooling system (responsive to the simulated winding hottest spot temperature)].

3. Form C alarm and trip contacts shall be wired out and terminated to terminal blocks in the transformer main control cabinet.

4. The ETM shall be mounted adjacent to or within the transformers main control cabinet, at an approximate height of 5 feet above the base of the transformer for easy viewing from ground level.

5. Source to the ETM shall be from a 125 VDC input power supply. On loss of DC, all stages of fans shall be triggered to energize.

6. A minimum of two (2) 0 to 1 mA DC analog (corresponding to 0 to 200°C) SCADA outputs for both top oil temperature and hot spot winding temperature.

7. Weather-tight NEMA 3R or better enclosure with outdoor-rated display and controls accessible without opening the enclosure's front door. A switch or operator accessible front panel menu for manual control of the system. Basic Temperature error (including probe) to be less than 1°C.

8. RS232/485 digital interface and MS Windows-based programming software for setup and monitoring from a PC.

9. Acceptable ETM manufacturers/models are as follows:

Manufacturer	**Model Number**
Weschler Instruments	Transformer Advantage CT - Electronic
Qualitrol	509-100 Series – Electronic

T. Transformers shall be equipped with the following valves and fittings:

1. A combination drain and lower filter valve shall be provided to drain the oil as completely as possible but to at least within 1 inch of the bottom of the main tank and for outlet to the filtering means. The drain valve shall be 2 inches with a built-in 3/8-inch sampling device.

2. Lower filter press valve with malleable iron pipe plug.

3. A 1 ½-inch upper filter press valve with malleable iron pipe plug.

4. Standard 4-inch bolted round pipe flange with gasketed cover plate for attaching the Company's vacuum valve and hose. The flange shall be located on the corner farthest from the upper filter press valve to insure that oil does not enter the Company's vacuum system.

5. A shut-off valve shall be provided on each end of the connection piping to the main tank.

U. Transformer shall be equipped with a gas detector relay with seal in coil, mounted in the control cabinet. Gas detector relay shall be a EMB Buchholz Type BF80-10, twin float relay DR80, Model 09-236 with form C contacts wired out to a seal-in relay panel (Qualitrol model 909-200-01 AC/DC Seal-In relay). Seal-in relay panel to be mounted in the control cabinet.

V. Transformer shall be equipped with a GE Hydran M-2 dissolved gas-in-oil intelligent monitor/transmitter.

W. Transformer shall be equipped with the following fall protection devices:

1. Brackets for mounting of 2-inch diameter pipes for use as safety rails shall be provided at the top of the transformer. Design and fabricate brackets to meet OSHA-required lateral loads at the top of the safety rail. Brackets shall be spaced a maximum of 4 feet apart, with one on each corner of the transformer. Brackets shall be in accordance with Exhibit C, Figure 1, Safety Rail Pocket Detail.

2. A weld-on base shall be provided near the center of the transformer top. It will be used for attaching a 4-foot Company-supplied tether pole to meet OSHA 29 CFR 1926.502(d). The base shall be designed to support a horizontal force of 10,800 lbs at the top of a 4’ tether pole. The area above the base should be clear of obstructions as to facilitate attachment of the Company- supplied tether pole. Tether pole base shall be in accordance with Exhibit C, Figure 2, Tether Pole Base Plate Detail.

3. Unique Concepts Ltd. weld-on base, Part Number 10816, shall be installed by the Seller for attachment of a portable fall arrest system provided by the Company. Weld-on bases shall be installed on the transformer cover within three (3) inches of each manhole and shall be in accordance with Exhibit C, Figure 3, Portable Fall Arrest Weld-on Base Detail.

X. Nameplates: All nameplates shall be inked and engraved stainless steel. At least four (4) bolts or rivets shall attach nameplates. Mounting holes shall be provided with rubber grommets or equivalent to decrease vibration noise. Nameplate shall be located to be accessible and readable from grade level with no other equipment blocking or otherwise limiting view of the nameplate

1. A temperature relay nameplate shall be supplied and shall give the recommended temperatures at which the first set of cooling equipment shall be started, the second set of cooling equipment shall be started, and the temperature at which an alarm shall be actuated. All of these shall be calculated on the basis of operation at 65°C winding temperature rise. This information shall also be provided on the wiring diagram. The nameplate shall be mounted on or near to the temperature indicator(s)

2. De-energized tap changer nameplates shall be provided and shall include make and model information. These nameplates shall be mounted next to the main nameplate or the information may be incorporated into the main nameplate

2.6 INSULATING LIQUID

2.6.1 Insulating oil shall be Type II and shall meet ANSI C57.106 requirements. It shall be free of PCB's, chemically stable, free from acidity or other corrosive ingredients, and shall contain a suitable oxidation inhibitor. Maximum oxidation inhibitor content shall be 0.3% by weight and transformer nameplates shall indicate that the oil is inhibited. The oil shall contain less than 30 ppm water when tested in accordance with the procedures of ASTM D1533-88 (Karl Fischer method). The dielectric strength of the oil shall be at least 30 kV when tested in accordance with the procedures of ASTM D877-87, or 20 kV when tested in accordance with the procedures of ASTM D1816-84A using a 0.04-inch gap.

2.7 SOURCE QUALITY CONTROL

2.7.1 Transformers shall be tested in accordance with ANSI/IEEE C57.12.00 and ANSI/IEEE C57.12.90.

2.7.2 The following tests shall be performed and certified by the Seller for each transformer:

A. Resistance measurements on all windings. The test report shall indicate how windings were connected, either series or parallel.

B. Ratio tests on the rated voltage connection and on all tap connections.

C. Polarity and phase relation test on the rated voltage connection.

D. No load loss and exciting current at rated frequency and voltage and at maximum raise and lower tap position.

E. No load loss and exciting current at rated frequency at 90% rated voltage (0.9 p.u.).

F. No load loss and exciting current at rated frequency at 110% rated voltage (1.10 p.u.).

G. Auxiliary losses shall be verified by actual test measurements.

H. Impedance volts at rated current and at maximum raise and lower tap positions.

I. Load loss at rated current and at maximum raise and lower tap positions.

J. Temperature rise test made at the transformer self-cooled KVA rating at rated current.

K. Applied voltage test.

L. Induced voltage test for Class II power transformers with radio influence voltage (RIV) for partial discharge measurement.

M. Impulse tests. The neutral current method of fault detection shall be employed and oscillographic or digital records of all impulse tests shall be furnished with the test report.

N. Core insulation resistance test.

O. Sweep Frequency Response Analysis. For use in creating a baseline response analysis.

P. Transformer noise frequency spectrum analysis (under no load and full load conditions).

Q. Insulation power factor test.

2.7.3 The certified test report shall indicate all impedance values (positive, negative, and zero sequence); oil test reports, which include all tests indicated in ANSI C57.106.

2.7.4 Copies of all factory power factor tests or equivalents shall be furnished with the certified test reports. Certified test reports shall be prepared and submitted to the Company following completion of the testing and prior to transformer shipment.

END OF EXHIBIT

EXHIBIT B

GENERATOR STEP-UP TRANSFORMER DATA SHEETS

DATA SHEETS

GENERATOR STEP UP TRANSFORMER	UNITS	REQUIREMENTS	SELLER RESPONSE
Manufacturer		Seller	
City & Country of Manufacture		Seller	
Duty Cycle		Continuous	
ELECTRICAL PARAMETERS:			
Capacity	MVA		
Capacity with one section of the cooling inoperative	MVA	Seller	
Temperature Rise	^{o}C	**65**	
Type of Cooling			
Phase Displacement		**High Voltage leads Low Voltage by 30 ^{o}**	
Frequency	Hz	60	
Connection - High Voltage Winding		**Wye**	
Connection - Low Voltage Winding		**Delta**	
Voltage Rating - High Voltage Winding	kV		
Voltage Rating - Low Voltage Winding	kV		
No Load Tap Voltages (Full Capacity Taps) – High Voltage Winding	kV	**-____% to +____% @ ____ % Steps**	
No Load Tap Voltages (Full Capacity Taps) - Low Voltage Winding	kV	None	
BIL - High Voltage Winding	kV		
BIL - Low Voltage Winding	kV		
BIL - High Voltage Winding at Neutral Point	kV		
No Load Loss at - 100% of Rated Voltage	kW	Seller	
No Load Loss at - 105% of Rated Voltage	kW	Seller	
No Load Loss at – 110% of Rated Voltage	kW	Seller	
Load Loss at 100% of Rated Voltage, 100% ONAN Loading Of Transformer	kW	Seller	
Load Loss at 100% of Rated Voltage, 100% ONAF Loading Of Transformer	kW	Seller	

Total Cooling System Losses (@ max ONAF Loading).	kW	Seller	
Total Loss (No Load + Load) at 100% of Rated ONAN Loading Of transformer, 100% Voltage.	kW	Seller	
Total Loss (No Load + Load + Cooling) at 100% of Rated max ONAF Loading of transformer, 100% Voltage.	kW	Seller	
Impedance at Rated Capacity (at ONAN rating)	%		
Reactance at Rated Capacity	%	Seller	
Resistance at Rated Capacity	%	Seller	
X/R Ratio		Seller	
Maximum Overvoltage Excitation Capability at Full Load in % of Rated Voltage	%	ANSI	
Exciting Current in % of Full Load Current at Rated Voltage and Frequency	%	Seller	
Three Phase Capacitance to Ground H.V. Side Only	pF	Seller	
MATERIALS			
Color		**ANSI Z55.1 Color 70, Light Gray**	
Tank		Plate steel	
H.V. Windings		Copper	
L.V. Windings		Copper	
Fall Protection Brackets (for railing on top of transformer)		Yes	
Fall Protection Tether Pole Base		Yes	
Fall Arrest Brackets near each Manhole		Yes	
NOISE DATA			
Audible Sound Level @ 100% Load	dBA	NEMA TR1	
Audible Sound Level @ No Load	dBA	NEMA TR1	
APPROXIMATE WEIGHTS			
Core and coils	lb	Seller	
Tank and Fittings	lb	Seller	
Oil	lb	Seller	
Shipping Weight (without oil)	lb	Seller	

APPROXIMATE DIMENSIONS			
Overall height	in	Seller	
Width	in	Seller	
Depth	in	Seller	
Untanking	in	Seller	
Minimum Clearance of Jacking Lugs to base	in	16	
COOLING			
Quantity of Fans		Seller	
Rated Voltage	V	480	
OIL PRESERVATION SYSTEM			
Conservator Tank System		Yes	
High/Low Pressure Gauges & Alarm Contacts		Yes	
Minimum Positive Pressure	PSIG	0.5	
Maximum Positive Pressure	PSIG	5	
Maintenance-Free Dehydrating Breather (High Voltage Supply model 1030-012K)		Yes	
CONTROL CABINET			
Enclosure type	NEMA	4X	
Heater Voltage	VAC	120	
Heater Wattage	Watts	Seller	
Alarm Annunciator		Seekirk (per spec)	
INSTRUMENTATION / ALARMS			
Electronic Temperature Management (ETM) for cooling fan control, High temperature alarms, Hot Spot Winding Temperature (49T), and Top Oil Temperature (26Q)		Qualitrol ETM 509-100 Or Weschler Instruments Transformer Advantage CT – Electronic	
Pressure/Vacuum gage (63P) & bleeder device.		Yes	
Oil Level Indicator (71Q-HA) for Main tank and conservator tank.		Yes	
Oil Level Indicator (71Q-LA) for Main tank and conservator tank		Yes	
Oil Level Indicator (71Q-LT) for Main tank and conservator tank		Yes	
Transformer Gas Detection Relay (Buchholz) (71GD)		Yes	

Combustible Gas Monitor (GE Hydran M-2)		Yes	
Pressure Relief Device (63P-1) w/ trip contact and alarm contact		Yes	
Loss of Main AC Supply (27-1)		Yes	
Stage 1 Cooling – Loss of AC (27-2)		Yes	
Stage 2 Cooling – Loss of AC (27-3)		Yes	
Loss of cooling control voltage – AC (27-4)		Yes	
Loss of DC control voltage (27-5)		Yes	
TERMINAL BUSHINGS			
Manufacturer - High Voltage		ABB	
Manufacturer - Low Voltage		ABB	
Manufacturer - High Voltage Neutral		ABB	
Type/Style - High Voltage		Oil-Filled/Porcelain	
Type/Style - Low Voltage		Oil-Filled/Porcelain	
Type/Style - High Voltage Neutral		Oil-Filled/Porcelain	
Arrangement of Bushings – High Voltage (Sidewall or Cover).		Cover	
Arrangement of Bushings – Low Voltage (Sidewall or Cover).		Cover	
Arrangement of Bushings – High Voltage Neutral (Sidewall or Cover).		Cover	
Creepage Distance - High Voltage	In	Seller	
Creepage Distance - Low Voltage	In	Seller	
Creepage Distance - High Voltage Neutral	In	Seller	
Rated Voltage - High Voltage	kV		
Rated Voltage - Low Voltage	kV		
Rated Voltage - High Voltage Neutral	kV		
Rated Amps - High Voltage	Amps		
Rated Amps - Low Voltage	Amps		
Rated Amps - High Voltage Neutral	Amps		
BIL - High Voltage	kV		
BIL - Low Voltage	kV		
BIL - High Voltage Neutral	kV		
Terminal Bushings Shipped Loose		Yes	
Core Ground Bushing		Yes	

BUSHING CURRENT TRANSFORMERS			
High Voltage Bushing CT Quantity/Bushing			
High Voltage Bushing CT Ratio			
High Voltage Bushing CT Accuracy		**_____ @ C800,** **_____ @ 0.3-B1.8**	
High Voltage Bushing CT Burden		Seller	
Low Voltage Bushing CT Quantity/Bushing			
Low Voltage Bushing CT Ratio			
Low Voltage Bushing CT Accuracy		**_____ @ C800,** **_____ @ 0.3-B1.8**	
Low Voltage Bushing CT Burden		Seller	
High Voltage Neutral Bushing CT Quantity/Bushing		1	
High Voltage Neutral Bushing CT Ratio			
High Voltage Neutral Bushing CT Accuracy		C800	
High Voltage Neutral Bushing CT Burden		Seller	
HV SURGE ARRESTERS			
Manufacturer/Model No		ABB, Cooper, GE or Ohio Brass	
Type		Porcelain/MOV	
Rating	kV rms		
Maximum Continuous Voltage Capability, MCOV	kV rms		
GROUND PROVISIONS			
Tank Grounds – Two, NEMA 4-Hole		Yes	
Core Ground – with Bushing / Cover / Ground Pad		Yes	
HO Ground Bus / Pad		Yes	
Surge Arrestor Grounding Cable		Yes	
Grounding Brackets – Four brackets / side of Transformer		Yes	
(3) High Voltage Insulators with Grounding Brackets		Yes	
TERMINAL CONNECTIONS			
High Voltage		**Open Air**	
Low Voltage		**Iso-Phase**	

END OF EXHIBIT

SECTION 16950

INSTRUMENTATION AND CONTROL

PART 1: GENERAL

1.01 DESCRIPTION

A. Bidding requirements, conditions of the Agreement and pertinent portions of Sections in Division One of these Specifications apply to the Work of this Section as fully as though repeated herein.

B. The scope of the work includes the furnishing and installation of the electrical equipment building as required. The building shall be complete with door, door hardware, and exhaust fan. The contractor shall furnish and install the 480 and 240 volt panelboards, stepdown transformer, lights, outlets, exterior light and pole, SCADA panel and other appurtenances as required by the documents.

C. The work specified in this section includes furnishing, installing, startup, and testing of required equipment, including field instruments, the SCADA panel and components, wiring, piping, conduits, hardware, accessory equipment, and training.

1.02 SCHEDULING

A. The Contractor shall schedule execution of the installation and startup of the process instrumentation system to meet requirements of the overall Project.

1.03 SUBMITTALS

A. The Contractor shall submit complete shop drawings, instruction manuals, and record drawings in compliance with the General Conditions. As a minimum the information shall include:

1. System schematic diagrams (3 line drawings), ladder format
2. Sub-system schematic diagrams
3. Component schematic diagrams and specification sheets
4. Component instruction manuals
5. Dimension drawings and piping and wiring diagrams
6. Enclosure layout, structural and equipment layout drawings

B. The submittal shall conform with the requirements of the contract documents.

C. After installation and before the final acceptance of the equipment, final bound books containing the record drawings in addition to complete information in connection with the assembly, operation, adjustments, maintenance and repair of all equipment, together with a detailed parts list with drawings and photographs shall be furnished to the Company.

D. Where the contract documents indicate a nomenclature for terminal strips then the shop drawings and manufactured equipment shall also utilize the same nomenclature. Where none is assigned on the contract documents the Contractor shall assign a nomenclature. The nomenclature shall be approved by the Company with shop drawings.

1.04 GUARANTEE

A. The Contractor shall guarantee the operation of the system and that materials and workmanship of the equipment be free from defects for a period as defined in the General Conditions of the project manual providing the equipment has been operated and maintained in accordance with the manufacturer's recommendations.

1.05 TESTING AGENCY CERTIFICATION

A. All panels furnished under this Section shall be constructed in accordance with Underwriter's Laboratories (UL) Standard 508 - AIndustrial Control Equipment@.

B. Each panel shall be shop-inspected by UL, or constructed in a UL-recognized facility. Each completed panel shall bear a serialized UL label indicating acceptance under Standard 508.

1.06 FUNCTIONAL DESCRIPTIONS

A. General

1. Functional descriptions define how each portion of the instrumentation and control system is to operate. The descriptions, in conjunction with the drawings and the minimum technical requirements for products as described in Part 2 of this Section define the minimum requirements for the installation.

B. Functional Descriptions.

1. The Contractor shall furnish and install the channel level and temperature transmitter. The level transmitter shall transmit a 4 - 20 mAdc signal to the SCADA panel. The channel temperature transmitter shall transmit a 4 - 20 mAdc signal to the SCADA panel. The Contractor shall furnish and install the terminal strips in the SCADA panel. Furnish and install the isolation transformer and associated outlets. The isolation transformer can be mounted on top of the SCADA panel. Outlets shall be furnished and installed next to the isolation transformer and in the SCADA panel. Connections to the Company PLC will be by Company personnel. Company personnel will calibrate the channel level and temperature transmitter. Furnish and install the cable holding clamp. The wiring shall be routed from the transmitter to the signal junction box. The signals shall be consolidated into a single conduit and routed to the SCADA panel.

2. The Contractor shall furnish and install the three trash rack level transmitters. The level transmitters shall transmit 4 - 20 mAdc signals to the SCADA panel. The HART signal shall be superimposed on the analog signal. The Contractor shall install terminal strips in the SCADA panel. Connections to the Company PLC will be by Company personnel. Company personnel will calibrate the trash rack level transmitters. Furnish and install the cable holding clamps. The wiring shall be routed from the transmitter to the Endress & Hauser signal terminal boxes. The signals shall be consolidated into a single conduit in the signal junction box and routed to the SCADA panel.

3. The Contractor shall furnish and install the river level and temperature transmitters. The level and temperature transmitters shall transmit a 4 - 20 mAdc signal to the SCADA panel. The HART signal shall be superimposed on the analog signal loops. Furnish and install the cable holding clamp and the Endress & Hauser transmitter terminal box. The Contractor shall install terminal strips in the SCADA panel. Connections to the Company PLC will be by Company personnel. Company personnel will calibrate the river level and temperature transmitters. The wiring shall be routed from the transmitters to the signal junction box. The signals shall be consolidated into a single conduit in the signal junction box and routed to the SCADA panel.

4. The Contractor shall provide power and signal wiring from the three gate actuators to the distribution panelboard for power, and to the SCADA panel for control, torque switches and signals. The power wiring shall be in separate conduits and the control wiring shall be in

separate conduits to the control junction box. The wiring shall be consolidated into one conduit in the control junction box and the control circuits routed to the SCADA panel. The signal wiring from the actuators for position, and for the torque switches shall be routed to the signal junction box, consolidated with other signal wiring and extended to the SCADA junction box.

5. The Contractor shall furnish and install the stainless steel control junction box to be located adjacent to the signal junction box. The Contractor shall furnish and install the SCADA junction box, quad-outlet and the UPS. The Contractor shall furnish and install the 24 VDC power supply that shall source the transmitters as required.

PART 2: PRODUCTS

2.01 ENCLOSURES

A. NEMA 4X. Stainless steel enclosure.

B. Steel subpanel for components

C. 14 gauge stainless steel with 16 gauge stainless steel door minimum

D. Stainless steel hinges and hardware

E. Doors flanged with stiffeners for rigidity

F. Latches.

2.02 SYSTEM WIRING

A. Instrumentation and control wiring shall be terminated on barrier type terminal strips using ring or spade connectors. All terminal strips shall have each point, as well as the terminal strip, identified. The labels shall be engraved plastic labels bonded to the enclosure with a two part epoxy adhesive.

B. Ring or spade connectors shall be of the "crimp" type.

2.03 SUBMERSIBLE LEVEL TRANSDUCER

A. Submersible level transducer housings shall be stainless steel. Assembly shall be UL labeled, or labeled by a third party organization approved by the local inspection authority. The transducer shall be Endress & Hauser FMX21 with HART communication protocol. The transducer for the channel monitoring shall include level (pressure) and temperature. Provide a Pt100 RTD with a transmitter located in a Endress & Hauser junction box above the probe for the channel level transmitter.

B. Span shall be from 0 to 12 feet of water. Output shall be a 4 - 20 mAdc signal proportional to the measured depth of the liquid. Provide a HART signal superimposed on the 4 – 20 mAdc signal line. Power supply shall be 23 to 40 volts, DC, with reverse polarity protection.

C. The following specifications shall apply: overrange to 580 psi; thermal change ∀0.5% of span; loop resistance, 500 ohms; accuracy, ∀0.25% of span; stability, ∀0.1% of upper range for 12 months. Power supply effect, ∀0.005% per volt. Surge protection shall be standard.

D. The transducer shall have a cap to protect the diaphragm.

E. Cable to the Endress and Hauser terminal box above the transducer shall be furnished. This shall be up to 50 feet (field confirm). The cable shall be submersible and approved for the application.

2.04 PANELBOARDS

A. Panelboards that are referred to as "power panels" refer to a system voltage of 120/240. Panelboards that are referred to as "distribution panelboards" refer to a system voltage of 277/480. Panelboards shall be surface mounted. Panelboards shall be mounted on 2 inch plywood. Unless shown otherwise the bussing shall be suitable for 200 amps, minimum. The number of circuits shall be not less than indicated on the schedules shown on the drawings. Unless shown otherwise, panelboards shall be NEMA 1. All panelboards on the project shall be by the same manufacturer, shall bear the U.L. label and listed as "suitable for use as service equipment" where applicable.

B. Cabinet rough-in boxes shall be code gauge steel, zinc galvanized, on both inside and outside surfaces, with an inturned flange on all sides of the front. The front covers shall be sheet steel, with a rust inhibitor primer and a baked enamel finish for surface mounted panels. The front covers shall be fitted with a door with a continuous butt type hinge concealed and welded to the back of the door. The other three sides shall have door stops. Doors over 48 inches high shall have auxiliary fasteners at the top and bottom. The doors shall have locks with two keys per lock. When the front cover and door assembly is removed, access to the wiring gutters shall be provided. The sub-plate shall be fastened to the panelboard with screws. The entire panelboard shall be of dead-front construction. The trim shall be adjustable.

C. Unless otherwise shown, main and branch circuit breakers rated at 240 volts shall have an interrupting rating of not less than 10,000 amps, r.m.s., sym. Unless otherwise shown, main and branch circuit breakers rated at 480 volts shall have an interrupting rating of not less than 22,000 amps. r.m.s., sym. Where panelboards and breakers are UL labeled for the application, series rated main and branch breakers may be used. Circuit breakers shall indicate open, closed, or trip conditions by handle position. Circuit breakers shall be quick-make, quick-break with thermal-magnetic trips having long-time and instantaneous tripping characteristics. Multi-pole breakers shall have one handle with internal trip bar with the circuit breaker cases fastened together. Panelboards are to be of bolt-on circuit breaker construction.

D. Install closure plates in each space not occupied by a breaker where the knockout has been removed. Accurately list the circuit numbers on the panelboard schedule utilizing a typewriter. Use actual room numbers.

2.05 DISTRIBUTION TRANSFORMER

A. Distribution transformer shall be a dry type suitable for indoor service. Transformers shall have a basic impulse level of not less than 10 kV. Transformers shall have not less than two 2-1/2% full capacity above normal primary voltage and two 2-1/2% full capacity below normal primary voltage taps. The transformers shall have a kVA rating as required. The primary voltage shall be 480 volts with a secondary voltage of 120/240 volts, single phase, three wire. The transformers shall have the insulations suitable for NEMA Class H, 150°C.

B. Transformers shall meet NEMA Standard TP-1, Energy Efficient Transformer Requirements.

C. Transformers shall be constructed in accordance with NEMA and ANSI standards. The transformers shall be finished with one coat of rust inhibiting primer and two finish coats of paint.

2.06 UPS

A. APS ES-450G, 450 VA, 120 VAC back-up UPS.

B. Input voltage range: 88 - 139 volts. Output 120 VAC when on UPS.

2.07 ELECTRICAL EQUIPMENT BUILDING

A. Plasti-Fab guardian, 8’ by 8’ shelter. Exterior surface, smooth gel coat. Interior surface white with webbing. 30% minimum glass content. Exterior color shall be tan.

B. Walls and roof to be sandwich construction with 1/8” (minimum) FRP skins, ½” thick (min) CDX plywood and 1” thick foam core. Insulated structure.

C. Insulated per energy code. Building shall include data plate indicating conformance with Minnesota State Building Code requirements.

D. Exterior door shall include not fewer than three hinges, door lockset assembly with key lock. Exterior door shall include ventilation opening with bug screen. Opening shall include insulated damper assembly for closing the opening in the winter.

E. Stainless steel hardware. 10” exhaust fan with motorized damper.mounted in wall opposite door.

2.08 ISOLATION TRANSFORMER

A. Isolation and transient protection. 1000 watts continuous capability. Reduce 6kV, IEEE587 Cat A&B ring wave test surge to 0.5 volts common mode.

B. 680 joules suppression rating.

C. Tripp-lite model IS1000 or equal.

PART 3: EXECUTION

3.01 FABRICATION

A. Fabricate per requirements of documents

B. Refer to project manual requirements concerning installation, inspection, etc.

C. All components and subassemblies shall be mounted to the sub-chassis or chassis, and sub-chassis shall be attached to the chassis with bolts or screws. Adhesives are not acceptable.

D. Front panel labels shall be attached with screws.

E. Internal components and labels shall be attached with screws.

3.02 INSTALLATION

A. Supplier shall define to Contractor dimensions, space requirements, access requirements for instrumentation devices.

3.03 MAINTENANCE EQUIPMENT

A. All special tools required for servicing equipment furnished under this division shall be delivered, properly identified as to use, to the Company prior to acceptance of the work. Adapters, electrical, pneumatic or otherwise necessary for servicing and maintaining the system shall also be delivered to the Company in the same manner.

3.04 CALIBRATION, ADJUSTING AND TESTING

A. All instruments will be calibrated by Company personnel.

3.05 START-UP SERVICE

A. When the equipment is ready, an instrumentation technician shall complete troubleshooting and start-up, at the Company's discretion, to place the instrumentation into satisfactory operation. The engineer or technician will make the necessary inspection of the completed installation, make the necessary final field adjustments, and instruct the operating personnel in the proper care and use of the equipment.

END OF SECTION 16950

SECTION 16500

LIGHTING

PART 1: GENERAL

1.01 DESCRIPTION

A. Bidding requirements, conditions of the Agreement and pertinent portions of Sections in Division One of these Specifications apply to the Work of this Section as fully as though repeated herein.

B. The Contractor shall furnish and install all lighting fixtures as required by the contract documents and in accordance with the fixture schedule. No lighting fixtures shall be substituted without prior written approval. Proposed substitutions shall be accompanied with complete engineering data including foot candle distribution curves.

1.02 SUBMITTALS

A. The Contractor shall submit complete shop drawings, instruction manuals, and record drawings to the Company for review and approval. The quantity and general format shall be as defined in the General Conditions.

B. After installation and before the final acceptance of the equipment, bound books containing the record drawings in addition to complete information in connection with the assembly, operation, adjustments, maintenance and repair of all equipment, together with a detailed parts list with drawings and photographs shall be furnished to the Company.

C. Submit lamp list for all lamp types provided under this project for inclusion in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 FIXTURES

A. All fixtures shall bear the seal of the Underwriter's Laboratories (UL). The seal shall be for the type of area the fixture is to be located in.

B. On all HID fixtures that utilize ballasts, the entire assembly shall have a power factor of not less than 0.90 at its designated voltage. All ballasts shall be of the type where the starting current does not exceed the operating current. Ballasts on fixtures that are located outside the building envelope shall be suitable for starting and operating at -20°F.

C. All fixtures shall be complete with lamps, starters, diffusers, guards, clips, retainers, etc. in accordance with the drawings, specifications and ordinances governing the installation of the fixtures.

D. Outdoor fixtures shall be complete with a pole as required. The pole shall be suitable to support the fixture in winds to 70 miles per hour.

E. Provide anchor bolts for the fixtures.

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall verify, prior to ordering the fixtures, that the fixture bears the UL label and meets the requirements for the location where the fixtures are to be installed.

B. The Contractor shall install fixtures in accordance with the manufacturer's recommendations and shall be mounted carefully and rigidly.

C. The fixtures shall be connected into the power distribution system per the requirements of the National Electrical Code, the manufacturer's requirements, or the contract documents, whichever is more stringent.

END OF SECTION 16500

MASTER SPECIFICTION
FOR
METAL ENCLOSED SWTICHGEAR (MV)

Revision _0_
Date 20131202

Responsible Technical Specialist ___________________

Author: John J Howard Jr	Revision No.:	Specification Approval:

METAL ENCLOSED SWTICHGEAR (MV)

GENERAL

A. Description

1. Switchgear equipment shall be arc-resistant metal-clad and mounted in one-high or two-high designed vertical sections fabricated of steel and assembled to provide rigid self-supporting, completely enclosed structures.
2. Contractor shall furnish and install all switchgear gas ducting from the switchgear to building exterior.
3. The breakers/contactors shall be removable from the front. All live parts shall be completely enclosed. Grounded removable steel barriers shall be provided between adjacent sections and solid removable metal barriers shall isolate the major primary sections of each circuit. The medium voltage switchgear, breakers and contactors shall be designed and furnished with remote racking.
4. Each breaker cubicle shall have individual back panels to allow rear access to associated cables etc. and shall be able to be removed without exposure to adjacent breaker live parts.
5. The switchgear shall be capable of extension from either end at a future date without modification to existing structural members.
6. Switchgear shall be installed on concrete floors.
7. If louvers are furnished as part of the switchgear enclosure they shall be provided with air filters.
8. The depth of cable entries shall allow for entrance, bending, and termination of power cables, including stress cones, and shall have a minimum of 24 inches of clearance between the terminal pads and the cable entrance point to the cubicle. Cable supports shall be provided every 24 inches to properly support and brace cables for lugs not located near the cable entrance.
9. Switchgear sections shall allow top and bottom entry of power cables and control and instrumentation cables.
10. The MV motor contactor assemblies shall be equipped with at least a 10 inch rear cubicle extension to provide for additional space for MV cable entry and termination.
11. Medium voltage breakers shall have separate DC sources for closing and tripping circuits.
12. Medium Voltage switchgear shall be located in HVAC-controlled rooms.
13. Minimum switchgear bus rating shall be 4,000A.

Specifier – Add discussion of options and criteria that must be addressed

B. Bus Duct Layout
1. Refer to site layout and powerhouse layout drawings for location and orientation of powerhouse and auxiliary power transformer equipment.
2. The following estimated bus duct lengths, number of supports, and fittings may be used for bidding purposes (per bus duct run).
    a. Outdoor bus duct length/run
    b. Indoor bus duct length/run
    c. Fittings (quantity)
    d. Outdoor supports(quantity)/run
3. Include separate additional add/deduct pricing in proposal for elbows and a cost per foot of bus for final price adjustments.

C. Reference Information
See Attachment 4

D. Technical Proposal Documentation
See Attachment 1

E. Approved Manufacturers
See Attachment 8

SUMMARY: Specifier to include 2 to 3 sentences of requirements of the specification.

APPLICABLE CODES AND STANDARDS
A. State and local codes, laws, ordinances, rules and regulations
B. ANSI - American National Standards Institute
C. ASTM - American Society for Testing and Materials
D. ICEA - Insulated Cable Engineers Association
E. IEEE - Institute of Electrical and Electronic Engineers
F. NEMA - National Electrical Manufacturer's Association
G. NFPA - National Fire Protection Association
H. OSHA - Occupational, Health and Safety Administration
I. UL Underwriter's Laboratories

In case of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

PERFORMANCE REQUIREMENTS & GUARANTEES
See Appendix 3

DESIGN & CONSTRUCTION FEATURES
A. ENVIRONMENTAL

1. The following ambient and site conditions shall be used in the designed of all furnished equipment.
   See Appendix 4
2. Considerations shall be given to the exposure to solar heat in the areas of outdoor installation.

B. INFRARED INSPECTION VIEWING PANES

1. Infrared (IR) inspection viewing panes shall be installed to permit thermography inspection of all line and load connections. IR inspection viewing panes shall be oriented to allow viewing from ground level.
2. IR inspection viewing pane NEMA rating shall be equal to, or greater than, that of the enclosure in which it is being installed.
3. IR inspection viewing panes shall be NFPA 70E compliant.
4. IR inspection viewing panes shall be 3" minimum diameter and shall consist of reinforced polymeric optic material.

C. SPACE HEATERS

1. Compartment Space Heaters – Each vertical section shall be provided with thermostatically controlled space heaters. Heaters shall be rated for 240 VAC and energized and sized for application at 120 VAC.
2. Motor Space Heaters – Motor heaters shall be powered from their respective switchgear. An individual circuit breaker and ammeter shall be furnished and flush mounted on the door for protection of the motor space heater circuit.

D. POWER BUS BARS

1. Switchgear bussing shall consist of electrical grade high-conductivity copper bars, silver plated at all contact surfaces, and shall be designed to continuously carry rated design current.
2. The bus shall be braced with rigid, tracking-resistant, fire-resistant, and moisture-resistant insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the momentary current rating of the largest circuit breaker in the assembly.
3. All power bus bars shall have fluidized bed epoxy, flame resistant, non-hygroscopic insulation with a continuous current rating. Bus joints shall have insulated boots that can be easily removed and reinstalled to allow inspection of the joints. The bus bar insulation shall be flame resistant and shall be flame resistant in accordance with ANSI standards.
4. For motor controller lineups installed as an extension to a medium voltage switchgear lineup, the power bus connections between the switchgear and motor controllers shall be solid bus bars.

5. Phase sequencing for power connections and main bus shall have proper identifications which shall be left-to-right, top-to-bottom, front-to-back (phase A-B-C) when facing the front of the switchgear.

E. GROUND BUS

1. A non-insulated, predrilled copper bar ground bus shall extend the entire length of each switchgear lineup and to each cubicle. The minimum size of the copper ground bar shall be 1/4 inch by 2 inches.

F. POWER CIRCUIT BREAKERS

1. The switchgear shall be furnished with draw-out medium voltage power circuit breakers. The power circuit breakers shall be vacuum type.
2. Each breaker shall have three (3) positions: operate, test, and disconnected. Breaker position shall be indicated on the breaker.
3. The power circuit breaker operating mechanism shall be fully mechanically and electrically trip-free in any position. The main contacts of the power circuit breakers shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.
4. Each breaker shall be furnished with a manual trip push button, which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.
5. Each circuit breaker shall be capable of being padlocked in the disconnected position.

G. MOTOR CONTROLLER ASSEMBLIES

1. Motor controller assemblies shall be draw-out two-high construction where possible. Each motor controller cubicle shall have individual rear panels to allow rear access to associated cables etc. and shall be able to be removed without exposure to adjacent compartment live parts.
2. All motor controllers shall be NEMA Class E2.
3. The contactors in the motor controller assemblies shall be vacuum type.
4. Each motor controller assembly shall be furnished with primary current-limiting fuses on each phase of the incoming side of each contactor for short-circuit protection, and with controls and relays specified on the drawings provided by the Company for overload and single-phase protection. Primary fuses shall be the largest size available that still protects the contactor.
5. Primary fuses shall be an integral part of the motor controller assembly and shall not require special tools for installation or

removal. Primary fuses shall be selected according to the motor locked rotor current and to provide coordinate with the motor protection relay such that the contactor is allowed to clear low and medium level faults without blowing any of the fuses and without exceeding the contactor interrupter ratings. The primary fuses shall be allowed to interrupt high-level fault currents that exceed the current interrupter rating. Primary fuses shall have visible blown fuse indicators.

6. Each contactor shall have a control power transformer (CPT). The CPT shall be protected on the high side by current limiting fuses and on the secondary by fuses or breaker.
7. Each draw-out motor controller unit shall have line and load stab fingers to allow complete removal of the draw-out unit without disconnecting any field or factory-installed power cabling.
8. Each starter or contactor shall have an externally operated, manual, three-pole, isolating switch with quick-make/quick-break contacts. The switch should be mechanically interlocked to prevent opening under load or closing with the high voltage door open. Each unit shall be capable of being padlocked in the disconnected or open position.
9. The racking mechanism for each controller shall be designed such that it is impossible to rack the contactor in or out of the bus without first opening the contactor. Likewise, the mechanism must prevent opening of the compartment door unless the contactor is in the open position.
10. Contactors shall be provided with remote racking.
11. The contactor in each motor controller assembly shall be magnetically-held and non-latching for motors and latching for transformer feeders.
12. Each controller shall be provided with a built-in test circuit connection to test operation of the contactor. This circuit shall be interlocked to only function when the contactor is disconnected from the bus.

H. SHUTTERS

1. Grounded automatic metal safety shutters shall be provided which isolate the primary connections in the power circuit breaker or voltage transformer compartment when the power circuit breaker or voltage transformer is withdrawn from the connected position.
2. The shutters shall automatically operate when the power circuit breaker/contactor or voltage transformer is racked in or out.

I. AUXILIARY SWITCHES

1. Breaker/Contactor Draw-out Auxiliary Position Switches

(52/a/b/M)

a. Each power circuit breaker/contactor shall be furnished with breaker/contactor-mounted auxiliary position switches mounted on the breaker/contactor frame.
b. The breaker/contactor-mounted auxiliary position switches provide breaker/contactor opened or closed indication only when the breaker/contactor is in the fully “in-service” and “test” position.
c. A minimum of two (2) normally-open (“a”) and two (2) normally-closed (“b”) contacts shall be furnished for Company’s future use in addition to those required by the Contractor’s design.

2. Breaker/Contactor Stationary Position Switches (52S/a/b/MX)
   a. Each breaker/contactor shall be furnished with stationary auxiliary position switches mounted in the breaker/contactor cell compartment.
   b. The breaker/contactor stationary auxiliary position switches provide breaker/contactor opened or closed indication only when the breaker/contactor is in the fully “in-service” position. When the breaker/contactor is not in the “in-service” position (e.g. in the “test” position or “disconnected” positions) the breaker/contactor stationary auxiliary position switches shall indicate the breaker/contactor is open at all times.
   c. A minimum of two (2) normally-open (“a”) and two (2) normally-closed (“b”) contacts shall be furnished for Company’s future use in addition to those required by the Contractor’s design.
3. Breaker/Contactor Truck Position Switches (52H/MH)
   a. Each breaker/contactor shall be furnished with truck position switches mounted in the breaker/contactor cell compartment. Each switch shall be field convertible to be either normally open or normally-closed.
   b. The breaker/contactor truck position switches shall provide breaker/contactor “in-service”/“not inservice” indication. The switches shall indicate that the breaker/contactor is “in-service” only when the breaker/contactor is fully racked in to the “in-service” position.
   c. A minimum of two (2) normally-open (“a”) and two (2) normally-closed (“b”) contacts shall be furnished for Company’s future use in addition to those required by

the Contractor's design.

J. CONTROL AND INSTRUMENT WIRING

1. Wiring installed by the Contractor shall be stranded Type SIS, VW-1, extra flexible, insulated to 600 V with XLPE or EPR insulation. The wiring shall have the following minimum sizes:

Service	Minimum Wire Size
Current Transformer Circuits	10 AWG
All Other Wiring	14 AWG or Larger if Required for Load and Voltage Drop Considerations

2. The switchgear and motor controllers shall be controlled and monitored by the DCS and the DCS requirements herein.
3. All low voltage control and instrument wiring shall be installed and tested at the factory.
4. All interior wiring shall be installed in wiring gutters or conduit and secured with nylon ties. All wiring shall be protected from contact with sharp edges with grommets. Flexible wire guards shall be furnished for wiring at hinge points.
5. The Manufacturer shall install heat-shrinkable wire markers labeling at each end of each wire.

K. TERMINAL BLOCKS

1. All terminal blocks shall be one-piece UL94-VO material terminal blocks with strap-screw connectors and a minimum rating of 600 V, 30 amperes.
2. All current transformer circuits shall be wired to shorting-type terminal blocks.
3. All terminal blocks and terminals on terminal blocks shall have plainly legible machine lettering.
4. No more than two (2) wires shall be terminated at any one (1) terminal point.
5. One (1) side of each terminal block used for external connections shall be reserved solely for external connections.

L. TERMINATIONS

1. Terminal blocks shall be provided 20% spare terminals.
2. When compatible with Manufacturer's standard supply, all circuits shall be terminated with ring-type connectors.
3. All spare contacts shall be wired to terminal blocks.

M. CONTROL POWER

1. A common 125 VDC bus shall be wired throughout each switchgear lineup to provide power for breaker control, charging motor, protective relaying, and other auxiliary components. The common 125 VDC bus shall have one (1) supply point in each switchgear lineup. A single, visible break disconnecting device shall be provided to disconnect both the closing and tripping circuits.

2. Each breaker's close and trip circuit shall be fused separately in each cubicle. Any control or protective devices that are common to more than one (1) breaker shall be fused on separately fused circuits. Minimum trip circuit fuse rating shall be 30 A.
3. The contactors shall be powered from the control power transformers.

N. PROTECTIVE RELAYING, CONTROLS, AND INDICATION

1. At a minimum, the Manufacturer shall furnish and install protective relaying, controls, and indication as shown on Appendix I – Relaying One-Line Diagrams. The schemes and equipment furnished by the Manufacturer shall be based on the drawings provided by the Company.
2. Test switches shall be provided for all metering, CTs, PTs and shall be provided as shown on Appendix I – Relaying One-Line Diagrams. Test switches shall be ABB FT-1 or States Type FMS. Test switches shall have black handles for current and potential poles, red handles for trip poles. Test switches shall have clear switch covers.
3. The power for the closing circuit for each breaker shall be sub-fused from the power supply for the tripping circuit for hat breaker.
4. Control switches shall be furnished and installed for each breaker. The switches shall be wired such that the power circuit breakers cannot be closed with the power circuit breakers racked in to the "inservice" position.
5. Lock-out relays (LOR) shall be Electroswitch Series 24, lighted target nameplate with (2) LEDs.
6. Indicating lights shall be provided and installed. Indicating lights shall be long-life LED type with push-to-test feature. Red lights shall indicate breaker in "closed" position, green lights shall indicate breaker "open" position.
7. Coil monitoring relays shall be furnished and installed. These relays shall be flush mounted on the front door so that the red indicating light is visible from the front.
8. Interposing relays shall be provided for interfacing with the DCS controls.
9. Optical arc flash detection relays shall be furnished and installed for all medium voltage switchgear. Optical relays shall coordinate with protective devices specified herein and are intended to reduce the arc flash hazard to plant personnel.

O. METERING

1. At a minimum, the Contractor shall furnish and install metering as shown on Appendix I – Relaying One-Line Diagrams.

2. Switchgear metering shall have factory installed meter parameter settings.

P. CURRENT TRANSFORMERS

1. Current transformer installation shall be designed to permit maintenance or replacement of the current transformers without damage to the connections. Current transformers shall be mechanically braced to withstand the same momentary current as the circuit breakers/contactors with which they are used.
2. Current transformer mechanical and thermal limits shall be coordinated with the momentary and short time ratings of the circuit breakers with which they are used.
3. All spare breakers/contactors and equipped spaces shall be furnished with multi-ratio current transformers. Unless otherwise specified or shown on the as shown on Appendix I – Relaying One-Line Diagrams, the polarity marking shall be toward the power circuit breaker.
4. Excitation curves shall be furnished by Contractor for all the current transformers.

Q. VOLTAGE TRANSFORMERS

1. Voltage transformers shall be mounted on draw-out type removable units designed to isolate and ground the potential circuits when the unit is in the fully withdrawn position.
2. Each voltage transformer shall be provided with current limiting primary fuses. Secondary fusing shall also be provided and shall be fast-acting type and selected to fully coordinate with the primary fuses for a fault on the secondary control circuits.

R. NAME PLATES

1. Engraved nameplates shall be furnished on the outside of each switchgear lineup and individual switchgear section. Engraved nameplates shall also be furnished for devices mounted inside compartments.
2. Switchgear nameplates shall be 1/16 inch laminated phenolic resin with white background and black core. Name plates shall indicate the following minimum information:
   a. Equipment name
   b. Equipment tag number
   c. Service Information: Voltage, current rating
3. Nameplates shall be mounted using stainless pan-head self-tapping screws.

S. SPARE PARTS AND TOOLS

1. The switchgear shall be furnished, at a minimum, with the following spare parts, maintenance and operating equipment for each lineup location:
   a. One (1) portable lift truck to move the draw-out

breaker units into and out of the compartments.

b. One (1) ground and test device per switchgear class.
c. Manual lever or crank for moving the breaker elements into and out of the operating position.
d. Manual spring charging handle for circuit breaker.
e. Remote racking device(s) for breakers and contactors.
f. Equipment necessary for testing the circuit breaker outside the cubicle and in the test position.
g. Special tools required for operation or maintenance.
h. Per Line-Up – test module/test device/test equipment, software, and software licenses for testing and setting relays or protective devices.
i. Provide 50% spare set of fuses for each size and type of fuse furnished and 10% spare set of indicating lights and lenses.

SOUND CONTROL REQUIREMENTS

Specifier Note: Additional information required

ELECTRICAL REQUIREMENTS

Specifier Note: Additional information required

INSTRUMENTATION & CONTROL REQUIREMENTS

Specifier Note: Additional information required

MATERIALS & WELDING

Specifier Note: Additional information required

CLEANING, PAINTING & COATING

Specifier Note: Additional information required

PACKAGING & SHIPPING

See Appendix 7

STORAGE & HANDLING PROCEDURES

See Appendix 7

SPARE PARTS

Commissioning spares to be included/supplied with the equipment.

QUALITY ASSURANCE

See Appendix 5

TESTING

See Appendix 5

SELLER'S DATA SUBMISSION SCHEDULE

See Appendix 2

APPENDICES

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES

2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES

4. SITE CONDITIONS AND REFERENCE MATERIALS

1.0 Summary

1.1. This Schedule outlines the Site conditions used for the design of all equipment covered under this contract.

2.0 Location

2.1. Xcel Energy's xxxxxx Station site is located xxxxxxxxx.

2.2. The property consists of approximately xxx acres.

2.3. Existing plant site consists of xxxxxx generating units.

3.0 Ambient Design Criteria

3.1. Meteorology

3.1.1. Local meteorological data with long periods of record for xxxxxx is available. Xxxxx data is used for design wet-bulb temperature, dry-bulb temperature, wind, and other design criteria. Contractor is responsible for verifying Meteorological data by obtaining the most recent information available.

3.1.1.1. Temperature and Humidity

- Maximum Summer Extreme Temperature xx°F
- Minimum Winter Extreme Temperature xx°F
- Summer Design Dry Bulb Temperature xx°F
- Summer Design Wet Bulb Temperature xx°F
- Winter Design Dry Bulb Temperature xx°F
- Average Annual Dry Bulb Temperature xx°F
- Average Annual Wet Bulb Temperature xx°F

3.1.1.2. Indoor Temperatures

- Indoor temperatures can be expected to range from xx°F to xx°F.

3.1.1.3. Precipitation and Snow

- Annual precipitation in the site vicinity is expected to average about xx inches. Annual snowfall in the plant vicinity averages about xx inches.
- The snow load for xxxxxx is xx lb/ft2.

3.2. Barometric Pressure

3.2.1. The standard barometric pressure adjusted to the site elevation of xxxxx feet is xx psia..

5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE SUPPLIERS

Complete technical requirements as required for the identified topic.

Table of Contents

A Equipment and Materials

A.1 Summary

These specifications are for the purchase of wire and cable for Xcel Energy's Energy Supply construction projects.

A.2 Product Selection

A.2.1 General Product Requirements

Provide products that comply with this Specification, that are undamaged, and unless otherwise specified or indicated, new at the time of installation.

Conform to applicable specifications, codes, standards, and regulatory agencies.

A.2.2 Manufactured and Fabricated Products

Fabricate and assemble in accordance with industry acceptable engineering and shop practices.

Materials shall be suitable for service conditions intended.

Provide labels where required by regulatory agencies or to state identification and essential operating data.

Do not use products for any purpose other than for which designed.

A.2.3 Labels and Identification System

Supplier shall use the Company's existing identification system for electrical wiring and cables.

All wiring within cabinets, panels and termination boxes shall have circuit/wiring numbering as shown on the drawings provided by the Company.

B Products

B.1 Medium Voltage Cable

This Section covers 5 kV, 8 kV, 15 kV, 25 kV and 35 kV single conductor shielded power cable rated for use in wet or dry locations. The cable will be placed in cable tray, conduit, and/or underground duct. All materials furnished herein shall be designed to meet or exceed all applicable standards of ICEA, AEIC, NEMA, and ASTM.

B.1.1 Temperature Rating:

B.1.1.1 The cable shall be rated at the following minimum values:

B.1.1.1.1 90° C for normal operation.

B.1.1.1.2 130° C for emergency overload.

B.1.1.1.3 250° C for short circuit conditions.

B.1.2 Conductor:

B.1.2.1 The conductor shall be soft, annealed, coated or uncoated copper.

B.1.2.2 The electrical and tensile properties shall comply with the latest ASTM specifications: B-3, B-33 and B-189.

B.1.2.3 Cables shall be stranded per ICEA S-19-81, Section 2.3, Class B. The lay of concentric stranded conductors shall be in accordance with ASTM B-8.

B.1.3 Construction:

B.1.3.1 Single conductor with metallic tape insulation shielding.

B.1.4 Insulation:

B.1.4.1 Insulation level shall be 133%.

B.1.4.2 The insulation shall be a thermosetting dielectric based on an ethylene-propylene rubber (EPR) elastomer.

B.1.4.3 All electrical and physical characteristics of the insulation shall meet or exceed values given in ICEA S-68-516 for ethylene-propylene insulation.

B.1.4.4 The insulation shall fit tightly to the conductor, yet be “free-stripping”.

B.1.4.5 The average wall thickness at any cross section of the insulation shall be in accordance with ICEA S-68-516 Table 3-2 for voltages 5 kV, 8 kV, 15 kV, 25 kV and 35 kV at 133% insulation level. Maximum wall thickness deviation from these values shall be from –10% to +15% from the nominal values.

B.1.5 Conductor Shield:

B.1.5.1 The conductor shield shall be an extruded, semi-conducting material. The conducting material shall be extruded, compatible with the insulation and the conductor, and firmly bonded to the inner surface of the insulation.

B.1.5.2 The shield shall have a volume resistivity less than 100,000 ohm-centimeters at 90° C.

B.1.6 Insulation Shield:

B.1.6.1 The insulation shield shall be an extruded or taped non-metallic, semi-conducting layer.

B.1.7 Metallic Shield:

B.1.7.1 Metallic shield shall be 5 mil tinned copper tape helically applied with a minimum of 12.5% overlap.

B.1.8 Insulation Jacket:

B.1.8.1 The insulated shielded conductor, covered with a jacketing material which is either a chloro-sulfonated polyethylene (Hypalon) compound, or polychloroprene (Neoprene) compound, or a chlorinated polyethylene (CPE) compound. The jacket shall be oil-resistant, moisture resistant, and self-extinguishing flame resistant. Sunlight resistant and flame retardant Polyvinyl Chloride (PVC) jacket shall be allowed for 15 kV to 35 kV cables.

B.1.8.2 All cable jackets shall have printed in a clearly visible fashion, every 18”-24”, information indicating gauge size or MCM, voltage rating, sequential footage, and manufacturer. All cables shall also bear on the jacket surface a unique traceability number.

B.1.9 Final Assembly Testing:

B.1.9.1 Tests shall be performed in accordance with ICEA S-68-516, Section 6. Testing shall be performed in the order of listing.

B.1.9.2 High Voltage AC Test: Each length of cable shall be subjected to and withstand a high voltage 60-cycle test of 5 minutes. The test voltage and procedure shall be performed in accordance with Part 6 of ICEA S-68-516.

B.1.9.3 Insulation Resistance Test: An insulation resistance test shall be made on each sample in accordance with ICEA S-68-516, Part 6.28, corrected to 15.6° C (60° F) per ICEA S-68-516, Table 6-10. The measured value shall not be less than the applicable calculated value for the specific cable.

B.1.9.4 High Voltage DC Test: Each sample shall be subjected to, and shall withstand, a high voltage DC test for 15 minutes at a potential stated in Part 6.27 of ICEA S-68-516.

B.1.9.5 Partial Discharge Test: A partial discharge test shall be carried out in accordance with AEIC CS-6, Parts F and G.

B.1.9.6 Flame Resistance Test: Samples shall be subjected to and shall pass the flame test as set forth in Section 2.5 of IEEE 383-1974.

B.1.10 Manufacturers:

Recommended manufacturers for shielded power cables are:

B.1.10.1 Cable Continental Cables Co.

B.1.10.2 The Okonite Company

B.1.10.3 Pireli Cable Corporation

B.1.10.4 Kerite Cable Corporation

B.2 600 Volt Power Cable

This section covers multi-conductor and single-conductor power cable rated for use at 600 volts in wet or dry locations. The cable will be placed in cable tray, conduit, and/or underground duct. Cables shall be either single, three conductor, or four conductor as specified. The finished cable shall be bunched and filled to be round in cross-section. All fillers and binder tape (if required) shall be non-hygroscopic and flame retardant. All materials furnished herein shall be designated to meet or exceed all applicable standards of ICEA, AEIC, NEMA, and ASTM.

B.2.1 Temperature Rating:

B.2.1.1 The cable shall be rated at the following minimum vales:

B.2.1.1.1 90° C for normal operation

B.2.1.1.2 130° C for emergency overload

B.2.1.1.3 250° C for short circuit conditions

B.2.2 Conductor

B.2.2.1 The conductor shall be soft, annealed, coated or uncoated copper.

B.2.2.2 The electrical and tensile properties shall comply with the latest ASTM Specifications: B-3, B-33 and B189.

B.2.2.3 Cables shall be stranded per ICEA S-19-81, Section 2.3, Class B. The lay of concentric stranded conductors shall be in accordance with ASTM B-8.

B.2.3 Insulation

B.2.3.1 The insulation shall be a cross-linked thermosetting polyethylene (XHHW) compound.

B.2.3.2 All electrical and physical characteristics of the insulation shall be tested in accordance with ICEA S-66-524 for cross-linked polyethylene insulation.

B.2.3.3 The insulation shall fit tightly to the conductor, yet be “free-stripping”.

B.2.3.4 The average wall thickness at any cross section of the insulation shall be in accordance with IECA S-66-524. Maximum wall thickness deviation from these values shall be from –10% to +15% from the nominal values.

B.2.3.5 Guaranteed values for the physical and electrical requirements for all insulation shall be in accordance with values given in ICEA S-66-524 for the specific insulation.

B.2.4 Jacket:

B.2.4.1 The insulated conductor shall be covered with a jacketing material, which is either a chlorosulfonated polyethylene (Hypalon) compound or a polychloroprene (Neoprene) compound, or a chlorinated polyethylene (CPE) compound.

B.2.4.2 The jacket shall be oil-resistant, moisture resistant, self-extinguishing flame resistant, and shall be in accordance with ICEA S-19-81.

B.2.4.3 The jacket wall thickness shall be in accordance with NEMA WC-3 (ICEA S-19-81), Table 4-15 and shall exhibit a maximum wall thickness deviation between 90% and 125% of the nominal value.

B.2.4.4 All cable jackets shall have printed in a clearly visible fashion, every 18" – 24", information indicating gauge size or MCM, voltage rating, sequential footage, and manufacturer. All cables shall also bear on the jacket surface a unique traceability number.

B.2.4.5 Guaranteed values for the physical and electrical properties of the jacket shall be in accordance with NEMA WC 3 (ICEA S-19-81).

B.2.5 Final Assembly Testing:

B.2.5.1 Testing shall be performed in accordance with ICEA 8-66-524. Each cable shall meet or exceed the values given in the applicable ICEA publication. Test shall be performed in the order of listing.

B.2.5.2 High Voltage AC Test: Each length of cable shall be subjected to and withstand a high voltage 60-cycle test of 5 minutes. The test voltage and procedure shall be performed in accordance with ICEA S-66-524.

B.2.5.3 Insulation Resistance Test: An insulation resistance test shall be performed on each sample and shall be in accordance with ICEA S-66-524.

B.2.5.4 Flame Resistance Test: Samples shall be subjected to and shall pass the flame test as set forth in Section 2.5 of IEEE 383-1974.

B.3 Multi-Conductor Control Cable

This section covers multi-conductor control cable designed for service at 600 volts with a continuous operating temperature of 90° C. The cable will be used in cable tray, conduit, and/or underground duct. All materials furnished herein shall be designed to meet or exceed all applicable standards of ICEA, AEIC, NEMA, and ASTM.

B.3.1 Ratings:

B.3.1.1 The cable shall be designed for service at 600 volts with a continuous operating temperature of 90° C.

B.3.2 Conductor:

B.3.2.1 The conductor shall be of soft, annealed, coated or uncoated copper.

B.3.2.2 The electrical, tensile, and coating properties shall comply with the latest ASTM specifications, B-3, B-8, B-33, and B189.

B.3.2.3 The control cables shall be stranded per ICEA S-19-81, Section 2.3, Class B.

B.3.3 Insulation:

B.3.3.1 The insulation shall be a cross-linked thermosetting polyethylene (XHHW) compound or ethylene-propylene rubber (EPR) elastomer.

B.3.3.2 All electrical and physical characteristics of the insulation shall be tested in accordance with ICEA S-66-524 for cross-linked polyethylene insulation wire and in accordance with ICEA S-68-516 for ethylene-propylene rubber (EPR) insulation.

B.3.3.3 The insulation shall fit tightly to the conductor, yet be "free-stripping".

B.3.3.4 The average wall thickness at any cross section of the insulation shall be in accordance with ICEA S-66-524. Maximum wall thickness deviation from these values shall be from –10% to +15% from the nominal value.

B.3.3.5 Guaranteed values for the physical and electrical requirements for all insulations shall be in accordance with values given in ICEA S-66-524 for the specific insulation.

B.3.4 Circuit Identification

B.3.4.1 Conductors shall be identified by Color Coding in accordance with ICEA S-66-524, Appendix K, Method I, Table K-2.

B.3.5 Conductor Assembly

B.3.5.1 The required number of conductors shall be cabled concentrically with the outer layer having a left-hand lay.

B.3.5.2 When necessary to make a multiple conductor cable assembly round, non-hygroscopic flame resistant fillers shall be used. The overall conductor assembly shall be covered with a non-hygroscopic flame barrier tape.

B.3.6 Outer Jacket

B.3.6.1 The assembled, bound cable shall be covered with a jacketing material, which is either a chlorosulfonated polyethylene (Hypalon) compound or a polychloroprene (Neoprene) compound, a chlorinated polyethylene (CPE) compound.

B.3.6.2 The jacket shall be oil-resistant, moisture resistant, and self-extinguishing flame resistant meeting the specifications of ICEA S-19-81.

B.3.6.3 The jacket wall thickness shall be 45 mils and shall exhibit a minimum wall thickness deviation between 90% and 125% of the nominal value.

B.3.6.4 All cable jackets shall have printed in clearly visible fashion, every 18" - 24", information indicating gauge size, number or conductors, voltage ratings, sequential footage, and manufacturer. All cables shall also bear on the jacket surface a unique traceability number.

B.3.6.5 Guaranteed values for the physical and electrical requirements of all specified jacket materials shall meet or exceed the values given in the appropriate ICEA publication for the specific jacket.

B.3.7 Final Assembly Testing:

B.3.7.1 All cables shall pass the IEEE-383 - 70,000 BTU gas ribbon burner vertical tray flame test.

B.3.7.2 All insulated singles shall be subjected to a 5-minute wet AC voltage withstand test after a 6 hour immersion in water prior to cabling.

B.3.7.3 All completed cables are subjected to a conductor resistance test, a 5-minute dry AC voltage withstand test, and an I.R. test.

B.3.7.4 Test voltages shall be 4000 volts.

B.4 Instrument Cable

This section covers shielded, twisted pairs and triads. The cable is designed for service at 600V with a continuous operating temperature of 90°C. The cable will be used in cable tray, conduit, and/or underground duct. All materials furnished herein shall be designed to meet or exceed all applicable standards of ICEA, AEIC, NEMA, and ASTM.

B.4.1 Conductor:

B.4.1.1 The stranded conductor shall be of soft annealed, coated or uncoated copper.

B.4.1.2 The electrical, tensile, and coating properties shall comply with the latest ASTM specifications B-3, B-33, and B-189.

B.4.1.3 Resistance shall be in accordance with ICEA S-61-402, Section 2.6.

B.4.2 Insulation:

B.4.2.1 The insulation shall be either a thermosetting dielectric based on an ethylene propylene elastomer (EPR), or a cross-linked thermosetting polyethylene (XLPE) compound.

B.4.2.2 All electrical and physical characteristics of the insulation shall be tested in accordance with ICEA S-68-516 for ethylene-propylene insulation and ICEA S-66-524 for cross-linked polyethylene insulation, and shall meet or exceed the values given for the specific insulating material.

B.4.2.3 The insulation shall fit tightly to the conductor, yet be "free-stripping."

B.4.2.4 The average wall thickness at any cross section of the insulation shall be in accordance with the applicable ICEA standard and values shall exhibit a maximum wall thickness deviation of -10% and +25% from the nominal thickness.

B.4.3 Circuit Identification:

B.4.3.1 Each pair of conductors shall be made up of a black pigmented conductor and a white pigmented conductor.

B.4.3.2 For multi-pair assemblies, the pair number shall be stamped on both conductors of that pair.

B.4.3.3 For triad construction, each triad shall be made up of a black pigmented conductor, a white pigmented conductor, and a red pigmented conductor.

B.4.3.4 For multi-triad assemblies, the triad number shall be stamped on all three conductors.

B.4.4 Conductor Assembly

B.4.4.1 Each pair or triad shall have an individual drain wire, with a minimum size of #20 AWG.

B.4.4.2 This assembly shall then be twisted with a maximum twisting lay of 2.5" for pairs and 3.5" for triads.

B.4.4.3 Each pair or triad shall then be shielded by helically wrapping with a 2 mil polyester/aluminum tape with the metal side down. Isolation tape shall be wrapped over the shielded pair assembly.

B.4.4.4 Assembled pairs or triads, and multi-pairs or multi-triads shall then be cabled concentrically.

B.4.4.5 When necessary to make a multi-pair cable or multi-triad cable assembly round, moisture-resisting fillers shall be used.

B.4.4.6 In addition, an optional drain wire and 2 mil polyester/aluminum tape may be applied over the multi-pair or multi-triad cable.

B.4.4.7 A non-hygroscopic flame-barrier tape shall be applied over all conductor assemblies.

B.4.5 Outer Jacket:

B.4.5.1 The assembled, bound cable shall be covered with a jacketing material, which is either a chlorosulfonated polyethylene (Hypalon) compound or a chlorinated polyethylene (CPE) compound.

B.4.5.2 The jacket shall be oil-resistant, moisture resistant, self-extinguishing flame resistant, and shall meet the specifications of ICEA S-19-81.

B.4.5.3 The jacket wall thickness shall be 35 mils.

B.4.5.4 All cable jackets shall have printed in a clearly visible fashion every 18" - 24" information indicating gauge size, number of pairs or triads, voltage rating, sequential footage, and manufacturer.

B.4.6 Final Assembly Testing:

The following tests shall be made either on the individual conductors or on the completed cable as indicated:

B.4.6.1 Continuous Flaw Test: The insulated single conductors shall withstand for their entire length a potential of 3.0 kV AC as applied by conventional spark test equipment.

B.4.6.2 High Voltage AC Test: An alternating current voltage of 1.0 kV AC shall be applied to each conductor in the completed cable for one minute without breakdown.

B.4.6.3 Insulation Resistance: Following the high voltage AC test, the insulation resistance shall be measured at room temperature between adjacent conductors. The insulation resistance shall not be less than shown on ICEA S-19-81.

B.4.6.4 Flame Resistance: All cables shall pass the IEEE-383 70,000 BTU gas ribbon burner vertical tray flame test.

B.5 Thermocouple Extension Cable

This section covers shielded, twisted pairs thermocouple type KX or EX extension cable. The cable is designed for service at 600V with a continuous operating temperature of not more than 105°C. The cable will be used in cable tray, conduit, and/or underground duct. All materials furnished herein shall be designed to meet or exceed all applicable standards of ICEA, AEIC, NEMA, and ASTM.

B.5.1 Conductor

B.5.1.1 The conductor shall be manufactured from solid thermocouple extension grade alloys in accordance with ANSI MC 96.1. All thermocouple cable shall be type KX or EX.

B.5.2 Insulation:

B.5.2.1 The insulation shall be either a thermosetting dielectric based on an ethylene propylene elastomer (EPR) or a cross-linked thermosetting polyethylene (XLPE) compound.

B.5.2.2 All electrical and physical characteristics of the insulation shall be tested in accordance with ICEA S-68-516 for ethylene-propylene insulation and ICEA S-66-524 for cross-linked polyethylene insulation and shall meet or exceed the values given in these standards.

B.5.2.3 The insulation shall fit tightly to the conductor, yet be "free-stripping."

B.5.2.4 The average wall thickness at any cross section of the insulation shall be in accordance with applicable the ICEA standard publication for the specified insulation and the values, and shall exhibit a maximum wall thickness deviation of -10% and +25% from the nominal thickness.

B.5.3 Circuit Identification:

B.5.3.1 Type EX: Each pair conductor shall be made up of purple for (+) conductor and red for (-) conductor, and purple jacket.

B.5.3.2 Type KX: Each pair conductor shall be made up of yellow for (+) conductor and red for (-) conductor and yellow jacket.

B.5.3.3 For multi-pair assemblies, the pair number shall be stamped on both conductors of that pair.

B.5.4 Conductor Assembly

B.5.4.1 Each pair shall have an individual drain wire, with a minimum size of #20 AWG.

B.5.4.2 This assembly shall then be twisted with a maximum twisting lay of 2.5" for pairs.

B.5.4.3 Each pair shall then be shielded by helically wrapping with a 2-mil polyester/aluminum tape with the metal side down. Isolation tape shall be wrapped over the shielded pair assembly.

B.5.4.4 Assembled pairs and multi-pairs shall then be cabled concentrically. When necessary to make a multi-pair cable assembly round, moisture resistant fillers shall be used.

B.5.4.5 An optional drain wire and 2 mil polyester/aluminum tape may be applied over the multi-pair cable.

B.5.4.6 A non-hygroscopic flame-barrier tape shall be applied over all conductor assemblies.

B.5.5 Outer Jacket

B.5.5.1 The assembled, bound cable shall be covered with a jacketing material, which is either a chlorosulfonated polyethylene (Hypalon) compound or a chlorinated polyethylene (CPE) compound.

B.5.5.2 The jacket shall be oil-resistant, moisture resistant, self-extinguishing flame resistant, and shall be in accordance with applicable ICEA S-19-81.

B.5.5.3 The jacket wall thickness shall be 35 mils with maximum deviation of $\pm$ 10% from the nominal thickness.

B.5.5.4 All cable jackets shall have printed in a clearly visible fashion every 18" - 24" information indicating gauge size, number of pairs or triads, voltage rating, sequential footage, and manufacturer.

B.5.6 Final Assembly Testing

The following tests shall be made either on the individual conductors or on the completed cable as indicated:

B.5.6.1 Continuous Flaw Test: The insulated single conductors shall withstand for their entire length a potential of 3.0 kV ac as applied by conventional spark test equipment.

B.5.6.2 High Voltage AC Test: An alternating current voltage of 1.0 kV AC shall be applied to each conductor in the completed cable for one minute without breakdown.

B.5.6.3 Insulation Resistance: Following the high voltage AC test, the insulation resistance shall be measured at room temperature between adjacent conductors. The insulation resistance shall meet or exceed the values given in ICEA S-68-516.

B.5.6.4 Flame Resistance: All cables shall pass the IEEE-383 70,000 BTU gas ribbon burner vertical tray flame test.

B.6 Fire Detector Cable

This section covers fire detector cable at 600 volts with a continuous operating temperature of 90° degree C. The cable will be used in conduit. All material furnished herein shall be designed to meet or exceed all applicable standard of ICEA, AEIC, NEMA, and ASTM.

B.6.1 Ratings:

B.6.1.1 The cable shall be designed for service at 600 volts with a continuous operating temperature of 90° C.

B.6.2 Conductor:

B.6.2.1 The conductor shall be 16 AWG of soft, annealed, coated or uncoated copper.

B.6.2.2 The electrical, tensile, and coating properties shall comply with the latest ASTM specifications, B-3, B-8, B-33, and B-189.

B.6.2.3 The control cables shall be stranded per ICEA S-19-81, Section 2.3, Class B.

B.6.3 Insulation

B.6.3.1 The insulation shall be TFE, FEP, PAF, or PTF insulation for high temperature areas, or TFFN insulation for areas not classified as high temperature and listed for the purpose.

B.6.3.2 All electrical and physical characteristics of the insulation shall be tested in accordance with applicable ICEA standard for the proposed insulation.

B.6.3.3 The insulation shall fit tightly to the conductor, yet be "free-stripping."

B.6.3.4 Insulation thickness shall be in accordance with applicable ICEA standard for the specific insulation.

B.6.3.5 Guaranteed values for the physical and electrical requirements of the specific insulation material shall meet or exceed the values given in the appropriate ICEA standard for the proposed insulation.

B.6.4 Conductor Assembly:

B.6.4.1 The required number of conductors shall be cabled concentrically with the outer layer having a left-hand lay.

B.6.4.2 When necessary to make a multiple conductor cable assembly round, non-hygroscopic flame resistant fillers shall be used. The overall conductor assembly shall be covered with a non-hygroscopic flame barrier tape.

B.6.4.3 Exception: For point addressable fire alarm systems the communications wiring shall be arranged in a twisted pair configuration with an overall shield and in accordance with NFPA 70.

B.6.5 Outer Jacket:

B.6.5.1 The assembled, bound cable shall be covered with a jacketing material, which is either a chlorosulfonated polyethylene (Hypalon) compound or a chlorinated polyethylene (CPE) compound, or a Teflon compound.

B.6.5.2 The jacket shall be oil-resistant, moisture resistant, self-extinguishing flame resistant, and shall be in accordance with applicable ICEA S-19-81.

B.6.5.3 The jacket wall thickness shall be 35 mils.

B.6.5.4 All cable jackets shall have printed in a clearly visible fashion every 18" - 24" information indicating gauge size, number of pairs or triads, voltage rating, sequential footage, and manufacturer.

B.6.6 Final Assembly Testing:

Final assembly testing: The following tests shall be made either on the individual conductors or on the completed cable as indicated:

B.6.6.1 Continuous Flaw Test: The insulated single conductors shall withstand for their entire length a potential of 3.0 kV AC as applied by conventional spark test equipment.

B.6.6.2 High Voltage AC Test: An alternating current voltage of 1.0 kV AC shall be applied to each conductor in the completed cable for one minute without breakdown.

B.6.6.3 Insulation Resistance: Following the high voltage AC test, the insulation resistance shall be measured at room temperature between adjacent conductors. The insulation resistance shall meet or exceed the values given in applicable ICEA publications.

B.6.6.4 Flame Resistance: All cables shall pass the IEEE-383 70,000 BTU gas ribbon burner vertical tray flame test.

Table of Contents

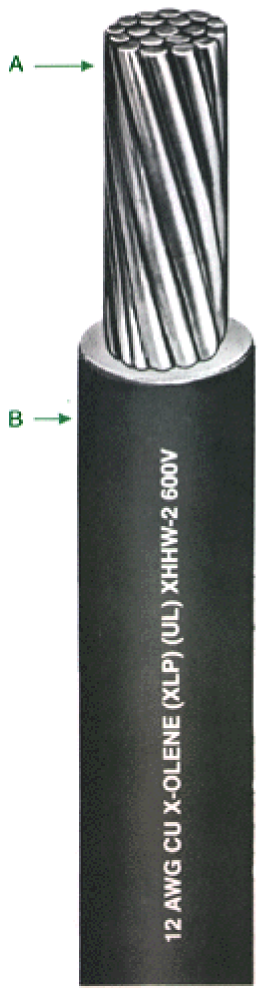
1. Example 600V Power Cable

X-Olene®

Type XHHW-2

600V Power and Control

Copper Conductor/90°C Wet or Dry



A Bare, Solid or Stranded Copper Conductor

B X-Olene Insulation

Insulation

X-Olene is Okonite's trade name for its chemically cross-linked polyethylene insulating compound with outstanding electrical and physical properties. Its excellent chemical physical resistance permits X-Olene's use in areas exposed to alcohol, ketones and dilute acids and bases, without additional coverings.

Applications

X-Olene Type XHHW-2 600 Volt Cables are recommended for general low voltage power and control applications. Where the National Electrical Code applies, Type XHHW-2 may be used up to 90°C in wet or dry locations. These cables may be installed in wet or dry locations, indoors or outdoors, in raceways, underground ducts, or lashed to a messenger for aerial installation.

Specifications

Conductor: Bare, solid or stranded copper per ASTM B-3 or B-8.

Insulation: Meets or exceeds all requirements of ICEA S-95-658, NEMA WC-70, and UL Standards.

Listed by Underwriters Laboratories, Inc. as Type XHHW-2.

Product Features

- Small diameter, permits use of smaller conduit or more wires per conduit.
- Excellent heat resistance.
- Rated 90°C in wet or dry locations.
- Mechanically rugged.
- Stable electrical properties.
- Low moisture absorption.
- Highly resistant to weather and most chemicals.
- UL Listed.

1-Catalog Number	**07-Approx.O.D. - mm**
2-Conductor Size - AWG or kcmil	**08-Approx. Net Weight lbs./1000'**
3-Number of Strands	**09-Approx. Ship Weight lbs./1000'**
4-Insulation Thickness - mils	**10-90°C Wet(1) NEC Ampacity**
5-Insulation Thickness - mm	**11-75°C Wet(1) NEC Ampacity**
6-Approx.O.D. - Inches	**12-ICEA Ampacity(2)**

1	2	3	4	5	6	7	8	9	10	11	12
112-31-3061	14	1	30	.76	.13	3.30	17	21	15	15	24
112-31-3071	14	7	30	.76	.14	3.56	18	22	15	15	24
112-31-3101	12	1	30	.76	.15	3.81	25	29	20	20	30
112-31-3111	12	7	30	.76	.15	3.81	26	30	20	20	30
112-31-3141	10	1	30	.76	.17	4.32	38	42	30	30	42
112-31-3151	10	7	30	.76	.18	4.57	40	44	30	30	42
112-31-3221	8	1	45	1.14	.24	6.10	64	72	55	50	55
112-31-3231	8	7	45	1.14	.24	6.10	67	75	55	50	55
112-31-3271	6	7	45	1.14	.28	7.11	100	108	75	65	75
112-31-3311	4	7	45	1.14	.32	8.13	150	158	95	85	97
112-31-3371	2	7	45	1.14	.38	9.65	231	245	130	115	130
112-31-3401	1	19	55	1.40	.44	11.2	294	328	150	130	156
112-31-3421	1/0	19	55	1.40	.48	12.2	365	382	170	150	179
112-31-3441	2/0	19	55	.53	.53	13.5	454	484	195	175	204
112-31-3461	3/0	19	55	.58	.58	14.7	566	586	225	200	242
112-31-3481	4/0	19	55	.64	.63	16.0	706	749	260	230	278
112-31-3511	250	37	65	.71	.70	17.8	839	882	290	255	317
112-31-3541	350	37	65	.81	.81	20.6	1158	1233	350	310	384
112-31-3581	500	37	65	.94	.98	24.9	1632	1710	430	380	477
112-31-3641	750	61	80	1.15	1.14	29.0	2447	2555	535	475	598
112-31-3701	1000	61	80	1.30	1.36	34.5	3233	3378	615	545	689

Minimum Manufacturing Quantity: 10,000 ft.

To order a color other than black, change the last digit of the catalog number as follows:	
White	2
Red	3
Green	4
Orange	5
Blue	6
Yellow	7
Example: To order #14/SOL - Red, the catalog number would be 112-31-3063.	

Ampacities

(1) Ampacities are based on Table 310-16 of the National Electrical Code for these 90°C rated conductors at an ambient temperature of 30°C. The 75°C wet column is provided for additional information.

The ampacities shown apply to open runs of cable, installation in any approved raceway, direct burial in the earth, or as aerial cable on a messenger. Derating for more than three current carrying conductors within a raceway is in accordance with Note 8 to NEC Tables 310-16 through 310-19.

(2) Based on three (3) conductors in a single enclosed or exposed conduit. Capacities based on 40°C air ambient using ICEA methods. For 30°C ambient multiply values by 1.10; for 50°C multiply by .90. For other ambients or installation conditions refer to Okonite's Engineering Data Book EHB-90.

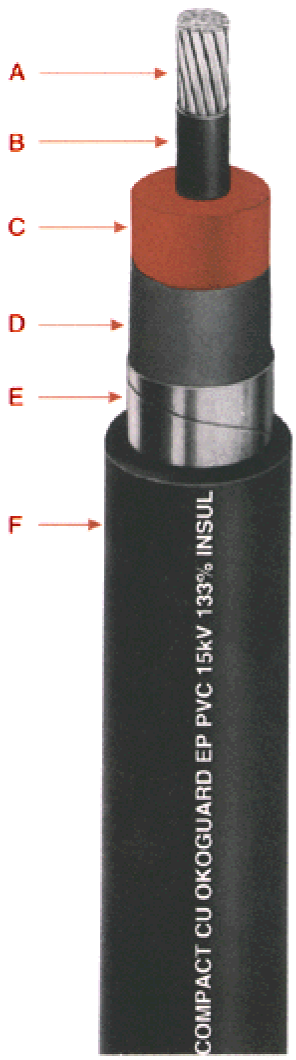
The ampacities shown also apply to cables installed in cable tray in accordance with NEC Section 318-11.

2. Example 15 kV Power Cable

Okoguard®-Okoseal® Type MV-105

15kV Shielded Power Cable

One Okopact® (Compact Stranded) Copper Conductor/105°C Rating
100% and 133% Insulation Level
For Cable Tray Use-Sunlight Resistant



A Uncoated, Okopact (Compact Stranded) Copper Conductor

B Strand Screen-Extruded Semiconducting EPR

C Insulation-Okoguard EPR

D Insulation Screen-Extruded Semiconducting EPR

E Shield-Copper Tape

F Jacket-Okoseal

Insulation

Okoguard is Okonite's registered trade name for its exclusive ethylene-propylene rubber (EPR) based, thermosetting compound, whose optimum balance of electrical and physical properties is unequalled in other solid dielectrics. Okoguard insulation, with the distinctive red color and a totally integrated EPR system, provides the optimum balance of electrical and physical properties for long, problem free service.

The triple tandem extrusion of the screens with the insulation provides optimum electrical characteristics.

Jacket

The Okoseal (PVC) jacket supplied with this cable is mechanically rugged and has excellent resistance to flame, oil, acids and most chemicals.

Applications

Okoguard shielded Okoseal Type MV-105 power cables are recommended for use as feeder circuits, in electric utility generating stations, for distribution circuits, and for feeders or branch circuits in industrial and commercial installations.

Type MV cables may be installed in wet or dry locations, indoors or outdoors (exposed to sunlight), in any raceway or underground duct, directly buried if installed in a system with a grounding conductor in close proximity that conforms with NEC Section 310.7, or messenger supported in industrial establishments and electric utilities. Sizes 1/0 AWG and larger may also be installed in cable tray.

Specifications

Conductor: Annealed uncoated copper compact stranded per ASTM B-496.

Strand Screen: Extruded EPR semiconducting strand screen. Meets or exceeds electrical and physical requirements of ICEA S-93-639/NEMA WC74 & S-97-682, AEIC CS8, CSA C68.3 and UL 1072.

Insulation: Meets or exceeds electrical and physical requirements of ICEA S-93-639/NEMA WC74 & S-97-682, AEIC CS8, CSA C68.3 and UL 1072.

Insulation Screen: Extruded EPR semiconducting insulation screen applied directly over the insulation. Meets or exceeds electrical and physical requirements of ICEA S-93-639/NEMA WC74 & S-97-682, AEIC CS8, CSA C68.3 and UL 1072.

Shield: 5 mil bare copper tape helically applied with 25% nominal overlap.

Jacket: Meets or exceeds electrical and physical requirements of ICEA S-93-

639/NEMA WC74 & S-97-682, CSA C68.3 and UL 1072 for polyvinyl chloride jackets.

UL Listed as Type MV-105, sunlight resistant and for use in cable tray in accordance with UL 1072.

CSA listed meeting the requirements of C68.3 and rated FT4 sizes 4/0 and larger are rated -40°C.

Product Features

Triple tandem extruded, all EPR system. Okoguard cables meet or exceed all recognized industry standards (UL, CSA, AEIC, NEMA/ICEA, IEEE). 105°C continuous operating temperature. 140°C emergency rating. 250°C short circuit rating. Passes the Vertical Tray Flame Test requirements of UL 1072 and IEEE 383. Excellent corona resistance. Screens are clean stripping. Exceptional resistance to "treeing". Moisture resistant. Resistant to most oils, acids, and alkalies. Sunlight resistant. For Cable Tray Use. Improved Temperature Rating.

1-Catalog Number	**09-Approx. O.D. - mm**
2-Conductor Size - AWG or kcmil	**10-Approx. Net Weight lbs./1000'**
3-Conductor Size - mm2	**11-Approx. Ship Weight lbs./1000'**
4-Approx. Dia. over Insulation(in.)	**12-Ampacities Conduit in Air(1)**
5-Approx. Dia. over Screen(in.)	**13-Ampacities Underground Duct(2)**
6-Jacket Thickness - mils	**14-Ampacities Cable Tray(3)**
7-Jacket Thickness - mm	**15-Conduit Size-Inches*(4)**
8-Approx. O.D. - Inches	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Okoguard Insulation:175 mils(4.45mm), 100% Insulation Level														
115-23-3064	1/0	53.5	0.73	0.79	80	2.03	0.98	24.8	760	850	215	215	220	3
115-23-3066	2/0	67.4	0.77	0.83	80	2.03	1.02	25.8	875	970	255	245	250	3
115-23-3067	3/0	85.0	0.82	0.88	80	2.03	1.07	27.1	1010	1075	290	275	290	3
115-23-3069	4/0	107.0	0.87	0.93	80	2.03	1.12	28.4	1175	1270	330	315	335	3
115-23-3074	250	127.0	0.91	0.97	80	2.03	1.16	29.5	1375	1435	365	345	370	3 1/2
115-23-3076	350	177.0	1.01	1.07	80	2.03	1.26	32.0	1695	1830	440	415	460	3 1/2
115-23-3090	500	253.0	1.13	1.21	80	2.03	1.40	35.5	2250	2445	535	500	575	4
115-23-3091	750	380.0	1.31	1.39	80	2.03	1.58	40.1	3145	3405	655	610	745	5
115-23-3092	1000	507.0	1.47	1.55	110	2.79	1.80	45.6	4120	4385	755	690	890	5
Okoguard Insulation:220 mils(5.59mm), 133% Insulation Level														
115-23-3230	1/0	53.5	0.82	0.88	80	2.03	1.07	27.2	855	945	215	215	220	3
▲115-23-3232	2/0	67.4	0.86	0.92	80	2.03	1.11	28.2	965	1060	255	245	250	3

115-23-3234	3/0	85.0	0.91	0.97	80	2.03	1.16	29.4	1110	1155	290	275	290	3 1/2
▲115-23-3236	4/0	107.0	0.96	1.02	80	2.03	1.21	30.7	1280	1390	330	315	335	3 1/2
115-23-3238	250	127.0	1.01	1.07	80	2.03	1.25	31.8	1430	1565	365	345	370	3 1/2
▲115-23-3240	350	177.0	1.11	1.18	80	2.03	1.37	34.7	1815	1950	440	415	460	4
▲115-23-3242	500	253.0	1.22	1.30	80	2.03	1.49	37.8	2375	2570	535	500	575	5
▲115-23-3243	750	380.0	1.40	1.48	80	2.03	1.66	42.2	3252	3517	655	610	745	5
115-23-3244	1000	507.0	1.56	1.66	110	2.79	1.91	48.5	4315	4730	755	690	890	6

▲**Authorized Stock Item.** Available from our Customer Service Centers.

Minimum Manufacturing Quantity for non-stock items is 5000'.

Ampacities

(1) Ampacities are in accordance with Table 310-73 of the NEC for three single Type MV-105 conductors, or single conductors twisted together (triplexed) and installed in an isolated conduit in air at an ambient temperature of 40°C and a conductor temperature of 105°C.

(2) Ampacities are in accordance with Table 310-77 of the NEC for three single conductors or triplexed cable in one underground raceway, three feet deep with a conductor temperature of 105°C, 100% Load Factor, an ambient earth temperature of 20°C, and thermal resistance (RHO) of 90.

Refer to the NEC, IEEE/ICEA S-135 Power Cable Ampacities, or the Okonite Engineering Data Bulletin EHB for installation in duct banks, multiple point ground shields, other ambient temperatures, circuit configurations or installation requirements.

(3) Ampacities based on single Type MV-105 conductors, or single conductors twisted together (triplexed, quadruplexed, etc.) size 1/0 AWG and larger, installed in uncovered cable tray in accordance with Section 318-13 of the NEC at an ambient temperature of 40°C and a conductor temperate rating of 105°C. In accordance with NEC Section 318-13(b) (copper conductors), the values are 75% of the values given in table 310-69. Where the cable tray is covered for more than six feet with solid unventilated covers, the ampacities shall not exceed 93% of the values shown above.

(4) Recommended size of rigid or nonmetallic conduit for three conductors based on 40% maximum fill.

*The jam ratio, conduit I.D. to cable O.D. should be checked to avoid possible jamming.

MASTER SPECIFICATION
FOR
PIPING DESIGN STANDARD

Revision _0_
Date 12-4-2013

Responsible Technical Specialist ___________________

Author:	Revision No.:	Specification Approval:

PIPING DESIGN STANDARD

GENERAL

A. Description
   1. The Piping Design Standard provides guidelines for the selection of materials and components for the design of piping systems.
   2. The Piping Design Standard will be used by project engineering and design personnel to specify, lay out and procure piping and valves for Energy Supply projects.
   3. The standard will allow uniformity in the design of piping systems. This standard is applicable to mechanical (non-nuclear) piping systems.

Specifier – Add discussion of options and criteria that must be addressed

B. Bus Duct Layout
C. Reference Information
   See Attachment 4
D. Technical Proposal Documentation
   See Attachment 1
E. Approved Manufacturers
   See Attachment 8

SUMMARY: Specifier to include 2 to 3 sentences of requirements of the specification.

APPLICABLE CODES AND STANDARDS

A. State and local codes, laws, ordinances, rules and regulations
B. **ASME BPVC** – American Society of Mechanical Engineers Boiler and Pressure Vessel Code.
C. **ASME Section IX** Welding and Brazing Qualifications
D. **ASME** B16.5 Steel Pipe Flanges and Flanged Fittings.
E. **ASME** B16.11 Socket Weld Couplings.
F. **ASME** B16.25 Butt Welding Ends.
G. **NBIC** – National Board Inspection Code.
H. **PFI** – Pipe Fabrication Institute.
I. ANSI - American National Standards Institute
J. ASTM - American Society for Testing and Materials
K. ICEA - Insulated Cable Engineers Association
L. IEEE - Institute of Electrical and Electronic Engineers
M. NEMA - National Electrical Manufacturer’s Association

N. NFPA - National Fire Protection Association
O. OSHA - Occupational, Health and Safety Administration
P. UL Underwriter's Laboratories

In case of conflict or disagreement between codes and standards, the more stringent conditions shall govern.

TECHNICAL REQUIREMENTS

PERFORMANCE REQUIREMENTS & GUARANTEES

See Appendix 3

DESIGN & CONSTRUCTION FEATURES

A. ENVIRONMENTAL
   1. The following ambient and site conditions shall be used in the designed of all furnished equipment.
      See Appendix 4
   2. Considerations shall be given to the exposure to solar heat in the areas of outdoor installation.

B. GENERAL STANDARDS
   1. When two lines of different design pressure ratings are connected, the higher rating shall prevail up to and including the first shutoff valve on the line of the lower rating.
   2. The design shall protect against freezing of fluids by the use of steam tracing, steam jacketing, and electric heating, insulating or draining.
   3. The design all provides for accessibility to and ease of dismantling of piping, instrument connections, and equipment.
   4. Welded joints joining two different P-numbered materials, as defined in ASME Section XI, shall be identified on the drawings. For example, carbon steel piping (P-1 material) joining a chrome-moly nozzle connection (P-5A material) shall be indicated on the drawing at the weld joint "P-1 to P-5A" materials.
   5. When welded joint of two different P-numbered materials exist, the Project Engineer shall be notified and action taken to eliminate this condition as follows:
      a. Weld transition pieces on equipment in the Vendor's shop.
      b. Change connection to flanged connection if design pressure and system requirements are not violated.
      c. Change connection to "Conoseal" type joint.
      d. Approve the joint for welding with Engineer's approval only.

6. Where required, low points of piping shall be provided with valved drains.
7. Where required, high points of piping shall be provided with valved vents.
8. All piping shall be designed with adequate flexibility to permit expansions of the piping without imposing excessive forces and moments on the connected equipment. Cold springing of piping is normally not preferred.
9. Main and auxiliary steam safety valve escape lines discharging directly to the atmosphere shall be provided with drain openings at the valve outlet, piped to a safe point of discharge. The flexibility of the system shall be checked to ensure its adequacy.
10. All connections on equipment drawings shall be checked to make sure that the nozzle material, thickness, and welding end machining details are shown. If possible, the schedule number of the connecting pipe shall also be shown. Weld ends shall match Standard weld ends. Exceptions shall be resolved or noted on the drawings.
11. Field welds or flanged joints required for assembly shall be indicated on drawings.
12. Fabricated pieces of irregular shape shall be designed with due consideration to shipping clearances and, in general, should not exceed 40 feet in length, 12 feet in width and 8 feet in height.
13. Piping around equipment shall be arranged and supported to permit ready access for maintenance and inspections of the equipment.
14. ASME B31.1 piping 2-1/2 inches and larger shall be dimensioned.
15. Cast iron valves shall not be used in ASME B31.1 systems requiring seismic analysis other than the fire protection system. The fire protection system valves require Underwriters' Laboratories approval and will be treated as separate entities.

C. CLEARANCES

1. Minimum clear width of passageways shall be 3 feet unless specifically approved by the Engineer.
2. Lines on sleepers on the ground shall be spaced for convenient external cleaning, painting, and inspection. Sleepers shall be a minimum of 12 inches high above paving or finished grade.
3. Minimum headroom clearance under all piping, covering, and appurtenances shall be as follows:
   a. 7ft-0 in. within structures
   b. 10ft-0 in. with yard areas

c. 14ft-0 in. over secondary unit roads
d. 22ft-0 in. over railroads and main plant roads

4. Piping runs shall not be located on building floors where they will obstruct passage or access.

D. WELD ACCESSIBILTY

1. Field welds shall be located so that the piping assembly can be installed without any interference from structures or equipment, and the field welds shall be accessible for initial installation and repair. Piping assemblies that will be installed through penetration sleeves shall have a field weld located on one side of the penetration sleeve.
2. Three basic requirements for working accessibility to a welded joint area:
   a. Head Room – The ability of the welder to get his head protective hood into the working area so that he can move freely around the weld and see directly into the weld area of the joint at all times.
   b. Arm Room – Freedom for the welder to move his arms so he can direct the arc into the weld and move it smoothly around the full circumference of the pipe without blockage from other pope or components.
   c. Visibility – Full vision into the joint and sufficient distance from the eyes to the weld for correct eye focus. This distance is variable, depending upon the individual. A distance of 6 inches from the face of the welder's hood eye shield is a practical minimum for short periods of work. For sustained work, the greatest possible focal distance should be provided to prevent tiring and double vision. The welder's line of sight should be at an angle to the perpendicular of the pipe less than the angle of bevel. For example, a joint beveled to 37-1/2 degrees requires line of sight not exceeding 30 degrees from perpendicular.

E. PIPING REQUIREMENTS

1. PIPE SIZES
   a. The following nominal pipe sizes shall not be used except where required to connect to equipment. Where these sizes are encountered, as soon as practical increase to a preferred size:
      1. 3/8 in.
      2. 3-1/2 in.
      3. *1-1/4 in.
      4. *5 in

      *May be used for building service piping
2. PIPING FURNISHED BY EQUIPMENT MANUFACTURER
   a. The fluid system diagrams and design drawings shall

clearly indicate the point at which the continuation of a line is furnished by an equipment manufacturer or supplier. That portion of a line furnished by an equipment manufacturer or supplier shall be shown on the design drawings “out of function” to an extent sufficient to clearly indicate its identity on the manufacturer’s drawing.

3. INTERSECTIONS
   a. Welding adapters and branch welded connections shall be reinforced to meet the requirements of ASME B31.1.
   b. Branch connections shall be as follows:
      1. Branch runs shall be made with full size tees or reducing tees when the ratio of the branch run nominal pipe size to the main run nominal pipe size is equal to or greater than ½.
      2. Branch runs should be made with weldolets or sockolets when the ratio of the branch run nominal pipe size to the main run nominal pipe size is less than ½.
   c. Branch Connections shall be weldolets starting at the first reduction from the main piping run nominal size. For 2” and under branch connection sockolets shall be used in on radioactive systems.
   d. Thermowells shall be as shown on drawings ENA-0-009-41-12-012 and ENA-0-009-41-12-013 for 600 Class and below systems. Thermowells shall be as shown on drawing ENA-0-009-41-12-014, and ENA-0-009-41-12-015 for radioactive and 900 and 1500 Class systems.
   e. Pressure taps for all systems shall be ¾ inch nipolets.
4. FLANGES
   a. In cases where ASME 150 Class series steel flange will be bolted to a Class 125 standard cast-iron flange, the steel flange shall be flat face. All steel flanges, except as above, shall be raised face per ASME B16.5 and MSS-SP44.
   b. Slip-on flanges shall be used only with permission of Engineer.
   c. Lap joint flanges shall be used on carbon steel or stainless steel pipe, unless specified.
   d. Carbon steel reducing slip-on threaded flanges shall be used only with permission of Engineer and their use shall be marked on drawings.
   e. Reducing welding neck flanges shall normally not be used.

f. Overall piping dimensions shall be indicated to the extreme raised face of flange.

g. Special flanges which do not conform to the line class shall have the size, rating, facing, and drilling noted on the drawings.

h. In all cases where a flanged connection is made between a steel and copper or brass pipe, the mating surfaces shall be electrically insulated from each other. The flanged joints shall be furnished with plastic washers under the bolt heads and plastic ferrules. Electrical non-conducting gaskets shall be used.

5. FITTINGS

a. Welding elbows as listed are <u>long radius</u> elbows. All other types are special and, if used, shall be so marked on the drawings.

b. Welding fittings shall be used in preference to flanged fittings.

c. All safety related, radioactive, and 2 inch and smaller piping shall use pipe bends to the maximum extent possible to eliminate welds.

d. Reducing elbows may be used where their use results in improved arrangements with approval of the Engineer.

e. Minimum schedule of piping used for nipples between pipelines or equipment, and first shutoff valves, shall be seamless Schedule 80, except as otherwise noted in the pipe classes.

f. Close threaded nipples shall not be used. Use full nipples.

6. VALVES

a. All valves (except wafer type butterfly or insert type swing check valves) adjacent to exchangers, vessels or expansion joints, shall have a 6” minimum spool piece between the valve and the nozzles.

b. Globe valves shall be installed with pressure under the seat, except for globe valves in lines under vacuum, in which case the valves shall have vacuum under the seat. Flow direction arrows shall be shown on drawings.

c. All operating valves shall be accessible for operation and maintenance when possible.

d. All safety valves, control valves, check valves, and rupture discs, which may receive servicing shall be located so that they shall be readily accessible from permanent platforms or ground level unless otherwise approved by the Engineer.

e. Safety valve discharge effects shall be considered during pipe stress analysis, i.e., for stresses both in nipple and connection on vessel. Valve allowable forces and moments shall be compared to calculated forces and moments for acceptability.

f. Infrequently used isolation valves shall be accessible but may be located more than 7 feet above the operating level.

g. Operating valves shall be oriented waist high when possible. Overhead valve hand wheels shall be oriented so that the centerlines of the valve hand wheels are 5 feet above the operating level. This orientation may be increased to 7 feet maximum provided that the valve can be opened or closed in this position. When this condition cannot be met, valves shall be provided with chain wheels, double end wrenches, or extension stems and hand wheel. Were such accessories are required, the length of chain, or length of extension stem from the center line of valve to hand wheel, shall be noted on the drawings.

h. Where valves are to be locked in an open or closed position, they shall be provided with a suitable locking device, and it shall be noted on the fluid system diagrams.

i. Wrench or lever operated plug, ball or butterfly valves shall be located to provide adequate clearance for turning wrenches and for lubricating. Special consideration shall be given to wrench clearance around control valve assemblies.

j. Operating valves located underground or in trenches or below platforms shall be provided with extension stems or otherwise arranged so that the hand wheels will be above the surface of the ground or grating, and in such a position as to be readily reached and operated.

k. All valves shall be tagged with a valve number. The valve number shall be stamped on a stainless steel tag 2” x 2” x 1/32” with figures no smaller than 3/16 inch high. The tag shall be wired to each valve using Number 20 gauge or thicker) stainless steel wire.

l. All loose parts associated with a valve shall also be tagged in the manner described above with the number of the associated valve.

m. Valves which are part of a Vendor supplied system or purchased by a Vendor will also contain the Vendor valve number stamped below the COM valve number.

7. PIPING AT PUMPS

a. Pump suction lines shall be as direct as possible. For centrifugal pumps, an elbow in the horizontal plane should be placed directly at the pump suction. If an elbow for the pump suction is required in the horizontal plane, a straight run of pipe of not less than 4 to 6 diameters shall be used between the elbow and the pump suction.

b. Piping to end suction pumps shall be arranged to permit removal of the pump impeller without removing the suction valve.

c. All valves and piping at pumps shall be arranged to permit removal of the pumps, impellers or pistons without hindering the operation of other equipment.

d. When a reducer is required between the pump suction nozzle and the line, an eccentric reducer shall be used if the pump has a horizontal suction. The reducer shall be located, horizontal side up, so that air pockets do not exist.

e. With the exception of deep well and pit type pumps, centrifugal pump suctions shall be provided with shutoff valves.

f. When a check valve is installed in the centrifugal pump discharge, it shall be installed upstream of the pump discharge shutoff valve.

g. Pump suctions shall be provided with temporary basket type strainers and spool pieces between the shutoff valve and the pumps. Strainers shall be installed before plant startup and removed after preliminary operation, unless otherwise specified. The Engineers shall specify location and type of strainers to be used.

8. BEND REQUIREMENTS
   a. To determine minimum radii for pipe bends, see table 1 below.

Table 1: Minimum Bending Radii, Inches

	Schedule of Pipe									
Nominal Size	10	20	30	40	60	80	100	120	140	160 and Heavier
¾				4		4				4
1				5		5				5
1-1/2				7-1/2		7-1/2				7-1/2
2				10		10				10
2-1/2				12-1/2		12-1/2				12-1/2
3				15		15				15
4				20		20				20
6				30		30				30
8		48	48	40	40	40	40	40	40	40
10		60	60	50	50	50	50	50	50	50
12		84	72	60	60	60	60	60	60	60
14		98	84	84	70	70	70	70	70	70
16	128	112	96	80	80	80	80	80	80	80
18	144	126	108	90	90	90	90	90	90	90
20	160	140	120	120	100	100	100	100	100	100
24	192	168	144	144	120	120	120	120	120	120

Wall thickness, tm =	.250 In.	.375 In.	.500 In.	.750 In.	1.00 In.
26	234	2085	182	130	130
28	280	224	196	168	140
30	300	240	210	180	150
32	320	288	256	192	160
34	374	306	272	204	170
36	432	324	288	216	180

F. WELD END PREPARATION
   1. GENERAL
      a. The governing codes are ASME B31.1 for power piping. Piping and Components (vessels, pumps and valves) shall have weld ends prepared in accordance with ASME B16.25, “Buttwelding Ends” or ASME B16.11, “Forged Fittings, Socket Welded and Threaded” as appropriate. These details shall be noted on the component drawings. Exceptions shall be noted so fabricator can prepare pipe ends.

2. BUTT WELDS
   a. Butt welds shall be used on all piping 2 ½ inches nominal pipe size and above.
   b. Open butt or welds shall be used on all piping including stainless steel piping, and dissimilar metal welds as appropriate for the pipe diameter to be welded. Weld end preparation shall be in accordance with ASME B16.25, "Buttwelding Ends".
   c. Tapered machined or split backing rings shall not be used. Consumable inserts shall only be used when specifically approved by the Company.

3. SOCKET WELDS
   a. Socket welds will be used on all piping 2 inches NPS and smaller not covered under Item 4.1.1. Socket weld configuration and joint geometry shall be in accordance with ASME B16.11, "Forged Fittings, Socket Welded and Threaded".

G. PIPE MATERIAL IDENTIFIER
1. Code Descriptions:
   A 125#
   B 150#
   C 300#
   D 300#
   E 600#
   F 900#
   G 1500#
   H 2500#
   J 4500#
   M No Class, Other Material
   P NO Class, Plastic
   T No Class, Tubing
2. Code Descriptions:
   AA ASTM A53, TYPE E (ERW), GRADE B, SEAMED C.S./A106 SMALL BORE
   AB ASTM A53, TYPE E (ERW), GRADE A, SEAMED C.S.
   BA ASTM A106/A53 GRADE B SEAMLESS C.S.
   BB ASTM A106 GRADE C SEAMLESS C.S.
   BC A333 GRADE 6 SEAMLESS C.S.
   BD ASTM A139 HELICAL SEAM WELDED, GRADE B C.S.
   BE ASTM A106/A53 GRADE B, EFW, EPOXY COATED
   CA ASTM A335 GRADE P11 SEAMLESS CR-MO

DA	ASTM A335 GRADE P22 SEAMLESS CR-MO - B31.1 CODE
EA	ASTM A335 GRADE P91 SEAMLESS CR-MO - B31.1 CODE
FA	ASTM A312 GRADE TP304H (SML, SEAMLESS) S.S.
FB	ASTM A312 GRADE TP304L (SML, SEAMLESS) S.S.
FC	ASTM A312 GRADE TP304L (WLD, SEAMED) S.S.
GA	ASTM A312 GRADE TP316H (SML, SEAMLESS) S.S.
GB	ASTM A 213 GRADE TP316H SEAMLESS S.S. - TUBING
GC	ASTM A312 GRADE TP316L (WLD, SEAMED) S.S.
GD	ASTM A213 GRADE TP316L SEAMLESS S.S. - TUBING
HA	ASTM B88 TYPE K COPPER – TUBING
HB	ASTM B88 TYPE L COPPER TUBING
JA	ASTM B75 COPPER TUBING
KA	ASTM A74 CAST IRON SOIL PIPE
KB	AWWA C151 DUCTILE IRON PIPE, PUSH JOINTS
KC	AWWA C151 DUCTILE IRON PIPE, MECHANICAL JOINTS
LA	ASTM A351 GRADE CN-7M (ALLOY 20)
MA	ASTM A269 VIC-PRESS 304L, GR T
NA	ASTM D1785 PVC PIPE TYPE 1, GRADE 1
QA	ASTM D2665 PVC DWV PIPING
RC	ASTM D4710 POLYETHYLENE PIPE, SDR 11
RF	ASTM D3350 POLYETHYLENE PIPE, FM CL200
UF	ASTM D1784 TYPE IV GRADE 1 CPVC PIPE
VA	AWWA C900, DR14, CLASS 200 PVC PIPE
WA	AWWA C301 CONCRETE PRESSURE PIPE

SOUND CONTROL REQUIREMENTS

Specifier Note: Additional information required

ELECTRICAL REQUIREMENTS

Specifier Note: Additional information required

INSTRUMENTATION & CONTROL REQUIREMENTS

Specifier Note: Additional information required

MATERIALS & WELDING

Specifier Note: Additional information required

CLEANING, PAINTING & COATING

Specifier Note: Additional information required

PACKAGING & SHIPPING

See Appendix 7

STORAGE & HANDLING PROCEDURES

See Appendix 7

SPARE PARTS

Commissioning spares to be included/supplied with the equipment.

QUALITY ASSURANCE

See Appendix 5

TESTING

See Appendix 5

SELLER'S DATA SUBMISSION SCHEDULE

See Appendix 2

APPENDICES

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. DELIVERABLES

2. PROPOSAL DATA REQUIREMENTS
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE SUPPLIERS

Complete technical requirements as required for the identified topic.

1. DELIVERABLES

a) Produce test report to include:

- **i.** Summary of the test procedures, equipment, results and observations in a written report.
- **ii.** Detailed breakdown of the results per location

b) Timeline for testing will begin after <DATE> upon execution of the Agreement.

2. PROPOSAL DATA REQUIREMENTS

<END USER – populate this section with specific instructions>

This information should be included in the SOW (Exhibit B) and is specific to the project.

3. PERFORMANCE GUARANTEES

Warrantee and Guarantee

a) Acceptance

For The purposes of payment under the contract, and for determining the warranty period, Acceptance shall be deemed to occur after completion of test and when the Contractor has resolved any/all issues on a corrective list developed by the Owner. Payment to the contractor shall be forthcoming once all list items are resolved.

4. SITE CONDITIONS AND REFERENCE MATERIAL

This is specific to each site. Include any applicable site layout drawings if available. Include in SOW any obstructions or other construction going on near the test sites. These obstructions could affect the contractors bid.

The Project must outline and identify the specific areas or boundaries of the testing in writing and through the markup of drawings. Include this in the SOW for the contractor

5. QA/QC (Including Inspection Test Plans)

<u>Quality Control</u>

Include Attachment 2.0, "Quality Management Program" and Attachment 2.1 "General Welding Requirements" with the RFQ and Contract.

The Contractor shall be responsible for implementation of a Quality Control program to ensure the installation meets the requirements of this Specification and industry standards. The independent monitoring activities performed by Xcel Energy shall not relieve the Contractor of this responsibility. The Contractor shall document and notify Xcel Energy of any non-conformance or deficient component condition. Any non-conformance of the code specification or drawings shall be documented by the Contractor and provided immediately in writing to Xcel Energy's representative. Non-conformances may also be initiated by Xcel Energy. The Contractor should present a disposition report with their recommendation/proposal on corrective action to Xcel Energy.

i. Click the box on the front page of the Exhibit B under Quality Management that states "The Quality Management QA/QC does/does not apply to this project."

6. STARTUP, TESTING, AND COMMISSIONING
Does not apply to this type of service.

7. PACKAGING, SHIPPING, AND STORAGE

8. ACCEPTABLE SUPPLIERS

MASTER SPECIFICTION
FOR
PIPING SPECIALTIES

Revision Date - 8-25-15

Responsible Technical Specialist: Curtis Crowe

100. GENERAL

101. SUMMARY

101.1 This Specification prescribes the minimum requirements for piping specialties and shall include steam traps, air vents for steam and liquid systems, compressed air drain traps, temporary and permanent strainers (including self-cleaning strainers) and restriction orifices for use in electric power generating stations.

101.2 This Section supplements the specialty data sheets, piping specialty list, piping line list, piping design tables and valve design tables on which the specialty requirements will be specified in one or more of the attachments.

102. GENERAL DESIGN REQUIREMENTS

102.1 Design Requirements:

a. The specialties shall be designed for the service conditions specified.

b. Specialties shall be designed to function to the appropriate ASME, NFPA and AWWA Standards as specified herein

c. All specialties and operators shall be suitable for indoor or outdoor installation, based on prevailing ambient conditions at their installed location.

d. The pressure-temperature ratings shall be those specified in the applicable ASME standard for the type of end connections used.

e. For specialties which must be installed with flow in a particular direction or with a particular orientation, the flow direction and/or orientation shall be clearly and indelibly marked.

f. Designed Systems:

f1. The specialty requirements will be specified in one or more of the following attachments to the Specification: Specialty Data Sheets, Piping Specialty List, Piping Line List, Piping Design Tables and Valve Design Tables.

f2. Company references the governing code classification and jurisdiction using Pipe Classes. The Pipe Classes are as follows:

f2.1 Class D: ASME B31.1 for Non-boiler External Piping

f2.2 Class E: ASME Section 1 for Boiler External Piping

f2.3 Class N: Others such as National Fire Protection Association (NFPA)

f2.4 Class W: AWWA

103. GENERAL QUALITY CONTROL AND QUALITY ASSURANCE PROVISIONS

103.1 Piping specialties shall conform to the requirements of the governing Code(s); in other respects, piping specialties shall conform to the requirements of this Section and shall satisfy all conditions and requirements specified.

103.2 In the event of variance between the general requirements delineated in this Section and the particular requirements set forth in the Specification, the Specification shall take precedence.

103.3 For systems designed by the Contractor, the requirements of this Section and the Specification shall be used to determine the appropriate specialty.

103.4 For systems designed by Company, the specialty type, size, materials, accessories and operating conditions will be specified.

103.5 ASME Code vessels, pipe, valves and other ASME components furnished by the Contractor shall be marked and stamped in accordance with the applicable requirements of the ASME Code designated in this Section.

103.6 Certification and Data Reports for all piping components furnished by Contractor shall be submitted in accordance with the requirements of the applicable section of the above codes and (where applicable) standards.

103.7 Each ASME Code vessel furnished by the Contractor shall be assigned a National Board Number which shall be indicated on the Manufacture's Data Report.

103.8 All welding shall be performed by operators and procedures that are qualified in accordance with the ASME Boiler and Pressure Vessel Code, Section IX, Welding Qualifications.

104. DEFINITIONS

104.1 Piping and Instrumentation Diagrams (P&IDs) – This document provides the diagrammatical representation of the piping system. P&IDs include the piping line numbers, valve numbers, specialty numbers, equipment numbers, pipe class breaks, PDTs and design conditions.

104.2 Piping Design Tables (PDT) – This document provides the dimensional and material requirements for the designated pipelines. The PDTs also reference the applicable valve design table. The PDTs are organized by ASME pressure class ratings (i.e., PDT 0300 corresponds to ASME pressure class rating of 300 lb. In this case, valves and flanges are required to be ASME 300 lb. rating).

104.3 Piping Line List – This document contains a numeric listing of all pipe lines designated on the P&IDs and design drawings. The list contains the Pipe Line Number, Furnish and Installation Specifications, P&ID number, Piping Design Table, pressure, temperature, insulation type and thickness and remarks.

104.4 Piping Specialty List – This document contains a numeric listing of all specialties designated on the P&IDs and design drawings. The Specialty List contains the Pipe Line Number, Piping Specialty Number, Furnish and Installation Specifications, P&ID number, Specialty Data Sheet Number and Remarks.

104.5 Valve Design Tables (VDT) – This document provides the dimensional, material and procurement requirements for the project designated valves.

104.6 Valve List – This document contains a numeric listing of all valves designated on the P&IDs and design drawings. The list contains the Valve Number, Furnish and Installation Specifications, P&ID number, Pipe Line Number, PDT, VDT, Pressure, Temperature and Remarks.

104.7 Valve Data Sheet – This document summarizes the valve list information and provides the requirements for operators and accessories to be furnished with the valve.

105. RELATED WORK SPECIFIED IN OTHER SECTIONS

a. Schedule B, Submittals and Document Review

b. Schedule A, Section xxxx – Design and Operating Data

c. Schedule A, Section xxxx – Nameplates and Tags

d. Schedule A, Section xxxx – Piping Systems

e. Schedule A, Section xxxx – Valves

2.0 APPLICABLE CODES AND STANDARDS

105.1 Standards, specifications, manuals, codes and other publications of nationally recognized organizations and associations are referenced herein. Methods, equipment and materials specified herein shall comply with the specified and applicable portions of the referenced documents indicated in Schedule A, in addition to federal, state or local codes having jurisdiction. References to these documents are to the latest issue date of each document, unless otherwise indicated, together with the applicable additions, addenda, amendments, supplements, thereto, in effect as of the date indicated in Schedule A.

105.2 ASME – American Society of Mechanical Engineers:

a. B 31.1 – Power Piping Code

b. Boiler and Pressure Vessel Code, Section I – Power Boilers (Boiler External Piping)

c. Boiler and Pressure Vessel Code, Section VIII – Division I Pressure Vessels

d. Boiler and Pressure Vessel Code, Section XI –Welding and Brazing Qualifications

105.3 ASTM – ASTM International:

a. A XXX –material specifications as required

b. A 106 – Specification for Seamless Carbon Steel Pipe for High Temperature Service

c. A 167 – Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

d. A 240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

e. A 515 – Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service

f. A 672 – Standard Specification for Electric-Fusion-Welded Steel Pipe for High-Pressure Service at Moderate Temperatures

105.4 AWWA – American Water Works Association

105.5 EJMA – Expansion Joint Manufacturer's Association

105.6 ISO – International Organization for Standardization

105.7 MSS – Manufacturers Standardization from Society of the Valves and Fitting Industry Inc.:

a. SP – 25 – Standard Marking System for Valves, Fittings, Flanges, and Unions

105.8 NFPA – National Fire Protection Association

3.0 TECHNICAL REQUIREMENTS

201. COMPONENTS

201.1 Steam Traps:

a. All traps shall be made with cast steel or forged steel bodies, covers, etc., except traps with cast iron bodies may be furnished in systems where the design, as set forth in the applicable Piping Design Tables, permits the use of cast iron and bronze valves or except as specified.

b. All traps shall have metal working parts of materials suitable for the temperatures and pressures encountered. All seats and discs shall be removable.

c. All actuating levers and arms for the traps shall be of cast or forged steel. No pressed steel construction for these parts shall be used.

d. All traps shall be provided with properly valved bypasses and blowdown valves.

e. The following types of steam traps shall be acceptable:

e1. Inverted Bucket

e2. Bucket

e3. Thermodynamic (Including Impulse)

e4. Thermostatic

e5. Float and Thermostatic (F&T)

f. Steam traps shall be self-purging to avoid air binding.

g. Trap Strainer combinations are acceptable.

h. Steam Traps on exposed lines located in a cold climate where a vacuum occurs during shut down shall be provided with an integral vacuum breaker to avoid condensate freezing in the line.

i. Steam traps shall be maintainable / repairable without being removed from the pipeline. If the traps are not maintainable / repairable, they shall be provided with flanged connections.

201.2 Strainers:

a. Strainers shall be designed so as to be completely drainable. Temporary cone strainers installed at the suction of a pump are exempt from this requirement.

b. Strainer mesh or baskets shall be accessible for removal and cleaning without removing the strainer from the pipeline. Temporary cone strainers are exempt from this requirement.

c. All except Y-type strainer inlet and outlet connections shall be drilled and tapped to accept Contractor's pressure instrumentation.

d. Strainer mesh or baskets shall be capable of taking the full line operating pressure across a fully blocked strainer without damage, and shall be suitably reinforced as required to accommodate this feature.

e. Each manual strainer with a heavy cover plate and large basket(s) shall be provided with a lifting device mounted on the strainer body to facilitate removal of cover and basket(s) by a single person performing manual cleaning.

f. All straining elements shall be constructed of ASTM A240 Type 316 stainless steel. Alternate material shall be used if stainless steel is not compatible with the fluid.

g. Strainer area shall be sized so that the fouled pressure drop (before cleaning) does not exceed limits required for proper system operation. Strainers shall also be sized so as not to exceed the velocity limits for flow through the mesh.

h. Plate or flat type strainers inserted between flange faces shall not be acceptable since the area open to flow is less than the pump suction pipe inside area. Conical strainers which may be inserted in a flanged spool piece in the pump suction close to the pump suction flange are acceptable for temporary use at startup. Tee type strainers with sufficient flow area may also be used.

i. The strainers shall be designed for the specified design pressure and temperature and shall be suitable for continuous operation at the specified flow rates. End connections shall be flanged, socket weld or buttwelded as specified.

j. Bodies on basket strainers shall have bolted top covers, unless otherwise specified. Strainer bodies shall have tapped and plugged drain connections.

k. Strainers which are specified as "Quick Opening" shall be provided with hinged strainer covers assemblies capable of holding the cover when maintenance is performed on the strainer.

l. Automatic self-cleaning strainers shall be equipped with a motorized rotating backwash arm, flanged end connections, with the body and cover designed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. Inspection openings shall be provided to permit visual inspection or changing of straining media without removing drum.

m. Minimum pressure rating for all strainers shall be ASME 150# class.

n. Backwashing system shall be capable of providing continuous or intermittent backwashing operations while maintaining the specified output flow through the strainer. A motor operated or pneumatic cylinder operated backwash valve shall be provided. Pneumatic valves shall be supplied with a solenoid air valve and an air pressure filter-regulator set mounted in the actuator.

o. No initial pipeline flushing should be permitted through the pump. Initial pump operation after line flushing shall be with temporary strainers in place and the strainers shall remain in place until full pump flow at full temperature has been reached and inspection has established that no debris is being collected.

p. A “Y” type strainer shall be installed upstream of each trap, unless the traps are provided with integral strainers.

q. Instrumentation and Controls:

q1. Contractor shall supply the self-cleaning strainer backwash controls, complete with adjustable timer, control transformer, indicating lights, manual start-stop control and all external power and control wiring. Each self-cleaning strainer shall have a local control panel.

q2. Self-cleaning strainer differential pressure switch shall be pre-installed, adjustable, and shall override the primary timed backwash control on high differential pressure. Differential pressure switches shall conform to the requirements of the Specification.

q3. Pressure measuring taps shall be provided on the body of each manual strainer (except “Y” type) and in the piping adjacent to temporary strainers upstream and downstream of each strainer element to enable determination of fouling by observing the increase in pressure drop across the strainer. The self-cleaning strainer shall be provided with pressure gauges and connections on the strainer for indication of inlet and outlet pressure.

201.3 Restriction Orifices:

a. Orifice plates shall be circular concentric paddle type with square edge inlet. Orifice plate and paddle shall be either formed from a single solid plate or properly welded together. Minimum plate thickness shall be ¼ inches.

b. Orifice plates shall be constructed of ASTM A240 Type 316 stainless steel. Orifice plates for piping 2½ inches diameter and larger shall be suitable for mounting between raised face orifice flanges of the ASME pressure class required for the design pressure and temperature specified. Orifice plates for piping 2 inches diameter and smaller shall be suitable for mounting in orifice unions.

c. Orifice plate thickness and bore diameter shall be as specified. Each orifice plate for mounting between flanges shall be provided with a handle on which the orifice diameter and pipe diameter are stamped on the upstream side of the handle. This information shall be located where it can be read without removing the orifice plate from the pipeline.

d. Where plug resistant type orifices are specified, the orifices shall be of the stainless steel body socket weld type. The orifice plug shall be removable from the orifice body without disturbing the piping connections to the body.

e. Where multiple stage type orifices are specified, the orifices shall be supplied as one assembly, constructed of stainless steel.

201.4 Flexible Hoses:

a. Flexible hoses indicated for water service shall be stainless steel braided metal hoses or acceptable equal.

b. All hoses 2 inches and smaller shall have screwed end connections and all hoses 2½ inches and larger shall have ASME Class 150 flanged end connections and shall be designed for the pressure and temperature specified in the Pipeline List.

c. Flexible metal hose shall be of corrugated construction of stainless steel and shall have braided coverings. Fittings shall be attached to the hose with brazed joints.

201.5 Pipe Expansion Joints (Metal):

a. Design Requirements:

a1. Each expansion joint element shall be of the packless bellows type, hydraulically rolled or die-formed from a stainless steel cylinder. The stainless steel cylinder shall preferably be seamless, but in any case shall have no more than a single longitudinal weld in sizes under 16 inches in diameter and no more than two longitudinal welds in sizes 16 inches in diameter and larger. The longitudinal weld bead(s) shall have essentially the same thickness as the parent metal. No welds shall be used to form the corrugations. All restraining bolts and nuts shall be stainless steel.

a2. Each joint shall be designed to meet the internal design pressure and temperature conditions.

a3. For expansion joints within the condenser neck, the external design pressures and temperatures shall be –15 / +5 psig saturated.

a4. A ±¼ inch axial movement from neutral over that specified and a 1/8 inch lateral movement from the center line over that specified shall be included in the design of expansion joints to accommodate tolerances that will occur during installation. Rotational, lateral and axial movements will be imposed on the joints after they are welded in place. Contractor shall add an additional safety factor of 35% to the specified axial, rotational and lateral deflections over and above those added for installation tolerances.

a5. The lateral and rotational movements shall be applied on each side of the joint center line.

a6. The axial, lateral and rotational movements shall be accommodated simultaneously.

a7. Bellows design and construction shall be such that no single corrugation is permitted to deflect more than 90% of its design amount.

a8. Fabricated length (neutral position) tolerance shall be ± 1/16 inch.

a9. Each joint shall be stable against buckling or squirming when subjected to the operating conditions specified or during the specified hydrostatic test.

a10. Each joint shall be designed for at least 7000 operational cycles.

a11. Universal expansion joint assemblies shall be designed and constructed such that the full weight of the center spool piece and any connected piping shall be carried by the tie rods and not by the joint bellows.

a12. Limit stops and temporary positioning devices, when required, shall be designed so as not to interfere with the installation or removal of the joint from the piping system.

a13. All expansion joints shall have four (4) equidistant permanent tram-points around each welding neck. Points shall be clearly marked and so located as to prevent obliteration during installation. Distance between tram-points indicating neutral position shall be included in submitted shop drawings.

a14. Expansion joints weighing more than 500 lb. shall be provided with lifting lugs.

a15. The connections of bellows attached by welding to spool pieces shall be designed so as to minimize bending or thermal stresses in the attachment weld.

b. Internal Sleeves:

b1. Internal sleeves shall be provided in all expansion joints. The sleeves shall be installed prior to shipment of joints.

b2. The sleeves shall be designed and installed to preclude interference with the convolutions when the joint is in its maximum deflected position during operation, to preclude binding against the welding neck and to restrict entry of foreign material into the bellows area. The maximum deflected position during operation shall include the deflections arising from the tolerances specified.

b3. The sleeves shall not restrict steam flow and increase steam velocity. To avoid inducing vibration at either “normal operating conditions” or “the maximum flow conditions” the flow velocity inside the expansion joint lines shall not exceed:

b3.1 Wet Steam – 7,500 ft/min

b3.2 Superheated Steam – 20,000 ft/min

b4. Sleeve thickness shall be no less than 1/16 inch and otherwise shall be in accordance with EJMA design recommendations for internal sleeves.

c. Covers:

c1. The flexible portion of all expansion joints shall be provided with a permanent, stainless steel cover over the full circumference to protect it from damage by falling objects, prevent foreign objects from lodging between convolutions and protect convolutions from erosion. These covers should be removable to permit bellows inspection and shall in no way limit the free movement of the flexible portion of the joint. Clearances between the cover and the convolutions shall be based upon the specified deflections plus deflections due to the tolerances specified herein. The thickness of the covers shall be no less than 10-gauge. Covers shall be designed to preclude trapping of liquids after final cleaning. Covers shall be installed prior to shipment and shall be securely attached to the joints in order to prevent the covers from loosening due to vibration or steam impingement.

d. Materials:

d1. Materials for the expansion joints and components shall be in accordance with the following as appropriate for the application:

d1.1 Internal sleeves shall be Type 304 stainless steel per ASTM A167 or ASTM A240.

d1.2 Covers over flexible portion of expansion joints shall be Type 304 stainless steel per ASTM A167 or ASTM A240.

d1.3 The spool pieces and welding stubs shall be made of seamless carbon steel conforming to ASTM A106, Grade B, Schedule extra strong for sizes up to and including 24 inch. All sizes above 24 inch shall be per ASTM A672 for welded plate pipe Grade B-60 (plate materials per ASTM A515, Gr. 60) Class 22, 1/2 inch plate thickness.

d1.4 Expansion joint bellows element shall be Types 304 or 316 stainless steel per ASTM A167 or ASTM A240.

201.6 Pipe Expansion Joints (Rubber):

a. General Design and Construction:

a1. Straight spool type expansion joints shall be concentric and at right angles to the flanged ends.

a2. Contractor shall design and furnish expansion joints suitable for the movements specified.

a3. Expansion joints shall be reinforced as applicable to suit the particular location and service for which they are intended.

a4. Expansion joints shall be designed for the design and hydrotest pressures specified. Additionally, the expansion joints shall retain full function and not collapse under vacuum conditions.

a5. When specified, the expansion joint shall be furnished with tie rods to restrain pressure thrust forces. The tie rods shall not limit the ability of the expansion joint to satisfy the design movements and shall be adjustable by Company during piping system operation. The tie rods shall be equally distributed around the circumference of the expansion joint and shall be sized to restrain the resultant pipeline pressure thrust forces at the specified maximum design pressure. Tie rods shall be furnished complete with all flanges, gaskets, nuts, bolts, and mounting hardware.

a6. Expansion joints located outdoors will be exposed to sunlight and thus subject to ultraviolet light. Materials of construction for expansion joints located outside shall resist softening and deterioration resulting from prolonged exposure to ultraviolet light.

a7. Contractor shall furnish all required materials and accessories including tie rods, rubber bushings, gussets, nuts and spherical washers. Tie rods shall be designed to resist the total forces (including pressure thrust) on the expansion joint.

a8. Expansion joints for low temperature water service shall be elastomer or rubber expansion joints reinforced in each case to suit the particular location and service for which they are to be used. Elastomer expansion joints shall not be used in piping where the working temperature exceeds 150°F.

a9. Expansion joints shall be suitable for the working pressures or vacuum, temperatures, and pipe movements in the line where they are to be installed and shall be of design, type, and manufacture acceptable to the Contractor.

b. Materials:

b1. All materials used in construction of the expansion joints and appurtenances shall be the best suited for the application.

b2. All materials used in the expansion joints, unless otherwise specified, shall be manufacturer's standard suitable for services and operating conditions as specified.

201.7 Miscellaneous Specialties:

a. For specialties not discussed in this Section, the Contractor shall meet the design requirements of the Specification, Specialty List and Specialty Data Sheets, as applicable.

202. <u>MATERIAL REQUIREMENTS</u>

202.1 All pressure retaining materials shall be in accordance with and identified by ASTM material specifications. Non-pressure retaining materials, such as: gaskets, packing, etc. may be to

Contractor's standard if they meet the specified service conditions. Compatibility of materials with the fluid handled is the responsibility of the Contractor.

202.2 Gasket and packing materials, where supplied, shall not contain a leachable chloride content more than 100 ppm if the packing or gasket material is in contact with stainless steel.

202.3 Rubber or synthetic materials shall not be used in the backwash section of self-cleaning strainers.

202.4 Each steam trap shall have stainless steel trim.

202.5 Straining elements in manual strainers and orifice plates (including paddles) shall be stainless steel. Alternate material shall be used if stainless steel is not compatible with fluid.

202.6 Bolting material shall be the same generic material as the specified body material or of a more corrosive resistant material.

202.7 All austenitic stainless steel materials shall be in a solution-annealed condition, which shall consist of heating to 1900°F or higher and holding for an appropriate time. Subsequent cooling shall be from the annealing temperature to below 800°F so as to prevent carbide precipitation in the grain boundaries.

202.8 Austenitic stainless steel shall not be used if subjected to a post-weld heat treatment in the range of 800°F to 1800°F regardless of subsequent cooling rate.

203. <u>SOURCE QUALITY CONTROL</u>

203.1 Inspection and Testing:

a. Perform all examination and testing and furnish documentation required by the governing code(s).

b. All materials used in pressure boundary parts shall be tested and repaired in accordance with the applicable ASTM material specifications.

c. Contractor shall indicate full extent of nondestructive testing in data sheets.

d. In addition to any required inspections, all fabrication and material may be subject to inspection by a representative of Company:

d1. All welds shall be visually inspected. Visual inspection shall consist of observations by Company's inspector for assurance of proper joint preparation and fit-up, proper materials procedures, qualifications and workmanship in process, proper appearance, surface condition and workmanship of the finished weld and supplementary inspection techniques as required to evaluate unusual conditions.

e. Shop Tests:

e1. Equipment shall be given tests to assure that workmanship and materials are free from defects and to establish that the design, construction and performance meet the requirements of this Section.

e2. All equipment shall be hydrostatically tested to the test pressures of the applicable ASME Standard and/or pressure rating class.

e3. Pipe Expansion Joints (Metal) Tests:

e3.1 Each expansion joint assembly shall be hydrostatically tested at a minimum of 1½ times the specified working pressure prior to shipment from the manufacturer's plant.

e3.2 Expansion joints that fail during the shop hydrostatic tests due to faulty, improper or inadequate design, materials or fabrication shall be replaced at the expense of the Contractor. Any discernible leakage of the expansion joint or evidence of weld defect shall constitute failure.

Unless proposed repair procedure submitted by Contractor is approved in writing by Company, the joint shall be replaced at the expense of the Contractor.

e3.3 A qualification test shall be performed on at least one sample of the smallest size expansion joint offered of each design in the presence of a representative of the Contractor. A design shall mean that the corrugations of the expansion joint shall be identical in material, contour of corrugations, process of manufacture, details of construction, operating pressure and movement per corrugation regardless of diameter. A higher pressure design may be used for a lower pressure provided it has successfully passed the qualification test at the higher pressure. Each sample shall consist of an assembled expansion joint of at least three complete corrugations of the flexible portion together with welding nipples or flanges. The qualification test shall consist of proof test for allowable movements at design pressure and temperature.

204. FABRICATION REQUIREMENTS

204.1 Pipe Expansion Joints (Rubber):

a. Each expansion joint assembly shall be completely shop fabricated. The expansion joints shall be shipped to the field with the retaining rings and control units shipped unassembled. Assembly is to be performed in the field.

b. All work shall be performed in accordance with the best modern practice for the manufacture of high-grade expansion joints and appurtenances. All machined parts shall have accurately machined mounting and bearing surfaces so that they can be assembled without fitting, chipping, or re-machining. All parts shall conform accurately to the design dimensions and shall be free of all defects in workmanship or material that will impair their service.

204.2 Welding:

a. All welding shall be done in accordance with Contractor's welding requirements, which shall comply with the applicable codes and standards. No plugging, impregnation, brazing or welding repair shall be permitted on cast iron or ductile iron.

b. All welding on stainless steel and between stainless and carbon steel shall be by the gas tungsten arc welding method (GTAW).

c. Butt-welds should be used where possible.

d. All butt-weld end preps shall conform to the details of this Section.

204.3 Identification:

a. Unless otherwise specified, each specialty indicated on the P&IDs and/or the isometric drawings bears an identification figure (specialty number).

b. All specialties furnished by Contractor shall have a securely attached metal tag marked to identify each item and its particular service. Tags shall be furnished in accordance with Schedule A, Section xxxx, unless otherwise specified.

c. Pipe Expansion Joints (Metal) Nameplates:

c1. Contractor shall attach, by securely welding, a 12-gauge metal nameplate of ASTM A167, Type 304 material to each joint cover, bearing the following information (Information shall be die-stamped using ¼ in. high letters):

c1.1 Manufacturer

c1.2 Equipment specialty number

c1.3 Type and size of expansion joint

c1.4 Design pressure and temperature

c1.5 Design movements (axial and lateral) c1.6 Direction of flow arrow

c1.7 Heat number of bellows material

c1.8 Heat number of nozzle materials

204.4 Cleaning Pipe Expansion Joints (Metal):

a. All expansion joints assemblies shall be thoroughly cleaned on the interior and exterior of rust, scale, oil, grease and foreign matter. All surfaces (including welds) shall be free of all weld splatter and visible oxide. An aluminum oxide abrasive disc or stainless steel wire brush may be used to improve the surface finish. Vapor, glass bead or sandblasting may also be used; however, they shall be confined to the weld areas. Non-halogenated solvents shall be used to clean stainless steel components.

b. Exposed machined surfaces shall be coated with an easily removable rust preventative. All carbon steel interior and exterior parts shall be coated with an easily removable non-corrosive rust preventive film.

204.5 Shipping:

a. Materials shall be provided with protection against damage, corrosion and internal contamination in accordance with the following:

a1. All materials and equipment shall be packaged, packed or prepared for shipment in a manner which shall ensure arrival at destination in satisfactory condition.

a2. All openings shall be securely plugged, capped or otherwise blanked off, sealed with tape and suitably protected against damage and entry of foreign materials and moisture.

a3. Weld ends on all piping specialty items shall be capped and sealed with suitable, firmly attached protectors. Butt-weld ends on ferrous materials shall be coated with Special Chemicals Corporation Deoxaluminite, or acceptable equal, prior to capping, back to a ring whose length is the same as the weld preparation plus 2 inches minimum.

a4. Protectors for beveled ends shall have a plywood or hardboard liner disc held securely against the beveled end. Protectors for other weld ends may be metal caps without liner discs. Protectors shall not be welded to the weld end.

a5. All flange facings, bolt holes and other machined surfaces of ferrous materials (except butt joint end preparation) shall be coated with a suitable removable antitrust compound. No coatings shall be applied to nonferrous materials.

a6. All flanged connections and loose flanges shall be provided with suitable full face flange protectors bolted in place and sealed.

a7. All protectors for openings and all braces, brackets, spacers, ties, bindings and other shipping, packaging and packing materials and appurtenances used for protection in shipping, storing and handling of nonferrous piping and materials shall be of such design, type and/or arrangement as to prohibit contact between ferrous and nonferrous materials.

a8. Threaded connections shall be provided with plugs.

205. <u>FINISH REQUIREMENTS</u>

205.1 Unless otherwise specified, piping specialty items shall be cleaned and painted as follows:

a. Coatings shall meet the requirements in Schedule A, Section xxxx.

b. No paint having an asphaltum base shall be used.

c. Machined surfaces shall not be painted. Flange facings, bolt holes and other external machined surfaces of ferrous metal materials shall be coated with a suitable antirust compound.

d. Stainless steel and rubber parts shall not be painted.

MASTER SPECIFICATION
FOR
Safety Valves

REVISION HISTORY

Date	Revision	Change Description
8/30/2015	1.0	New

TABLE OF CONTENTS

PART 1 - GENERAL

1.1 SUMMARY

1.1.1 This document contains the minimum requirements for the design, sizing and selection of automatic pressure actuated safety valves, safety relief valves, and relief valves. The requirements should be supplemented by the Supplier's own requirements. The valves shall be delivered complete. Delivery dates are addressed in Exhibit 4.

1.1.2 The safety valves shall be supplied as per the Appendix 9 Safety Valve data sheets.

1.1.3 The Supplier shall comply with all the requirements of this specification. Approval of any drawings and/or test shall in no way relieve the Supplier from these responsibilities.

1.1.4 The valves shall be certified and stamped in accordance with ASME requirements.

1.1.5 All of the equipment and materials specified herein is intended to be standard equipment for use in controlling the flow of air or fluids.

1.1.6 Valves, appurtenances, and miscellaneous items shall be as specified so as to form complete, workable units.

1.1.7 No substitutes or alterations are authorized without written approval in the form of a change notice to the order.

1.1.8 The Supplier shall make a request for a change giving reasons and identifying the present and proposed method. Written consent in the form of a change notice is required. The change shall be duly noted and documents that are affected shall be changed as required.

1.1.9 Valves furnished under these requirements are classified as safety valves or safety relief valves. These valve types are functionally defined as follows.

1.1.9.1 Safety Valve - An automatic, re-closing, pressure-relieving device suitable for steam, gas or vapor service. Valve action is characterized by rapid full opening or "pop" action at valve set pressure.

1.1.9.2 Relief Valve – An automatic, re-closing, pressure relieving devices used for liquid service only. Valve action is characterized by opening in proportion to the increase in upstream static pressure over the valve set pressure.

1.1.9.3 Safety Relief Valve - An automatic, re-closing, pressure-relieving device suitable for use as either a safety or relief valve

1.2 SCOPE OF WORK

1.2.1 Equipment and service furnished by the Supplier shall include:

1.2.1.1 Design, fabrication, testing, certification and delivery of all valves, meeting the requirements of this specification and the safety valve data sheets.

1.2.1.2 Test rod and screw cap or other gagging mechanism shall be provided with each safety, safety relief and relief valves for hydrostatic testing. The hydrostatic test pressure will be at 1.5 times the design pressure of the system to which the safety valve is installed.

1.2.1.3 Any special tools required for assembly, disassembly and maintenance.

1.2.1.4 Valve drawings and calculations, including outline dimensions, weights, section drawings, part lists and materials.

1.2.1.5 Installation, operation, and manintenance manuals, including instructions for any sub-suppliers.

1.2.1.6 Perform shop testing and inspection.

1.2.1.7 Perform cleaning and shop painting of all valves, operators, and accessories.

1.2.1.8 Package and mark all valves, operators, and accessories for shipment.

1.2.1.9 Deliver all valves, operators, and accessories to jobsite.

1.2.1.10 Recommended spare parts list.

1.2.1.11 Valves shall be have permanent tags affixed to the valve and stamped with the information as required by the ASME Boiler and Pressure Vessel Code Sections I and VIII.

1.2.2 Equipment and services furnished by the Buyer shall include:

1.2.2.1 Receiving, unloading, storage and installation of all equipment supplied by Supplier

1.2.2.2 Electrical wiring for power and signals for position indicating lights, solenoids, and/or control stations

1.2.2.3 All external piping, tubing, valves, and fittings, except as specified to be furnished by the Supplier.

1.2.3 Supplier shall provide a recommended operational spare part list for two (2) years of operation as well as a pricing list for the items prior to delivery.

1.3 CODES AND STANDARDS

1.3.1 Publications of the following nationally recognized organizations are applicable to the engineering, design, manufacture, and testing of the equipment included in this Specification. All references to publications are to the latest issue of each together with all latest addenda, amendments, or additions thereto as of the date of Agreement. References will be made in accordance with the abbreviations listed below:

ASME B1.20.1	Pipe Threads, General Purpose (inch)
ASME B16.5	Steel Pipe Flanges and Flanged Fittings
ASME B16.10	Face-to-Face and End-to-End Dimensions of Valves
ASME B16.20	Ring-Joint Gaskets and Grooves for Steel Pipe Flanges
ASME B16.34	Valves – Flanged, Threaded, and Welding End
ASME B31.1	Power Piping
ASME B31.3	Chemical Plant and Petroleum Refinery Piping
ASME VIII	Rules for Construction of Pressure Vessels – Division 1
ASME I	Rules for Construction of Power Boilers
ISA Guide	Control Valves, Practical Guides for Measurement and Control
ISA S20.50	Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves
ISA S75.01	Flow Equations for Sizing Control Valves
ISA S75.05	Control Valve Terminology
ISA S75.11	Inherent Flow Characteristic and Rangeability of Control Valves
ISA SP75.17	Control Valve Aerodynamic Noise Prediction
ISA RP75.23	Considerations for Evaluating Control Valve CavitationHI Hydraulic Institute
IEEE	Institute of Electrical and Electronics Engineers
MSS	Manufacturers Standardization Society
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
SSPC	The Society for Protective Coatings
UL	Underwriters Laboratories

1.3.2 All valves shall be in accordance with the applicable requirements herewith and shall comply with all federal, state, and local codes that govern.

1.3.3 In case of conflict between the requirements of the various parts of these documents, the requirements of the different parts shall govern in the following sequence: Mandatory Governmental Body regulations, codes and standards, this Specification and the referenced industry codes and standards.

1.3.4 Supplier shall provide proper Code certification that all work complies with all requirements of the Code including design, materials, construction, and workmanship.

1.4 DELIVERY, STORAGE AND HANDLING

1.4.1 The valves shall be delivered FOB destination to the Company's XXX Plant, located in XXX.

1.4.2 The Supplier shall adequately prepare all of the equipment to withstand any possible damage or loss due to rough handling or exposure to weather during transit or extended outdoor storage for up to 6 months. Where required by the nature of the equipment, the Supplier shall furnish and install necessary covers to protect the equipment from rain, hail, wind, dust, etc. Flanges and openings shall be adequately sealed and protected during shipment to prevent corrosion, entrance of foreign matter and possible damage from rough handling during transit and storage. Flanged connections shall be provided with suitable flange protectors bolted on before shipment. Screwed outlets shall be provided with plugs. Instructions for storage shall be included with the Installation, Operating & Maintenance manuals.

1.4.3 All exposed-machined ferrous metal surfaces shall be coated with a suitable antirust compound before shipment.

1.4.4 Preservative coatings used on components shall be suitable for the conditions normally expected during shipping, storage and throughout the erection period. Toxic and hazardous-type preservatives will not be allowed. Information pertaining to preservatives shall be submitted two months prior to delivery.

1.4.5 The Supplier shall be responsible for its Subcontractor(s) adhering to the above shipping preparations on all equipment and items shipped to the Company by the Subcontractor.

1.5 MAINTENANCE MATERIALS

1.5.1 The Supplier shall furnish two (2) items each of any special tools required to operate and maintain the valves and accessories. A list of these tools shall be provided with the Agreement. If no special tools are required the Supplier shall indicate so.

END OF SECTION

PART 2 - PRODUCTS

2.1 GENERAL DESIGN AND CONSTRUCTION

2.1.1 Safety valves, relief valves and safety relief valves shall be sized and constructed in accordance with the ASME Boiler and Pressure Vessel Code Sections I and VIII as applicable. All valves shall be of the bottom inlet, side outlet type.

2.1.2 Safety valves, relief valves, and safety relief valves shall also meet or exceed the requirements of the following Codes: ASME B31.1, API 526, API 527, and ASME PTC 25 as applicable. Valve certification shall conform to ASME Section VIII, UG-131 or ASME Section I PG- 69 depending on jurisdiction as noted in valve data sheet. Valve testing shall be in accordance with ASME PTC 25.

2.1.3 The Data sheets in Appendix 9 indicate the operating conditions that the individual valves will encounter. All safety valve, relief valve, and safety relief valves shall be suitable for service under the conditions as specified in Appendix 9.

2.1.4 The Supplier shall be totally responsible for the proper sizing, selection, and application of all safety valves, relief valves, and safety relief valves.

2.1.5 The valve shall be rated to meet the design pressure and design temperature of the application according to an internationally recognized standard. For flanged valves, the valve body rating shall never be lower than the flange rating. All safety valves shall have flanged outlets. All flange faces shall be of the raised face type.

2.1.6 Valve class ratings indicated on the Data sheets are anticipated as ASME B16.34 pressure class ratings only. In all cases, it shall be the responsibility of the Supplier to properly and economically select valves with pressure-temperature ratings that meet or exceed the design pressure and temperature specified.

2.1.8 The valve construction including materials for each safety valve, relief valve, and safety relief valve shall be in accordance with the requirements specified herein, and in the Data sheets in Appendix B. Finish shall be the Manufacturers standard unless otherwise specified in the Data sheets in Appendix B. As required by the process conditions in Appendix 9, the Supplier shall select relief valves that include valve body drain ports.

2.1.9 Safety and relief valves shall be installed vertically and vented to a safe location. Safety relief valves shall have carbon steel bodies with stainless steel seats and disks, packed lifting levers and spring enclosures.

2.1.10 Valves shall be designed to operate without chattering.

2.1.11 Tungsten alloy springs shall be used for valve applications above 450°F.

2.1.12 All safety valves, relief valves, and safety relief valves shall be suitable for outdoor service unless specified otherwise in the Data sheets. All Safety valves, relief valves, and Safety relief valves with inlet sizes 2" and smaller shall have closed bonnets. All other safety valves, relief valves, and safety relief valves shall have either a closed bonnet or a weather hood.

2.1.13 Set point and blowdown shall be field adjustable after installation. Screwed caps shall be provided to cover the set point adjustment mechanism. Means shall be provided for sealing all external adjustments. Seals shall be installed by the manufacturer in such a manner as to prevent changing the adjustment without breaking the seal.

2.2 OPERATING PARAMETERS

2.2.1 Safety Valve Sizing

2.2.1.1 The flow capacity of each valve shall be as shown on the Data sheets when operating at the fluid conditions, including back pressure, set pressure, and over pressure as specified.

2.2.1.2 Each safety valve, relief valve, and safety relief valve shall be sized by the Supplier performing their own independent calculations to meet the specified conditions.

2.2.1.3 The sizing differential pressure shall be considered as the maximum differential pressure that is effective in producing flow, or the actual differential pressure, whichever is smaller.

2.2.1.4 Unless otherwise specified on the Data sheets, the estimated backpressure shown on the Data sheets is based on the valve outlet discharging into a short radius elbow with 1 foot of straight pipe open to a vent stack releasing to the atmosphere. The elbow and pipe shall be the same diameter as the valve outlet.

2.2.1.5 The Supplier shall calculate a backpressure for each proposed safety valve, relief valve, and safety relief valve based on this discharge configuration.

2.2.2 Valves shall have port and body flow areas adequate to pass the required capacity. Pressure accumulation shall not be greater than 10 percent of the valve set pressure or 3 psi, whichever is greater. Capacity ratings shall be certified in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. The valve outlet backpressure shall be not greater than 10 percent of the valve set pressure.

2.2.3 Valve capacity shall be based on the applicable service fluid.

2.2.4 Valves for steam, air, and hot water service over 140 degree F applications shall be provided with lifting devices. The lifting devices shall permit the valve disk to be positively lifted from its seat when the valve is subjected to a pressure of at least 75 percent of the valve set pressure. Lifting devices shall be packed to prevent leakage of the fluid when the disk lifts.

2.2.5 Body designs shall be such that crevices and retention pockets are minimized. If the body design for valves larger than 1-1/2 inch inlet is such that liquid can collect on the discharge side of the disk, a socket weld drain connection or a plain end pipe nipple of not less than 1/2 inch nominal pipe size shall be provided at the lowest point liquid can collect.

2.3 ELECTRICAL REQUIREMENTS

2.3.1 Section not required

2.4 INSTRUMENTATION AND CONTROL REQUIREMENTS GENERAL

2.4.1 Section not required

2.5 PAINTING AND COATING

2.5.5 All external ferrous steel surfaces shall be painted per manufacturer's standard coating.

2.6 FIELD SERVICES (OPTION)

2.6.1 Section not required

2.7 SPECIAL TOOLS

2.7.1 Supplier shall provide two (2) complete sets of special equipment and tools, required for repair, inspection, adjustment, complete dismantling and assembling of the equipment. Tools shall be new and of first-class quality. Tools shall be shipped to the project in a suitable, separate container clearly marked with the name of the equipment for which they are intended.

2.7.2 Supplier shall indicate if special equipment and tools are required for repair, inspection, adjustment, complete dismantling and assembling of the equipment in the Agreement.

2.8 SPARE PARTS

2.8.1 Supplier shall provide a quotation for recommended spare parts covering the first two (2) years of operation as identified below. Spare parts quotations shall:

a. Be submitted to Company prior to delivery.

b. Have been identified with Specification number, equipment name, unit number, and station name.

c. Have been inclusive for and applicable to all equipment components, auxiliaries, accessories, materials, and lubricants being furnished under the Agreement.

d. Have included for each recommended spare part, the unit prices, quantity, description, part number references, etc., to completely identify the item and the equipment component for which it is recommended.

e. Have been based upon furnishing and delivering the parts at the Project Site.

f. Include a list of recommended test equipment and special tools. Test equipment list and special tools list shall indicate the cost of each component.

g. All requirements regarding quality control and documentation that apply to the original parts of the specified equipment shall apply equally to the spare parts of the specified equipment.

2.8.2 Startup and Commissioning Spare Parts:

2.8.2.1 Supplier will submit a listing of startup and commissioning spare parts. The startup and commissioning spare parts list may be unit priced or lump-sum priced but will be included in the firm price offer and indicated separately from the condensate pumps price.

2.9 TRAINING (OPTION)

2.9.1 Section not required

2.10 SOURCE QUALITY CONTROL

2.10.1 Valves and appurtenances shall be products of well-established manufacturers who are fully experienced, reputable, and qualified in the manufacture of the particular equipment to be furnished. The manufacturer shall have a minimum of five years experience in the manufacture of control valves as specified herein. The equipment shall be designed, constructed, and installed in accordance with the best practices and methods and shall comply with these specifications as applicable.

2.10.2 It is the Supplier's responsibility to obtain copies of all documents referenced in this specification. Unless specific exception is requested formally by the Supplier, and formally granted by Purchaser, these referenced documents shall be binding.

2.10.3 Purchaser reserves the right to inspect the product and audit material and processes at any of the Supplier’s facilities that are performing work in support of this specification. Products and services supplied under this specification are subject to Purchaser's final inspection, acceptance, and release.

2.10.4 The following standard tests shall be performed on each Safety valve:

- Valve hydrostatic pressure test

2.10.5 Supplier shall furnish Certification of Compliance with ASTM specifications referenced for manufacture. Data on certificates of material compliance shall include the name of supplier, name and address of prime material manufacturer, material specification and grade, class, or type designation. In addition, Supplier shall provide a statement certifying compliance with material specifications, including the Supplier's Quality Assurance Manager signature and date.

2.10.6 Supplier shall also provide a complete MTR (Mill Test Report) showing results of all chemistry and physical tests for impact tested steels, alloy steel or stainless steels.

2.10.7 Supplier shall provide a Positive Material Identification or "PMI" report for the fabrication of all control valves to confirm valve body material. Carbon steel valves will not require a "PMI" report.

2.11 PERFORMANCE ACCEPTANCE TESTS

2.11.1 Supplier shall furnish a test procedure for testing the equipment. The test procedure shall clearly spell out the instrumentation, test connections, cycle isolation requirements, and any other equipment for the tests and where they must be located in the system to obtain the necessary test data.

2.11.2 All instrumentation required for Supplier's test procedure that is mounted on Supplier's equipment or interconnecting piping shall be provided by Supplier. This instrumentation may be permanent or temporary instrumentation. If temporary instrumentation will be utilized Supplier shall provide this instrumentation on a loan basis. Instrumentation required by Supplier's test procedure that requires installation on Company's equipment or piping shall be identified to Company prior to pump shipment to allow provisions for its installation. Supplier shall provide data sheets regarding the accuracy of such instrumentation. Instrumentation that requires backfitting into Company's equipment or piping will be backcharged to Supplier.

END OF SECTION

Appendices

Appendix 1

Deliverables

1. GENERAL INFORMATION.

1.1 Issuance

1.1.1 All Submittals shall be issued to Company, and other Company authorized parties by electronic transfer using a Company approved electronic media storage and retrieval system. Supplier's system shall be compatible with Company's software capability.

1.2 Definitions

1.2.1 Compliance Submittals include engineering calculation books, design drawings, and construction documents that are prepared by Supplier, or any sub-supplier and submitted by Supplier to Company as a basis for approval or Agreement compliance and materials proposed for incorporation in the Work or needed to describe installation, operation, maintenance, or technical properties.

1.2.2 Miscellaneous Submittals are Technical reports, Administrative Submittals, certificates, guarantees, Shop Drawings, product data, and samples.

1.2.2.1 Technical reports include laboratory reports, tests, technical procedures, technical records, and Supplier's design analysis.

1.2.2.2 Administrative Submittals are those nontechnical Submittals required by the Agreement. These Submittals include maintenance agreements, photographs, physical work records, statements of applicability, copies of industry standards, project record data, security / protection / safety data, and similar types of Submittals.

1.2.2.3 Certificates and Guarantees are those Submittals on equipment and materials where a written certificate or guarantee from the manufacturer or Supplier is called for in the Specifications.

1.2.2.4 Shop Drawings include custom-prepared data of all types including drawings, diagrams, performance curves, material schedules, templates, instructions, and similar information not in standard printed form applicable to other projects.

1.2.2.5 Product data include standard printed information on materials, products and systems; not custom-prepared for the Work under this Agreement, other than the designation of selections from available choices.

1.2.2.6 Samples include both fabricated and un-fabricated physical examples of materials, products, and Work; both as complete units and as smaller portions of units of Work; either for limited visual inspection or (where indicated) for more detailed testing and analysis. Mock-ups are a special form of samples, which are too large to be handled in the specified manner for transmittal of Sample Submittals.

1.3 Quality Requirements

1.3.1 Submittals shall be legible and of a quality for reproduction purposes. Drawings issued by electronic media shall be useable for further reproduction to yield a legible hard copy.

1.3.2 Supplier shall apply professional seal(s) to documents as required by the governing state laws, rules and regulations, where applicable.

1.4 Language and Dimensions

1.4.1 All dimensional units shall be in English units.

1.4.2 All words shall be in the English language, for use at the construction site.

1.5 Submittal Completeness

1.5.1 Submittals shall be complete with respect to dimensions, and other information specified to enable Company to review the information effectively.

1.5.2 Where standard drawings are furnished that cover a number of variations of the general class of equipment, each such drawing shall be highlighted to describe exactly which parts of the drawing apply to the equipment being furnished.

1.6 As-Built Requirements

1.6.1 All Drawing Submittals required for maintenance, operation and physical locations shall be conformed to as-built conditions.

1.6.2 As-built information shall be submitted at time of Acceptance.

2. COMPLIANCE SUBMITTALS.

2.1 General

The Compliance Submittals shall be broken down into two categories: Approval Required Compliance Submittals and Other Compliance Submittals.

2.2 Approval Required Compliance Submittals

2.2.1 All Approval Required Compliance Submittals shall be:

2.2.1.1 Approved by the Company.

2.2.1.2 Resubmitted on each revision for the number of times required to obtain compliance with the Agreement. Revisions by Company to re-Submittals shall be limited to those items that were not shown in the previous Submittals unless it is not in compliance with the Agreement. Any need for re-Submittals in excess of the number set forth in the accepted schedule, or any other delay for which Supplier is responsible, will not be grounds for extension of the Project Schedule.

2.2.2 Approval Required Compliance Submittal information categories developed by Supplier shall include the following data and information as applicable to the particular equipment and materials:

2.2.2.1 Equipment specifications.

2.2.2.2 General Arrangement drawings.

2.2.2.3 Piping and instrument diagrams for all systems, included in the Work.

2.2.2.4 Pump curves showing minimum, maximum and design point information.

2.2.2.5 Electrical one-line and three-line drawings.

2.2.2.6 Logic diagrams in SAMA (ISA) or IEC format.

2.2.2.7 All operating and maintenance manuals

2.2.3 If Supplier commences Work prior to approval, it shall be at Supplier's risk until the Submittal has been stamped "Submittal Accepted" or "Submittal Acceptable as Noted" by Company.

2.3 Other Compliance Submittals

2.3.1 Foundation Design Information- Not Required

2.3.1.1 Foundation loading and condensate pump center of gravity including weights of all accessories.

2.3.1.2 Details of foundation interface.

2.4.1.3 Structural loading data indicating the reactions transmitted to the foundation at each support location.

2.3.2 Test information:

2.3.2.1 Reports of factory and field tests.

2.3.2.2 Reports of factory and field inspections as specified in the technical specification divisions.

2.3.2.3 Test Reports:

a. Responsibilities of Supplier and Company regarding tests and inspections of equipment and materials and completed Work are set forth elsewhere in this Agreement.

b. The Party specified as responsible for testing or inspection shall in each case, unless otherwise specified, arrange for the testing laboratory or reporting agency to distribute test reports to all parties.

2.3.3 Instruction Books and Operating Manuals.

Equipment instruction books and operating manuals will contain the equipment Supplier's standard information and will follow the Supplier's standard format. They shall be prepared by the Suppler, or manufacturer, if applicable, including the following:

- Index and tabs.
- Instructions for installation, start-up, operation, inspection, maintenance, parts lists and recommended spare parts, and data sheets showing model numbers.
- Applicable drawings.
- Warranties and guarantees.
- Address of nearest manufacturer-authorized service facility.
- All additional data specified.

2.3.3.1 The electronic media equipment instruction books and operating manuals will utilize Company approved software. All information included in the manuals will be included in the electronic media document.

2.3.3.2 Installation, Operation, Maintenance and Spare Parts Manuals including inspection schedules shall be furnished containing the necessary information required to perform on-line and off-line routine maintenance and to maintain, overhaul, and repair all components of the plant.

2.3.3.3 Preventative maintenance activity schedules shall be provided that address operating and calendar hours, types of routine inspections, trouble-shooting check lists, replacement parts lists, and scheduling or inspection intervals.

2.3.4 Information listed above shall be bound into standard binders. Sheet size shall be (8-1/2 X 11). Binder color shall be selected by Supplier. Capacity shall be a minimum of 1-1/2-inches, but sufficient to contain and use sheets with ease. Provide with following auxiliaries:

- Label holder.
- Business card holder.
- Sheet lifters.
- Horizontal pockets.

2.3.5 The following information shall be imprinted, inserted or affixed by label on the binder front cover:

- Equipment name
- Manufacturer's name.
- Project name.
- Agreement Name and number.

2.3.6 The following information shall be imprinted, inserted, or affixed by label on the binder spine:

- Equipment name.
- Manufacturer's name.
- Volume number (if applicable).

2.4 Procedure for Compliance Submittals

2.4.1 Supplier shall prepare for Company's review and approval, a schedule for submission of Compliance Submittals specified for Company approval of the use of equipment and materials proposed for incorporation in the Work or needed for proper installation, operation, or maintenance. This schedule for Compliance Submittals will be agreed to prior to approval of the Agreement and attached to this Agreement Schedule.

2.4.2 The schedule shall indicate the required date for original submission of each item in the schedule and the anticipated date for Company's acceptance or comments thereof, and shall account for at least one resubmission of each item that requires Company approval.

2.5 Transmittal of Compliance Submittals

2.5.1 All Compliance Submittals shall be in an electronic format acceptable to the Company, .tif and / or .pdf is preferred.

2.5.2 All Compliance Submittals shall be accompanied with a Letter of Transmittal with the following information:

2.5.2.1 Supplier's file name / drawing number.

2.5.2.2 Supplier's revision number / letter.

2.5.2.3 Description of file / drawing title.

2.5.2.4 Sub-supplier's name (if applicable).

2.5.2.5 Sub-supplier's drawing number (if applicable).

2.5.2.6 Sub-supplier's revision number (if applicable).

2.5.3 Each drawing or sheet to be reviewed shall be in a separate file.

2.5.4 After checking and verifying, Supplier shall transmit all Compliance Submittals to Company and the Compliance Submittal or the Letter of Transmittal shall:

2.5.4.1 Identify each Compliance Submittal by project name and number, Agreement title and number, and the Specification Section and article number attached to the file and in a Letter of Transmittal file.

2.5.4.2 Check and annotate Compliance Submittals of Sub-supplier with Supplier's approval prior to transmitting them to Company. Supplier's stamp of approval shall constitute a representation to Company, that Supplier has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data, or Supplier assumes full responsibility for doing so, and that Supplier has coordinated each Compliance Submittal with the requirements of the Work and the Agreement.

2.5.4.3 At the time of each submission, call to the attention of Company in the Letter of Transmittal file any deviations from the requirements of the Agreement.

2.5.4.4 Direct specific attention in the Letter of Transmittal, or on revised Submittals, to changes other than the modifications called for by Company on previous Submittals.

2.5.5 Final Submittals.

2.5.5.1 After Submittals have been accepted, issue copies thereof for record. Files of accepted drawings transmitted for final distribution will not be further reviewed and are not to be revised. If errors are discovered during manufacture or fabrication, correct the Submittal and resubmit for review.

2.5.5.2 All FINAL drawings are required prior to shipment of the equipment. FINAL drawings, instruction books, and manuals shall incorporate all approval corrections made to the approval submittals.

2.5.6 Quantity Requirements.

2.5.6.1 Except as otherwise specified, transmit all of Supplier's or any Sub-supplier's Compliance Submittals in the quantity as follows:

- Initial Submittal: One electronic file to Company. Comments will be returned to Supplier.
- Re-Submittals: One electronic file to Company. Comments will be returned to Supplier.
- Submittal for Final Distribution: Two electronic media copies plus six hard copies to Company.
- As-Constructed Prints: Electronic file plus 2 hard copies to Company.

2.5.6.2 Transmit Submittals of equipment instruction books and operating manuals as follows:

- Initial Submittal: One electronic file to Company. Comments will be returned to Supplier.
- Re-Submittals: One electronic file to Company. Comments will be returned to Supplier.
- Submittal for Final Distribution: Two electronic media copies plus six (6) hard copies to Company.

2.5.6.3 Transmit Submittals for Reference Only: One electronic copy to Company.

2.5.6.4 Company may copy and use for internal operations and staff training purposes any and all document Submittals required by this Agreement, whether or not such documents are copyrighted, at no additional cost to Company. Supplier shall be responsible for obtaining all licenses and approvals to enable Company to make such use of the Submittals.

2.6 Company Review

2.6.1 Company will review and comment on Compliance Submittals to Supplier when Submittals do not conform to the Agreement. Instruction books and similar Submittals will be reviewed by Company for general content but not for detailed substance.

2.6.2 Company's acceptance of Compliance Submittals will not relieve Supplier from its obligations as stated in the Agreement.

2.6.3 Supplier shall allow in its schedule for the Work, fourteen (14) calendar days turnaround time from the day the Company/Engineer receives the Compliance Submittals to when the Supplier shall receive returned Compliance Submittals. Compliance Submittals will be returned electronically.

2.6.4 Any need for re-submittals or any other delay for which Supplier is responsible, will not be grounds for extension of the Project Schedule.

2.7 Submittal Action Stamp - For Approval Required Compliance Submittals:

Company will attach its review comment annotation to each Approval Required Compliance Submittal when Company returns such Submittal to Supplier. The Company/Engineer will stamp each drawing with one of the following status codes which instruct the Supplier how to proceed with fabrication:

2.7.1 Status 1: No exception taken. Supplier/Contractor may proceed with fabrication or construction in accordance with specification.

2.7.2 Status 2: Supplier/Contractor may proceed with fabrication in accordance with specification based on making revisions as noted and resubmit.

2.7.3 Status 3: Results do not meet specification requirements. Revise as noted and resubmit. Hold fabrication.

2.7.4 Status 4: For information only, review not required.

3. MISCELLANEOUS SUBMITTALS.

3.1 General

3.1.1 Miscellaneous Submittals do not require Company's review for compliance with the Agreement. Miscellaneous Submittals will be submitted in electronic media. Miscellaneous Submittals include:

3.1.2 Instrumentation Information:

3.1.2.1 Tabulation of all instruments furnished, with each assigned a unique designation, including type of instrument, manufacturer and manufacturer's model number.

3.1.2.2 Complete manufacturer's specifications for each type and model number of instrument.

3.1.2.3 Each instrument shall be identified by its unique designation whenever it appears.

3.1.2.4 Maximum operating torque requirements for all dampers and vanes. Provide maximum torque requirements for each such damper at full open, full closed and at least one intermediate position. At least one of these points shall represent the maximum torque requirement of the damper. Also provide the maximum allowable torque and forces to prevent damage to the damper components.

3.1.2.5 Provide functional description of drive operation plus all design details required to define the inputs from control systems furnished by others such as thrust or torque for control drives, linkage data, type of input control signal, etc.

3.1.3 Equipment lay-down and pull space area requirements with component weights and overall dimensions that will be required during the installation of the pumps. This information may be included on the outline drawings with boxed out areas representing reserved areas.

3.1.4 Motor nameplate data for all motors furnished in the form of nameplate drawing or a completed proposal data form certified to be actual nameplate data.

3.1.5 Schematic control diagrams:

3.1.5.1 Complete elementary diagram of all control and alarm functions, both internal and external to the equipment.

3.1.5.2 Identification of all external connection terminals and terminal blocks.

3.1.5.3 Symbols conforming generally to ANSI or ISA or other industry accepted standards.

3.1.5.4 External connection wire colors and circuit designations on Field Construction wiring drawings.

3.1.6 Wiring diagrams:

3.1.6.1 Complete physically oriented diagram of all wiring internal to the equipment.

3.1.6.2 Conventional type wiring diagram with each wire or wire bundle shown by a line, or a point-to-point-type wiring diagram with individual wire destinations listed at the location of each termination.

3.1.6.3 Identification of all device and equipment terminals, and all internal and external connection terminal blocks.

3.1.6.4 All external wiring connections with wire colors and circuit designations.

3.1.7 Printed circuit board information if provided by Supplier:

3.1.7.1 Schematic diagram and physical wiring diagram of board, or Photographs with parts labeled in lieu of physical wiring diagram for each type of board when available.

3.1.7.2 Parts list containing complete description of all discrete components and integrated circuits when available.

3.1.7.3 May be included in instruction book in lieu of separate Submittal.

3.1.8 Device list, or bill of material of all instrument and control devices:

3.1.8.1 Tag numbers

3.1.8.2 Manufacturers.

3.1.8.3 Data or specification sheet numbers or cross reference stating what the device is.

3.1.9 Process Control Diagrams:

3.1.9.1 All major items and their correct functional relationships. Diagrams shall be accomplished in SAMA (ISA) or IEC format.

3.1.9.2 Tag numbers.

3.1.10 Data Sheets or Specification Sheets for each significant device furnished by this Agreement. These shall be the actual sheets used for ordering and fabrication, and shall include the primary manufacturer's own sheets where applicable in addition to the Supplier's purchase order forms, including:

3.1.10.1 Tag numbers.

3.1.10.2 Manufacturer.

3.1.10.3 Complete catalog or model number.

3.1.10.4 Scale range.

3.1.10.5 Complete electrical information, including current and voltage ratings, contact action (SPST, DPDT, etc.).

3.1.10.6 Other pertinent technical data.

3.1.10.7 All auxiliaries required such as capillary tubes, diaphragm seals, etc.

3.1.11 Outline drawings for each type of device furnished. One typical drawing may be used for all devices of the same type, but the drawing shall be marked to list the tag numbers of all devices to which it applies.

3.1.12 Electric motor data:

3.1.12.1 Nameplate data for motors rated 460 volts and above, including:

- Manufacturer's name and serial number.
- Horsepower rating.
- Time rating.
- Temperature rise and method indicated.
- Maximum ambient temperature.
- Insulation class.
- RPM at rated load.
- Frequency.
- Number of phases.
- Voltage.
- Rated load amperes.
- Power Factor at rated load.
- Efficiency at rated load.
- Locked rotor amperes or code letter.
- Service factor.

3.1.12.2 Wire and Cable Data:

- Engineering Data Sheets from the manufacturer for each type and size of cable supplied to the project. The data sheet is to indicate the conductor material, type of stranding, conductor coating, strand shielding for medium voltage cable, insulation material, insulation, insulation shielding, and jacket material.
- The national or international standards that were used as the specification for the cable is to be listed with the applicable paragraphs noted.
- The cable is to be marked to identify the manufacturer, conductor size, insulation and jacketing material, and any designations that apply from the cable standards followed.
- Cable pulling compounds approved by the cable manufacturer is to be listed for use by the installing Supplier.

3.1.12.3 All drawings, catalogs or parts thereof, manufacturer's specifications and data, samples, instructions, written guarantees and other information specified or necessary:

- For the proper erection, installation, operation and maintenance of the equipment and materials which Company will review for general content but not for substance.
- For Company to determine what supports, anchorages, structural details, connections and services are required for the equipment and materials, and the effects on contiguous or related structures, equipment and materials.

3.2 Transmittal of Miscellaneous Submittals

3.2.1 All Miscellaneous Submittals furnished by any Sub-supplier shall be submitted to Company by Supplier in electronic media acceptable to Company unless otherwise specified. Each submission of a Miscellaneous Submittal shall be accompanied by a Letter of Transmittal and shall:

3.2.1.1 Identify each Miscellaneous Submittal by project name and number, Agreement title and number, and the Specification section and article number marked thereon or in the Letter of Transmittal.

3.2.1.2 At the time of each submission, call to the attention of Company's in the Letter of Transmittal any deviations from the requirements of the Agreement.

3.2.2 Quantity Requirements:

3.2.2.1 Technical reports and administrative Submittals except as otherwise specified:

One electronic file and one hard copy to Company.

3.2.2.2 Written Certificates and Guarantees:

One electronic file and one hard copy to Company.

3.2.2.3 Transmit Submittals of product data as follows:

- Initial Submittal: Electronic file to Company. Comments will be returned to Supplier.
- Re-Submittals: Electronic file to Company. Comments will be returned to Supplier.
- Submittal for Final Distribution: Electronic file plus six hard copies to Company.

3.2.2.4 Transmit Submittals of material samples, color charts, and similar items as follows:

- Initial Submittal: Three (3) each to Company.
- Re-Submittals: Three (3) each to Company.
- Upon approval, One (1) Sample will be returned to Supplier.

3.3 Company's Review:

3.3.1 Company will review Miscellaneous Submittals for material deficiencies.

3.3.2 Company will respond to Supplier on those Miscellaneous Submittals that indicate Work or Equipment and material deficiency.

3.3.3 Supplier shall allow in its schedule for the Work, fourteen (14) calendar days turnaround time from the day the Company/Engineer receives the Miscellaneous Submittals to when the Supplier shall receive returned Miscellaneous Submittals. Miscellaneous Submittals will be returned electronically.

3.3.4 Any need for re-submittals or any other delay for which Supplier is responsible, will not be grounds for extension of the Project Schedule.

The following documents or notices shall be required as deliverables as indicated below:

[Specifier – Revise submittal dates per project requirements.]

Submittal Item for Relief Valves Documentation	Calendar Days		Event	LD
General Submittals				
Quality Assurance/Quality Control Plan, ISO 9000 certification			With Proposal	No
Insurance Certificates	20	After	Agreement Effective Date	No
Recommended Spare Parts List	20	Before	Shipment	No
Shipment Plan	20	Before	Shipment	No
Estimated Force Majeure delay	5	After	Beginning of force majeure event	
Information and estimated delay related to labor disputes		Upon	Knowledge	No
Status Reports	1st	Business Day	Monthly	No
Startup and Commissioning spare parts list	20	Before	Shipment	No
Pre-shipment inspection notice (including window of inspection) for shipments that Company requests to inspect	14	Before	Shipment	No
Bill of materials	20	Before	Arrival of first equipment on site	No

Submittal Item for Relief Valves Documentation	Calendar Days		Event	LD
Hazardous Materials Documentation	20	Before	Arrival on Site	No
Shipping Notice and detailed Packing List		Upon	Shipment	No
Safet Valve Submittals				
Master Document List (MDL)	20	After	Agreement Effective Date	No
Schedule	10	After	Agreement Effective Date	No
Valve Cut Sheets		With	Proposal	No
Valve Data Sheets		With	Proposal	No
Noise Calculations		With	Agreement Effective Date	No
Hydrostatic test report	7	After	Test	No
Seat leakage test report	7	After	Test	No
Certified Material Test Reports		Upon	Shipment	No
Storage Procedures for Equipment		Upon	Shipment	No
Operating and Maintenance Manual		Upon	Shipment	No

Note: Submittals listed are generic categories and some submittals may be combined or split apart as Supplier

Appendix 2

Proposal Data Requirements

DATA TO BE FURNISHED BY SUPPLIER

3.1 Performance

Variable	Unit	Data
Set Pressure	Psig	
Valve Capasity	lb/hr	
Temperature	Deg. F	
Over pressure	%	
Blowdown	%	
Back pressure	Psig	
Sound Power Level	dB(A)	

3.2 Design Data

Manufacturer		
Model Number		
Size and Type		
Body Style		
	Design Temp	
	Design Pressure	
	End Connection – In	
	End Connection – Out	
	Material	
	Orientation	
Trim Material		
	Seat	
	Disc	
	Spring	
	Bonnet	
Orifice Designation		
Accessories		
	Cap without Lever	
	Lifting Lever	
	Test Gag	
	Flame Arrestor	
Service Condition		
Process Fluid		
Code Designation		
Weight		

3.1 Valve Cut Sheet

To be included

END OF SECTION

Appendix 3
Performance guarantees

Section not required

APPENDIX 4
SITE CONDITIONS

1. SITE CONDITIONS.

1.1 Summary

1.1.1 This Schedule outlines the site conditions used as the basis for Performance Guarantees, Performance Tests and Facility demonstration tests.

1.1.2 During all such tests, the Facility is required to meet the Environmental Compliance Guarantees.

1.2 Site Location

Company's XXX Station site is located XXX

2. AMBIENT DESIGN CRITERIA.

2.1 Plant Elevation

The site elevation of the top of concrete of the HRSG operating floor will be elevation XXX

2.2 Temperature and Humidity

- Maximum Summer Extreme Temperature — XXX °F
- Summer Design Dry Bulb Temperature — XXX °F
- Summer Design Wet Bulb Temperature — XXX °F
- Winter Design Dry Bulb Temperature — XXX °F
- Minimum Winter Extreme Temperature — XXX °F

XXX °F

2.3 Guarantee Point Conditions

- Dry Bulb Temperature — XXX °F
- Wet Bulb Temperature — XXX °F

2.4 Indoor Temperatures

- Summer design temperature (ventilated areas) — XXX °F
- Winter design temperature (heated areas) — XXX °F
- Winter design temperature (freeze protection) — XXX °F

XXX °F

2.5 Seismic Requirements

Site is located in a Seismiz zone X

APPENDIX 5
QA/QC

(Specifier, get with your QA/QC department for additional items for this section)

1. See section 2.10 for additional Quality Requirements.

Appendix 6

Startup, Commissioning, and Testing

1. Reference Section 2.15 for Startup and commissioning requirements.

2. **WORK SCHEDULE.**

2.1 General

2.1.1 Exhibit 4 sets the requirements for the Work Schedule. The Supplier shall use the critical path method (CPM) of scheduling to plan, manage and execute the Agreement Work. The Work Schedule will be used to report progress, evaluate changes and to validate progress payments in accordance with the Payment Schedule stated in Exhibit 5.

2.1.2 Supplier shall submit the Work Schedule to Company for review and acceptance. The Company shall review and comment on the schedule to ensure that the Supplier's plan meets the Project Schedule dates defined in Section 1.5 of this Exhibit 4 and does not conflict with any Company obligations. Upon agreement with Supplier concerning any necessary revisions, the Work Schedule will be accepted. The accepted Work Schedule shall become the Baseline Work Schedule and shall be binding to the Supplier. The Work Schedule will be updated at least once each month to show actual progress compared to the Baseline Work Schedule.

2.2 Definitions

2.2.1 "Activity" means, a separate and distinct part of the Agreement that can be identified for planning, scheduling, monitoring, and controlling the Work. Activities shall have a defined start date and finish date. The duration of an activity shall not normally exceed 30 calendar days. Activities shall not normally reflect the work of more than one discipline.

2.2.2 Critical Activities: Activities on the critical path, and have zero or negative total float.

2.2.3 Predecessor Activity: An activity that must start or finish before it's successor activity can start or finish.

2.2.4 Successor Activity: An activity that cannot start or finish until it's predecessor activity has started or finished.

2.2.5 "Baseline Work Schedule" means the original approved Work Schedule.

2.2.6 “Critical Path Method (CPM)” means a method of planning and scheduling a construction project where activities are arranged based on activity relationships and duration of each activity; and network mathematical calculations determine when activities can be performed and the critical path of the Work.

2.2.7 “Critical Path” means the longest continuous chain of activities through the Work Schedule that establishes the minimum overall duration from Full Notice To Proceed to Acceptance.

2.2.8 “Milestone” means a key or critical point in time for reference or measurement. A milestone has no duration.

2.2.9 “Total float” means the amount of time an activity can be delayed without adversely affecting an intermediate deadline or the Acceptance Date.

2.3 Work Schedule Requirements

2.3.1 The Work Schedule shall be developed and maintained in Primavera Project Planner (P3) version e/c. Use of P3 Enterprise is not an acceptable alternative. The activity code dictionary for the P3 Schedule shall be structured to allow codes for Phase, Discipline, Unit, Area, System, Component, Submittal Type / Number and Milestone Type / Number.

2.3.2 It is intended that the Work Schedule reflect the Supplier’s actual plan for accomplishment of the Work.

2.3.3 The Work Schedule shall represent the entire Agreement Scope of Work.

2.3.4 The Work Schedule shall divide Work into separate detailed activities that define each major portion of the Work, with dates activities are expected to start and finish.

2.3.5 The Work Schedule shall address all phases of the Work including but not limited to engineering, design, procurement, manufacturing, shipment, prefabrication, installation, testing, startup, commissioning, and closeout.

2.3.6 The Work Schedule shall indicate times when submissions, reviews or approvals by Company are required.

2.3.7 The Work Schedule shall include all guaranteed agreement dates.

2.3.8 The Work Schedule shall be defined in more detail for critical and near critical path activities.

2.3.9 To the greatest extent practical, predecessors and successors shall be applied to all activities. Adequate consideration shall be given to these logical relationships to represent requirements for design evolution, procurement lead times, activity sequencing, commissioning strategy and overall resource leveling.

2.3.10 The Procurement / Production / Shipping Schedule shall be an integral part of the Work Schedule. Each line item in the Procurement / Production / Shipping Schedule shall be represented in the Work Schedule. At a minimum, procurement scheduling shall indicate the date each item will be needed at the Facility Site, the time required for delivery, the time required for manufacturing, the date the order is placed and dates for receipt of Supplier's drawings.

2.3.11 The Submittal Schedule, as set forth in Exhibit 2, shall be an integral part of the Work Schedule. Each line item in the Submittal Schedule shall be represented in the Work Schedule. At a minimum, activities for prepare, submit, review, comment, re-submit and approval shall be represented in the schedule.

2.3.12 The Payment Schedule, as set forth in Exhibit 5, shall be an integral part of the Work Schedule. Each line item in the Payment Schedule shall be represented in the Work Schedule and shall be cost-loaded with the associated value. These values shall sum to the total Agreement Price and shall accurately reflect fair and reasonable amounts and include all elements of cost.

2.3.13 Schedule Liquidated Damage milestones, as set forth in Exhibit 6, shall be an integral part of the Work Schedule.

2.4 Schedule Updates and Reportings

2.4.1 On the first Business Day of each month, Supplier shall submit to Company an updated Work Schedule reporting the progress from the previous month. The Baseline Work Schedule and each subsequent update shall be submitted electronically in a format allowing Company to maintain an integrated master project schedule. The Work Schedule provided by the Supplier to Company shall be the most detailed schedule it has available.

2.4.2 Work Schedule updates shall be furnished to the Company in the form of electronic reports, in various sorts, so that the Company may easily read and analyze the information. Work Schedule reports shall show the Work in a horizontal bar chart or other graphic format suitable for displaying scheduled and actual progress. Work Schedule reports shall clearly identify actual start and finish dates in direct comparison to baseline dates. In-progress activities shall indicate percentage completion. Work Schedule reports shall include as a minimum, early start, early finish, late start, late finish, original duration, and remaining duration. Narratives of the Work Schedule update identifying problems and proposed solutions shall be included in the Monthly Progress Report.

2.5 Project Schedule

2.5.1 The following Project Schedule sets forth the schedule requirements for executing the Work. Suppliers shall review the Project Schedule provided herein and develop their Work Schedule in accordance.

XXX **PROJECT SCHEDULE**	**Start Date**	**End Date**
Delivery Complete	XXX	XXX

APPENDIX 7
Packaging, Shipping and Storage

1. Reference Section 1.4 for additional shipping and storage requirements.

APPENDIX 8
Acceptable Suppliers

[Verify preapproved Suppliers with your regional sourcing supply chain management.]

	COMPONENT	PREAPPROVED SUBSUPPLIER
	Safety & Relief Valves	Anderson-Greenwood Consolidated Dresser Crosby Kunkle
1.	Indicators (Electronic)	Dixon (Ametek)
2.	Indicators (Local – Flow, Press., Temp.)	Ashcroft Barton (NuFlo) Dwyer Helicoid (Bristol Babcock) US Gauge (Ametek) Weksler
3.	Limit Switches (Proximity Type)	GO (Topworx)
4.	Media Converters and Managed Switches (Fiber Optic, Ethernet, etc.)	Hirschmann Weed Instruments
5.	Programmable Logic Controllers (PLC)	Square D Allen Bradley (Rockwell Automation)
6.	Solenoid Valves	MAC
7.	Switches (Pressure and Differential Pressure)	ASCO Ashcroft Barksdale Barton (NuFlo) SOR Square D
8.	Switches (Temperature)	Barksdale SOR Square D
9.	Switches, Level	Drexelbrook FCI Magnetrol
10	Tubing Fittings	Swagelok
11	Transmitters (Flow – Non Differential Pressure)	FCI Kurz Yokogawa
12	Transmitters (Level – Non Differential Pressure)	Drexelbrook (Ametek) Endress + Hauser KTEK Magnetrol Ohmart/VEGA
13	Transmitters (Pressure and Differential Pressure - SMART)	Rosemount (Model 3051, 4-20 mA output with HART protocol and LCD display)
14	Vibration Monitoring Equipment	Vibrex, PMC Beta, Vitec, Metrix, Bentley Nevada

APPENDIX 9
Safety Valves Data Sheets

	Project Title		Data Sheet No.		
			Issued by		
			Revision		
			Date		
Safety Valve Data Sheet					
Tag No.	QTY of Valves		Fluid		
Manufacturer	Service/Use			Installation	
Model Type	Design Code			Max. Noise	
Protected System				**Basis of Selection**	
Design Pressure	Psig			Code Requirement:	
Design Temperature	F				
Accumulation	%			Basis of Selection:	
Discharge to					
Safety Valve Location					
Line Size	Size		Schedule		
Line		in.		in.	
Branch In	By Supplier	in.		in.	
Branch out	By Supplier	in.		in.	
Operating Conditions					
Fluid					
Required Capacity			lb/hr		
Max operating pressure			Psig		
Max operating temperature			F		
Valve Set Pressure			Psig		
Relieving Temperature			F		
Back pressure on valve			Psig		
Back pressure constant	Yes or No				
Back pressure variable	Yes or No				
Over pressure - % Set Pressure					
Spring Set Pressure hot-cold			Psig		
Cp/Cv					
Compressibility Factor					
Blowdown in % set pressure					
Calculated orifice area			Sq in		
Selected orifice area			Sq in		
Isentropic Exponent					
Capacity of Selected Valve			Lb/hr		
Valve Type			**Body**		
Type			Material		
Nozzle Type				End Conn.	Size/Class
Bonnet			Inlet		
Pilot			Outlet		
			Orifice Desig.		
Trim Material			Accessories		
Seat / Disc			Cap with Lever		
Springs			Lifing Lever		
Bellow			Test Gag		
			Flame Arrestor		
Supplier					
Manufacturer					
Model			Serial Number		
Weight			Cut Sheet Ref.		
Notes:					

MASTER SPECIFICTION
FOR
Pipe Supports and Hangers

REVISION HISTORY

Date	Revision	Change Description
11-19-2014	1.0	New

Pipe Supports and Hangers

GENERAL

DEFINITIONS

Contractor/Bidder - The Company proposing to supply the materials, erection services to fulfill the bid requirements of this specification. Also, the company who accepts the Owner's contract and overall responsibility for fulfilling the installation requirements of this specification.

Owner - Xcel Energy, the Owner of the Equipment.

Pipe Supports – The term "pipe supports" includes all assemblies such as hangers, floor stands, anchors, guides, brackets, sway braces, vibration dampeners, positioners, and any supplementary steel required to attach pipe supports.

PPE – Personal Protective Equipment, the workers individual protective equipment provided to him by contractor that is necessary to do the work in compliance with the plant rules and all OSHA and EPA rules. (Hard hats, gloves, hearing protection, proper safety glasses, harnesses, respirators etc. used on the job)

SUMMARY

Introduction
This is a project to remove, furnish, and install Pipe Supports on the said project.

Scope Description
Contractor shall provide all materials, labor, and equipment to remove, furnish, and install all Pipe Supports per the provided SOW for the (System) servicing the ___________ Station.

The work includes ____. Removal and proper disposal of all debris and materials; supply of all materials and consumables, erection in place of components and all construction, including warranties and guarantees described below.

APPLICABLE CODES AND STANDARDS

Codes and Standards

1. **Materials and Components**
   All pipe hanger and supports shall be designed and manufactured to the following codes and standards:
   1. American Society Mechanical Engineers (ASME)
   2. American National Standards Institute (ANSI)
   3. Manufactures Standardization Society (MSS)
   4. UL203 Standard for Pipe Hanger Equipment and Fire Protection Service
   5. Metal Framing Manufactures Association
   6. Local Building Codes.
   7. National Fire Protection Association (NFPA0

2. **Access and Safety**
   All provisions for access and safety shall comply with the latest requirements of OSHA, and any state and local ordinances and standards. Also, see section 6.3 for requirements of the contractor's dedicated safety officer. This project is identified as **(Risk Level)**; the awarded contractor shall submit a written site (project/job)-specific safety and health plan (SSSHP) that addresses each potential hazard identified in the assessment (See appendix B) to the Project/Contracting Manager and Safety Representative. This plan must be submitted to Xcel Energy for review, prior to work beginning. It is the responsibility of the contractor to inform their employees and subcontractors of the SSSHP.

TECHNICAL REQUIREMENTS

Demolition and Removal

1. **Demolition**
   The Contractor shall be responsible for all removed demolition debris from the existing Piping. During demolition, if any significant damage is caused by the Contractor of any existing plant materials or equipment the costs of repair will be paid by the Contractor. The cost of repair(s) will be directly deducted from the Contractor's invoice(s).
2. **Removal of Debris**
   The Contractor shall be responsible for removing all demolition debris from the jobsite, including disposal of hazardous material and any applicable environmental protection, as may be appropriate. The Contractor shall be responsible for all workers PPE during the demolition and removal process. Any hazardous materials; lead based, asbestos, PCB or other, will be handled according to their own requirements, stored and hauled away in compliance with Xcel Energy Environmental services.

   - The Contractor shall bear all handling and transportation costs for the materials to be delivered to the approved landfill.

- The Contractor shall be required to fill out any manifest(s) for transportation as required. Xcel Energy shall prepare and sign all source manifests as well as pay all disposal fees for the materials.

Engineering

1. **Pipe Support and Hangers**
   The specification, codes and standards are used as a reference and guide only. The final design is the design engineer's responsibility. Proper standards, load calculations, materials and hangar spacing are to be designed by the Contractor and approved by the Company. Codes and Standards applicable to this design are not limited to the ones listed above and it is the responsibility of the Contractor to verify the proper codes and standards are followed when engineering the Pipe Support and Hangers.

Materials of Construction

1. **Pipe Support and Hangers**
   Support component materials shall be suitable for service at the operating temperature of the pipe to which they are attached. Where support component temperature is below 750°F, component material shall be carbon steel or of an ASTM type having minimum yield strength of 35,000 psi, and a minimum ultimate strength of 58,000 psi.

   Where support component temperature is 750°F to 939°F, component material shall be chromium-molybdenum alloy steel having material, strength, and creep properties equal to or better than the pipe being supported. Where support component temperature exceeds 950°F, they shall be fabricated from materials having physical properties equal to or better than the following.

   These material requirements apply to parts that are wholly, or partially, within 9 inches of the outside of the pipe, including further extension of the part until it is completed:

Material nominally 2 1/4% chromium, 1% molybdenum	
Plate	ASTM A387 Grade 22
Pipe	ASTM A335 Grade P22
Material nominally 1% chromium 1/5% molybdenum	
Bolts, studs, and rod	ASTM A193 Grade B7
Nuts	ASTM A193 Grade 7
Material nominally 9% chromium, 1% molybdenum	
Plate	ASTM
Pipe	ASTM A335 Grade P91

On copper piping or tubing, the pipe clamp shall be of copper or copper-plated steel. Supports shall be of fireproof construction; no combustible materials shall be used. Malleable iron materials shall not be allowed. Miscellaneous support beams required for attaching supports to the building structure shall conform to ASTM A36. Recommended pipe support spacing is per ASME B31.1Welded pipe attachments are to be minimized.

2. **Mechanical Equipment**
   If it is necessary to remove the existing mechanical equipment, it shall be reused unless otherwise specified in the SOW document. Contractor shall install the existing mechanical components and align them as originally found.
3. **Access and Safety Provisions**
   Any ladders, lifts etc. needed to access the piping will be the responsibility of the contractor. Only certified individuals are allowed to operate machinery.

   Safety Provisions are the responsibility of the Contractor. The Contractor will follow all Xcel Energy Safety Rules stated in the Appendix B and have appropriate equipment on site for the job.

Field Erection

1. **Labor / Manpower**
   The Contractor shall provide sufficient skilled manpower in appropriate trades to execute the work in an efficient and practical manner in accordance with this specification, the schedule and the terms of the contract.
2. **Supervision**
   The Contractor shall provide a Site Superintendent who shall be responsible for supervising Contractor's work force, and for handling all responsibilities for payroll, scheduling, safety, and reporting on progress to the Owner's site representative. If the Contractor deems that a construction trailer is necessary for its operations, then it shall be provided at the Contractor's expense, including installation, removal, and all utilities. It is the responsibility of the Superintendent to have all personnel sign in and out of the plant each day on the main sign in sheet provided at main entrance of each station.
3. **Dedicated Safety Officer**
   The Contractor shall provide a Site Safety officer with considerable project experience who shall be responsible for training and supervision of the entire Contractor's work force including any subcontractors. The site safety officer will be responsible for making sure that all personnel under the Contractors direction are trained in the demolition & construction activities to be undertaken and are planned suitably in advance to be conducted in a safe manner. The site safety officer shall fill out weekly reporting, identify/record any unsafe behaviors, site conditions or work practices, and document these in writing to the Owner. Any near miss or other incident reporting will be required in the format directed by Xcel Energy.
4. **Equipment**
   The Contractor shall provide all equipment necessary to rig, hoist, load, store, or otherwise unload, handle or move materials in the safest, most expeditious means possible in order to meet the schedule.
5. **Other Items**
   Below is a list of project items that will be supplied by the Contractor as to safely complete the project.

   a. Receiving, unloading, storage and protection of delivered materials to Work Area
   b. Temporary scaffolding materials and associated labor for performance of the Work
   c. Temporary rigging for performance of the Work
   d. Containers for construction debris, and waste

e. Contractor's construction trailer
f. Construction crane, JLG, man-lift and qualified operators
g. Power source for Contractor's construction trailer only (supplied by Xcel Energy)
h. Sanitary facilities for the construction crews
i. Potable water, telephone service, lighting, ventilation, electrical service and hook-up
j. Final cleaning and inspection services after installed
k. All preparations for startup/commissioning before turnover of the new tower to Xcel Energy

- All of the above items shall be provided under the Contractor's work scope and in the Contractor's firm price quote. Any/all equipment, machinery, consumables, electrical work and all incidental items not specified or directly referenced herein that must be supplied or conducted for successful completion of the Scope of Work provided by the contractor.

Alternative Materials

- Bidders are invited to propose alternates in terms of materials, or construction, which will be evaluated by the Owner during the bid evaluation process.

<u>Warrantee and Guarantee</u>

1. **Materials and Workmanship**
   The Pipe Support work shall be warranted by the Contractor against any and all defects in materials and/or workmanship for a period of 1 years from the date of acceptance of the work by the Owner.
2. **Acceptance**
   For The purposes of payment under the contract, and for determining the warranty period, Acceptance shall be deemed to occur after mechanical completion, and when the Contractor has resolved any/all issues on a corrective list developed by the Owner. Payment to the contractor shall be forthcoming once all list items are resolved.

QA/QC (Including Inspection Test Plans)

Quality Control

a. The Contractor shall be responsible for implementation of a Quality Control program to ensure the installation meets the particular requirements of this Specification and industry standards. The independent monitoring activities performed by Xcel Energy shall not relieve the Contractor of this responsibility. The Contractor shall document and notify Xcel Energy of any non-conformance or deficient component condition. Any non-conformance of drawings or industry standard construction shall be documented by the Contractor and provided immediately in writing to Xcel Energy's representative. Non-conformances may also be initiated by Xcel Energy. The Contractor should present a disposition report with their recommendation/proposal on corrective action to Xcel Energy.

MASTER SPECIFICTION
FOR

PIPING and VALVES
INSULATION AND JACKETING

Revision 1.0
Date 10-21-14

Revision History

Approved 10-21-14	1.0	New

PIPING AND VALVES INSULATION AND JACKETING

GENERAL

Insulation and jacketing shall be provided on all piping and valves with surface temperatures above 140F. Insulation and jacketing shall also be provided on all piping and valves that are subject to freezing conditions after heat tracing has been installed to prevent freezing when not in operation or during intermittent service. Use of asbestos containing materials is not allowed.

SUMMARY

Specifier – Add discussion of project scope and criteria that must be addressed

APPLICABLE CODES AND STANDARDS

1. ASTM C547 – Standard Specification for Mineral Fiber Pipe Insulation
2. ASTM C335 – Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
3. ASTM E96 – Standard Test Method for Water Vapor Transmission of Materials
4. ASTM C195 – Standard Specification for Mineral Fiber Thermal Insulating Cement
5. ASTM C449 – Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
6. ASTM C552 – Standard Specification for Cellular Glass Thermal Insulation
7. ASTM C578 – Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
8. ASTM C610 – Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
9. ASTM C533 – Standard Specification for Calcium Silicate Bolck and Pipe Thermal Insulation
10. ASTM C177 -
11. ASTM C518 -
12. ASTM C547 – Standard Specification for Mineral Fiber Insulation
13. ASTM C612 – Standard Specification for Mineral Fiber Block and Board Thermal Insulation
14. ASTM C591 -
15. ASTM D2842 -
16. ASTM E84 -

17. ASTM D1056 -
18. ASTM D1667 -
19. ASTM C177 -
20. ASTM C921 -
21. ASTM B209 -
22. ASTM A36 -
23. ASTM C 1728 – Standard Specification for Flexible Aerogel Insulation

TECHNICAL REQUIREMENTS

Specifier – Add discussion of options and criteria that must be addressed

B.1 PIPING INSULATION

B.1.1 Qualifications

Applicator: Company specializing in performing the work of this Section with minimum 3 years experience.

B.1.2 Glass Fiber

Vendors:

- Johns Manville Model AP-T, or Company-approved equal
- Other acceptable vendors offering equivalent products:

Armstrong

Knauf

Owens Corning

Insulation: ASTM C547; rigid molded, non combustible.

- 'K' ('ksi') value : ASTM C335, 0.24 at 75°F
- Minimum Service Temperature: -20°F
- Maximum Service Temperature: ?
- Maximum Moisture Absorption: 0.2% volume

Vapor Barrier Jacket:

- White craft paper reinforced with glass fiber yarn and bonded to aluminized film.
- Moisture Vapor Transmission: ASTM E96; 0.02 perm.
- Secure with self sealing longitudinal laps and butt strips.
- Secure with outward clinch expanding staples and vapor barrier mastic.

All tie wires shall be 18-gauge stainless steel with twisted ends on maximum 12 inch centers.

The vapor barrier lap Adhesive shall be compatible with insulation.

Insulating Cement/Mastic:

- ASTM C195; hydraulic setting on mineral wool

Fibrous Glass Fabric:

- Cloth Weight: Untreated; 9 ounces per square yard (305 g/sq m)
- Blanket Density: 1.0 pounds per cubic foot (16 kg/cu m)

Indoor Vapor Barrier Finish:

- Vinyl emulsion type acrylic, compatible with insulation, white color

Outdoor Vapor Barrier Mastic:

- Vinyl emulsion type acrylic, compatible with insulation, white color

Insulating Cement:

- ASTM C449.

B.1.3 Cellular Glass

Vendors:

- Johns Manville or Company approved equal

Insulation: ASTM C552.

- 'K' ('ksi') value: 0.40 at 75°F
- Maximum Service Temperature: ?ASTM C552 indicates up to 800F?
- Maximum Water Vapor Transmission: 0.1 perm

B.1.4 Expanded Polystyrene

Vendors:

- Owens Corning or approved equal

Insulation: ASTM C578; rigid closed cell:

- 'K' ('ksi') value: 0.23 at 75°F
- Maximum service temperature: 180°F
- Maximum Water Vapor Transmission: 0.1 perm

B.1.5 Expanded Perlite

Vendors:

- Company Approved

Insulation: ASTM C610; granular poured

- 'K' ('ksi') value: 0.28 at 75°F
- Maximum Service Temperature: ?
- Maximum Water Vapor Transmission: 0.1 perm

B.1.6 Hydrous Calcium Silicate

Vendors:

- Johns Manville or Company-approved equal

Insulation: ASTM C533; rigid molded white; asbestos free

- 'K' ('ksi') value: ASTM C177 and C518; 0.44 at 300°F (0.060 at

147°C)

- Maximum Service Temperature: 1,500°F (815°C)
- Density: 13 pounds per cubic foot (208 kg/cu m)

All tie wires shall be 18-gauge stainless steel with twisted ends on maximum 12-inch centers.

Insulating Cement:

- ASTM C449

B.1.7 Mineral Fiber

Vendors:

- Certain Teed
- Eslin
- Company approved equal

Insulation:

- For pipe, ASTM C547, molded; for block ASTM C612, Class 3 with a density of 8 to 12 pounds per cubic foot.
- Maximum Service Temperature 1,200°F

All tie wires shall be 18-gauge stainless steel with twisted ends on maximum 12 inch centers.

B.1.8 Aerogel

Vendors:

Aspen Aerogel

Insulation:

ASTM C 1728

Maximum Service Temperature 1,200°F

Tie Wire:

18-gauge stainless steel on maximum 12-inch centers

B.1.8 Polyurethane Foam

Vendors:

- Company Approved

Insulation:

- ASTM C591, rigid molded modified polyisocyanurate cellular plastic.
- 'K' ('ksi') value: ASTM 518; 0.14 at 75°F
- Minimum Service Temperature: -250°F
- Maximum Service Temperature: 250°F
- Maximum Moisture Absorption: ASTM D2842; 0.054% by volume
- Moisture Vapor Transmission: 1.26 perm
- Maximum Flame Spread: ASTM E84; 20
- Connection: Waterproof vapor barrier adhesive

B.1.9 Polyethylene

Vendors:

- Company Approved

Insulation:

- ASTM D1056 or D1667; flexible, closed cell, polyethylene, slit tubing.
- 'K' ('ksi') Value: ASTM C177; 0.25 at 75°F
- Minimum Service Temperature: -90°F
- Maximum Service Temperature: 212°F
- Density: ASTM 1667; 2 pounds per cubic foot (32 kg/cu m)

- Maximum Moisture Absorption: 1.0% by volume
- Moisture Vapor Transmission: ASTM E96; 0.01 perm
- Maximum Flame Spread: ASTM E84; 25
- Maximum Smoke Developed: ASTM E84; 50
- Connection: Contact adhesive

B.1.10 Cellular Foam

Vendors:

- Company Approved

Insulation:

- ASTM C534; flexible, cellular elastomeric, molded or sheet
- 'K' ('ksi') Value: ASTM C177 or C518; 0.27 at 75°F
- Minimum Service Temperature: -40°F
- Maximum Service Temperature: 220°F
- Maximum Moisture Absorption: ASTM D1056; 1.0% (pipe) by volume, 1.0% (sheet) by volume
- Moisture Vapor Transmission: ASTM E96; 0.20 perm inches
- Maximum Flame Spread: ASTM E84; 25
- Maximum Smoke Developed: ASTM E84; 50
- Connection: Waterproof vapor barrier adhesive

Elastomeric Foam Adhesive:

- Air-dried, contact adhesive, compatible with insulation.

B.1.11 Jackets

PVC Plastic:

- Jacket: (ASTM C921) One (1) piece molded type fitting covers and sheet material:

- Minimum Service Temperature: -40°F
- Maximum Service Temperature: 150°F
- Moisture Vapor Transmission: ASTM E96; 0.002 perm inches
- Maximum Flame Spread: ASTM E84; 25
- Maximum Smoke Developed: ASTM E84; 50
- Thickness: 30 mil
- Connections: Pressure sensitive color matching vinyl tape
- Cover Adhesive Mastic:

Compatible with insulation

ABS Plastic:

- Jacket: One piece molded type fitting covers and sheet material:

Minimum Service Temperature: -40°F

Maximum Service Temperature of 180°F

Moisture Vapor Transmission: ASTM E96; 0.012 perm

Thickness: 30 mil

Connections: Brush on welding adhesive

- Canvas Jacket: UL listed:

Fabric: (ASTM C921) 6 ounces per square yard (220 g/sq m), plain weave cotton treated with dilute fire retardant lagging adhesive.

Lagging Adhesive:

- Compatible with insulation

- Aluminum Jacket: ASTM B209:

Thickness: 0.020 inch for applications up to 13 inch outside diameter, and 0.024 inch for all other applications.

Finish: Stucco embossed

Joining: Longitudinal slip joints and 2-inch (50-mm) laps

Metal Jacket Bands: 3/8 inch (10 mm) wide, stainless steel

B.1.12 Examination

Verify that piping has been tested before applying insulation materials except for systems approved for initial service test in which case joints shall be exposed.

Verify that surfaces are clean, foreign material removed, and dry.

B.1.13 Installation

Install insulation type and thickness as specified on drawings.

Install materials in accordance with vendor's instructions.

On indoor exposed piping, locate insulation and cover seams in least visible locations.

Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature shall be insulated per following requirements:

- Provide vapor barrier jackets, factory applied or field applied.
- Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe.
- Finish with glass cloth and vapor barrier adhesive.
- PVC fitting covers may be used.
- Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
- Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

- Outdoor cold pipe insulation shall be protected with paint or lagging in accordance with Manufacturer's recommendations.
- Insulate cold pipes with elastomeric cellular thermal insulation.

Insulated pipes conveying fluids above ambient temperature shall be insulated per following requirements:

- Provide standard jackets, with or without vapor barrier, factory applied or field applied.
- Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Insulate with either molded insulation or by insulation fabricated from straight pipe insulation segments.
- Finish with glass cloth and adhesive.
- Provide aluminum lagging.
- For hot piping conveying fluids 140°F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- For hot piping conveying fluids over 140°F, insulate flanges and unions at equipment. Use calcium silicate molded insulation, molded mineral fiber insulation, or high density fiberglass rigid molded insulation.

Inserts and Shields:

- Application: Piping 2 inches diameter or larger.
- Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
- Insert Location: Between support shield and piping and under the finish jacket.
- Insert Configuration: Minimum 6 inches (150 mm) long, of same

thickness and contour as adjoining insulation; may be factory fabricated.

- Insert Material: Heavy density insulating material suitable for the planned temperature range.

Finish insulation at supports, protrusions, and interruptions.

For pipe exposed in finished spaces below 10 feet above finished floor, that require insulation finish with PVC jacket and fitting covers.

For exterior applications, provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side 45 degrees off center of horizontal piping. Installation shall protect insulation from the weather. All lagging shall be secured in place using panhead self-tapping screws fitted with neoprene washers. In addition to screws, outdoor lagging shall be secured by machine-attached stainless steel bands spaced on not greater than 24 inch centers

For buried piping, provide factory fabricated assembly with inner all-purpose service jacket with self sealing lap, and asphalt impregnated open mesh glass fabric, with 1 mil (0.025 mm) thick aluminum foil sandwiched between three (3) layers of bituminous compound; outer surface faced with a polyester film.

For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum or stainless steel jacket with seams located on bottom side of horizontal piping. Provide permanent labels identifying line as heat traced visible from access ways at no greater than 20 foot intervals.

Blocks shall be reinforced on the exterior face with expanded metal, if necessary, to prevent sagging or cutting of insulation by lacing wire.

Vertical runs of piping shall utilize support lugs and collars to prevent slippage of the insulation.

All areas of contact between dissimilar metals shall be protected against galvanic corrosion by a suitable insulating coating.

All lagging on curved surfaces shall be machine rolled and formed to fit the insulation curvatures. All joints shall be lapped a minimum of 2 inches and placed to shed water.

Install insulation material and thickness per the drawings.

Top surfaces which are insulated and which could be subject to foot traffic shall also be capable of withstanding a live load of 100 lb/ft^2 without suffering permanent deformation.

No oil or lubrication piping, nor valves or fittings thereof shall be embedded in insulation or covered over with removable panels, flashing, etc.

Insulation of all surfaces shall be applied in two (2) layers using staggered joint construction.

All insulation shall be installed free of gaps and voids.

All insulated and metal lagged surfaces shall be completely water and weather tight, and shall be completely drainable with horizontal surfaces sloped.

Insulation materials shall be inhibited and have low halogen content. Insulation materials shall contain no asbestos.

Antisweat insulation shall be flexible elastomeric cellular thermal insulation. Outdoor antisweat insulation shall be protected with paint or lagging in accordance with the Manufacturer's recommendations.

Piping and small diameter cylindrical equipment insulation shall be hollow cylindrical shapes split in half lengthwise, or curved segments. Large diameter cylindrical equipment and other items of equipment shall be insulated with block or scored block insulation as required to obtain a close fit to the contour. Pipefittings and accessories shall be insulated using either molded insulation or by insulation fabricated from straight pipe insulation segments. Fittings on piping 4 inches and smaller shall be insulated with a fiberglass blanket, where permissible by system temperature, and then covered with preformed lagging.

Methods of fastening insulation, metal lagging, flashing, etc., shall prevent rattling and shall be structurally adequate so that forces due to expansion and contraction, vibration, wind, weight of insulation and lagging or other normal loads shall not loosen or break fasteners.

Spacing of fasteners shall be in a set pattern, both horizontally and vertically, forming straight lines, and shall be placed in order to prevent rattling of the panels or flashing vibration. Any areas of the insulation and metal lagging system noted by the Company to not meet this requirement shall be reworked at the sole cost to the Contractor.

All insulated surfaces of piping and valves shall be lagged except where antisweat insulation is used.

Except as otherwise specified herein, metal lagging for all walls shall be a minimum of 0.040-inch thick, with box-ribbed 4 inches center-to-center, 1 inch depth, ribbed aluminum type 3004.

Except as otherwise specified herein, metal lagging for all roofs and horizontal surfaces shall be a minimum of 0.050 inch thick, with box-ribbed, 4 inches center-to-center, 1 inch depth, ribbed aluminum type 3004.

Flashing and flat lagging, where required in panel work, shall be a minimum of 0.050 inch thick aluminum, type 3003, Alclad.

Outdoor lagging shall be installed to secure a weatherproof installation. Lagging shall be carefully fabricated and fitted to ensure a neat appearance. Open ends of all fluted sections shall be provided with tight-fitting closure pieces.

Removable insulated covers shall be provided over equipment requiring normal maintenance and all equipment manholes, nameplates, and code stampings. Access doors through lagging shall be provided as required.

The finish of all aluminum lagging shall be stucco embossed.

Structural Support Members:

- Structural steel shapes such as angles or Z-sections shall be constructed of ASTM A36 material.
- All hat sections shall be a minimum of 12-gauge aluminized steel.

Fasteners:

- Weld pins shall be 10-gauge capacitor discharge pins, 10-gauge carbon steel or type 304 stainless steel stored arc pins, lengths to suit.
- Insulation clips (speed washers) shall be 2 1/2 inch square for use with 10-gauge weld pins. Clips shall be carbon steel, except that type 304 stainless steel clips only shall be used on type 304 weld pins.
- The option exists of using cup head weld pins meeting the material specifications stated in the preceding two (2) paragraphs in place of pins and clips.
- Welded stud fasteners shall be end weld studs; 1/2 inch diameter by lengths required each with hex nut and standard washer.
- Screwed fasteners shall be No. 14 self-tapping, 410 cadmium plated stainless steel screws and neoprene sealing washers with a

minimum length of 3/4 inch. The washer material shall not stain the lagging material due to environmental or operating conditions and shall not deteriorate due to heat and vibration transferred through the screw from the ductwork or collector.

- The use of “pop” type rivets is not acceptable.
- No welding, pop rivets or friction fasteners shall be allowed for attachment of shop-fabricated panels or field-installed system.
- Any powder actuated or similar device to forcibly impact construction fasteners into the collector, ductwork, or insulation support stiffeners shall not be permitted.

Miscellaneous:

- Galvanized wire mesh shall be used for insulation backing. Mesh shall be 16-gauge, 2 inches by 2 inches, and shall be galvanized after forming.
- Aluminum foil backing for insulation systems shall be 0.0025 inch thick aluminum.
- Material for all siding closure strips shall be Ethylene-Propylene-Diene-Monomer (EPDM).
- Caulking and mastic for weatherproofing outdoor penetrations, laps, etc., shall be Childers, Chil-Joint CP-70 or Company-approved equal. All mastics shall bear the UL label.

Penetration Covers:

- Cover plates, boots, hoods, or flashing required because of penetrations for mechanical components, tubing or piping; and electric devices or conduit, shall be furnished and constructed of materials which are compatible with the specified insulation and metal lagging system.

- All hanger rods, pipes, or other items penetrating any of the insulation and metal lagging systems shall be provided with cover plates, boots, hoods, or flashing to prevent water from penetrating into the installed insulation and so none of the insulation is visible.
- All exterior instrument taps, test connection and other lagging penetrations shall be sealed using a flexible rubber boot seal to prevent the ingress of water. These flexible rubber boot seals shall be manufactured by Sealite Building Fasteners, Tyler, TX (800-352-4864), Construction Fasteners, Inc., Wyomissing, PA (800-CFI-4533) or Company-approved equal.

Insulation Classes for Piping:

- Insulation shall be designed for conditions of 75°F ambient, emissivity of 0.09, no incident solar heating, and 2 mph airflow velocity for a calculated surface temperature of 140°F. Additional insulation shall be provided as necessary to provide freeze protection.

TABLE OF PIPING INSULATION MINIMUM THICKNESS										
	Temperature Range °F									
Pipe Size	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1150
1 1/2 inch and Smaller	1	1 1/2	1 1/2	2	2	2	2	2 1/2	2 1/2	3
2 inch	1	1 1/2	1 1/2	2	2-	3	3	3	3	3 1/2
2 1/2 inch	1	1 1/2	1 1/2	2	2	3	3	3 1/2	4	4 1/2
3 inch	1	1 1/2	1 1/2	2	2	3	3	3 1/2	4	4 1/2
4 inch	1	1	1	2	2	3	3	3	4	4 1/2

		1/2	1/2					1/2		
6 inch	1	1 1/2	2	2	2 1/2	3	3	3 1/2	4 1/2	5
8 inch	1 1/2	1 1/2	2	2	2 1/2	3	3	4	5	5
10 inch	1 1/2	1 1/2	2	2 1/2	3	3 1/2	3 1/2	4	5	5
12 inch and Larger	1 1/2	1 1/2	2	2 1/2	3	3 1/2	3 1/2	4	5	5

Lagging Material and Thickness

Piping	0.02 inch aluminum
Valves and fittings	0.02 inch aluminum

The insulation and lagging system shall be designed for upset temperature conditions for periods of 1 hour shall be considered in the insulation and lagging system design for expansion and contraction, as well as to service limitations and insulation used.

The insulation, lagging, and sub-girt system shall be arranged to accommodate thermal expansion of insulated surfaces so all surfaces are effectively insulated whether in the hot or cold position. The system shall be arranged so as to prevent crushing and distortion of the insulation and lagging due to expansion and contraction of the equipment.

Thermal barriers (flue stops) shall be installed between all vertically oriented stiffeners at a maximum spacing of every 5 feet and at the top of all vertical runs. The barriers shall consist of the same type of insulation as used for the overall application, suitably supported by minimum 16-gauge steel plates welded between the stiffeners. The height of the thermal barriers shall be a minimum of 3 inches. The thermal barrier shall completely fill the gap between the insulation and the surface being insulated.

The insulation for piping accessories shall be of the same class as is indicated for the piping. Insulation materials for miscellaneous piping and equipment shall be suitable for the actual operating temperatures and shall be of the same insulation class as insulated main piping and equipment operating under similar temperatures.

B.1.14 Tolerance

Substituted insulation materials shall provide thermal resistance within 10% at normal conditions, as materials indicated.

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. PROPOSAL DATA REQUIREMENTS
2. DELIVERABLES (Documentation After Award)
3. PERFORMANCE GUARANTEES
4. SITE CONDITIONS AND REFERENCE MATERIALS
5. QA/QC (Including Inspection Test Plans)
6. STARTUP, TESTING, AND COMMISSIONING
7. PACKAGING, SHIPPING, AND STORAGE
8. ACCEPTABLE SUPPLIERS

APPENDICES

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****

1. PROPOSAL DATA REQUIREMENTS
(To be inserted in the Bid Form)

PIPING AND VALVES INSULATION AND JACKETING

Manufacturer shall provide the following data applicable to the equipment in the proposed scope of supply.

DATA SHEETS			
INSULATION AND JACKETING			
Contractor Name & Address			
Project			
Facility Location			
Delivery Date			
	UNITS	REQUIRED	SUPPLIER RESPONSE
MSDS Forms for all Supplied Materials			

2. DOCUMENTATION AFTER AWARD
(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule B)

Seller's Data Submission Schedule

Specifier – Add discussion of options and criteria that must be addressed

Documentation

Specifier – Add discussion of options and criteria that must be addressed including drawings, parts lists, O&M manuals

The Contractor shall provide a complete listing of the insulation installed by line, and indicating the material and thickness utilized. Copies of applicable MSDS sheets shall be provided.

PERFORMANCE GUARANTEES

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add discussion and criteria that must be addressed, include Acceptance Criteria

The installation shall maintain specified surface temperature under operating conditions with no indications of hot spots. Areas not meeting criteria will be reinsulated by the Contractor.

SITE AND AMBIENT CONDITIONS AND REFERENCE MATERIALS
(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add discussion and criteria that must be addressed along with drawings of the piping and valves to be insulated and a Table of design temperatures to be insulated to.

Maximum Temperature, F	
Minimum Temperature, F	
Humidity Range	
Site Elevation, ft	
Seismic Design Criteria	

Drawing List

Line List

Pipe Line	**Design Temperature, F**

QUALITY ASSURANCE

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add discussion and criteria that must be addressed

3. STARTUP, TESTING, AND COMMISSIONING
(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add discussion and criteria that must be addressed

May be Not Applicable

4. PACKAGING, SHIPPING, AND STORAGE
(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add discussion and criteria that must be addressed with regard to storage and weather protection requirements.

5. ACCEPTABLE SUPPLIERS
(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add discussion and criteria that must be addressed

Insulation

Glass Fiber
Johns Manville Model AP-T
Knauf
Armstrong
Owens Corning
Cellular Glass
Johns Manville
Expanded Polystyrene
Owens Corning
Hydrous Calcium Silicate
Johns Manville
Mineral Fiber
Certain Teed
Aerogel
Aspen Aerogel

Jacketing

MASTER SPECIFICTION
FOR

Pre-Engineered Metal Building

Revision 1.0

REVISION HISTORY

Date	Revision	Change Description
3-4-2015	1.0	New

Pre-Engineered Metal Building

GENERAL

DEFINITIONS

Contractor/Bidder - The company proposing to supply, deliver, and erect a pre-engineered metal building matching the bid requirements of this specification.

Company - Xcel Energy, the Owner of the Equipment.

SUMMARY

Introduction

This is a specification for the minimum requirements for the supply, delivery, and erection of a pre-engineered metal building. The building and building components will be delivered to ____________________ per the provided Scope of Work and design documents. The building will be erected at the facility by ____________________. The foundation for the building will be provided by others utilizing design loads generated from the structural analysis as outlined in this specification. The certified building design loads will be provided to the Company by ____________________.

Specifier – The typical pre-engineered building is a metal building utilizing structural components noted below in Design Requirements. The building is dimensioned from architectural drawings provided by the Company. The same architectural drawings should include a code analysis completed by a registered architect which addresses all design occupancy requirements.

The supply and delivery of the pre-engineered building is by a sub-contractor to the general contractor capable of purchasing and erecting the metal building system. The general contractor may also be responsible for construction of the building foundation. The foundation design will be based on loads generated by the pre-engineered building structural analysis. This will require the contract for the building to be in-place prior to the design and construction of the foundation.

The building general contractor is determined from a best evaluated proposal based on this specification and thecorresponding architectural drawings. This package is provided by the Company.

This specification does not direct procurement and construction of the foundation. However, foundation design is dependant on the completion of the building's final design.

Scope Description

Contractor shall provide all materials for a complete pre-engineered metal building to include:

1. Pre-engineered, shop fabricated structural steel building frame, girts, purlins, and wind bracing.

2. Metal wall and sloped roof system including gutters, downspouts, and trim.

3. Framed openings for doors, windows, louvers, overhead doors, and miscellaneous openings for penetrations of equipment through the walls or roofs, including roof curbs.

4. Windows, frames, trim, and hardware. Fire rated where indicated on the drawings.

5. Exterior doors, frames, hardware, and trim.

6. Base angles, closures, flashings, sealants, trim, interior liner panels when required, and other miscellaneous metal building components, fasteners, or accessory items as required for a complete installation.

7. Batt insulation at wall and roof systems.

Specifier – Viable alternate insulation systems includes foam filled panels. The advantage to this type panel is ease of installation.

8. Louvers with screens and hardware.

9. Skylight (translucent) panels.

APPLICABLE CODES AND STANDARDS

Applicable Codes and Standards

A. AISC - “Specification for Structural Steel for Buildings - Allowable Stress Design and Plastic Design”

B. AISC - Quality Certification Program, Category MB

C. ANSI A117.1 - Specifications for Making Buildings and Facilities Accessible To and Usable By Physically Handicapped People

D. ANSI A156.1 - Builders Hardware Manufacturers Association

E. ANSI/SDI-100 - Standard Steel Doors and Frames

F. ASCE 7-10 - Minimum Design Loads for Buildings and Other Structures

G. ASTM A36/A36M - Structural Steel

H. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

I. ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware

J. ASTM A283/A283M – Low and Itermediate Tensile Strength Carbon Steel Plates

K. ASTM A325/A325M - High Strength Bolts for Structural Steel Joints

L. ASTM A446/A446M - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality

M. ASTM A525/A525M - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

N. ASTM A572/A572M – High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality

O. ASTM A653/A653M - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron-Alloy Coated (Galvannealed) by the Hot-Dip Process

P. ASTM C991 - Flexible Glass Fiber Insulation for Pre-Engineered Metal Buildings

Q. ASTM C1107 - Packaged, Dry, Hydraulic-Cement Grout (Non-shrink).

R. ASTM F1554 – Anchor Bolts, Steel, 36, 55, And 105 ksi Yield Strength

S. AWS A2.0 - Standard Welding Symbols

T. AWS D1.1 - Structural Welding Code – Steel

U. IBC – International Building Code

V. Door Hardware Institute (DHI) - The Installation of Commercial Steel Doors in Steel Frames, Insulated Steel Doors in Wood Frames, and Builder's Hardware

W. MBMA (Metal Building Manufacturers Association) - Metal Building Systems Manual, "Code of Standard Practices", and "Design Practices" Manual.

X. NFPA 80 - Fire Doors and Windows

Y. SSPC (Steel Structures Painting Council) - Steel Structures Painting Manual

Z. UL - Building Materials Directory - Roof Deck Construction

TECHNICAL REQUIREMENTS

<u>Design Requirements</u>

A. Structures and their members, components, and covering shall be designed in accordance with the International Building Code, AISC Allowable Stress Design, and Factory Mutual Loss Prevention Data, except where exceeded by other provisions of this document. The following loads shall be used for designing each structure as a minimum:

1. Roof Dead Load: Weight of the metal building system such as roof, framing, panels and other permanently attached construction.

2. Collateral Load: all additional dead loads, other than the weight of the metal building system, shall be a uniform load of at least 25 psf acting vertically on the horizontal projection

of the roof. Higher collateral loads may be indicated on design drawings. Additional concentrated equipment loads will be indicated on the drawings.

3. Roof Live Load: Loads induced by the use and occupancy of the building, not including wind load, snow load, seismic load, collateral load, or dead load. Minimum roof live load shall be 20 psf.

4. Elevated Floor Live Load: 100 psf.

5. Roof Snow Load: Compute snow loads in accordance with ASACE 7-10 and a snow importance factor of 1.10.

6. Seismic Load: Compute seismic forces in accordance with ASCE 7-10 and a seismic importance factor of 1.25.

7. Wind Load: Wind loads shall be computed in accordance with ASCE 7-10 for a Risk Category III. Account for building openings as appropriate.

B. Installed door assemblies should conform to NFPA 80 for fire rated class as scheduled in design drawings.

C. The basic design loads shall be applied and combined as specified in ASCE 7-10.

D. Gutters and downspouts shall be designed for a rainfall intensity of 4 in/hr applied for a duration of 5 minutes.

E. Auxiliary loads: Dynamic loads resulting from cranes, material, and material handling systems. Compute impact loads as a percentage of static loads:

Cranes – compute per ASCE 7-10.

Light machinery shaft or motor driven - 20%

Rotating and Reciprocating machinery - 50%

Hangers for floor - 33%

F. Size and fabricate wall and roof systems to be free of distortion or defects detrimental to appearance or performance.

G. The roof covering system design shall provide for thermal expansion joints. Design of expansion joints shall be as recommended by the building Manufacturer.

H. Lateral stability shall be obtained by pinned base rigid frames in one direction and braced bays in the other. Special bracing systems are allowed when diagonal bracing is not permitted in the plane of the sidewalls.

I. Calculations for deflection shall be done using only the bare frame method. Reductions based on engineering judgment using the assumed composite stiffness of the building envelope will not be allowed. Drift shall be limited to H/180.

J. Design and detail base plates to transfer lateral loads into the foundation with properly sized shear lugs. Transfer of lateral loads into the foundation with friction between the plate and the concrete surface shall be subject to Company approval.

K. Girts shall be designed to resist wind forces with a maximum deflection of 1/240 of the span. Roof framing shall be designed to deflect no more than 1/180 of the span when subjected to combined collateral and live loads.

L. Deflection of the roof panels shall not exceed 1/180 of a span when supporting a 200 pound concentrated load over a one square foot area or a 50 pound per square foot, uniformly distributed load.

Specifier – Design Requirement Section J. requires shear lugs to resist lateral reactions at the base plate. For a rigid framed structure, these loads can be significant especially when the column is subject to uplift. Proerly pretension anchors can resist the lateral loads through friction between the baseplate and the foundation. This alternate requires a full analysis by the building designer and should be subject to Company approval.

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
****

1. **DELIVERABLES**
2. **PROPOSAL DATA REQUIREMENTS**
3. **PERFORMANCE GUARANTEES**
4. **SITE CONDITIONS AND REFERENCE MATERIALS**
5. **QA/QC (Including Inspection Test Plans)**
6. **STARTUP, TESTING, AND COMMISSIONING**
7. **PACKAGING, SHIPPING, AND STORAGE**

1. DELIVERABLES

Submittals for Review

A. Product Data: Provide data on profiles, component dimensions, fasteners, and finishes.

B. Shop Drawings: Indicate assembly dimensions, locations of structural members, and openings; indicate wall and roof system dimensions, panel layout, general construction details, anchorages, and methods of anchorage; indicate method of panel and flashing installation and details for sealing watertight; indicate anchor bolt settings, requirements, and sizes; indicate anchor bolt locations from datum and foundation loads; indicate welded connections with AWS A2.0 welding symbols, including net weld lengths; provide professional seal and signature of an Engineer licensed to practice in the State of xxxxxxx.

Specifier – Building codes will require design data for building systems manufactured in a different location other than the final destination to be certified by an engineer registered in the State of the final erected location.

C. Samples: Submit two samples of pre-coated metal panels for each color selected, in 12 inch x 12 inch size, illustrating color and texture of finish. Also submit two samples of metal trim illustrating color and texture of finish. Panels and trim will be required to match existing buildings.

D. Submit complete design analysis calculations for all structural components for review. Calculations shall include lateral drift values for gravity loads and wind loads. Calculations shall be submitted with the shop drawings and shall bear the seal and signature of an Engineer licensed to practice in the State of xxxxxx. Foundation loads and foundation requirements shall be included with the calculation package.

E. Manufacturer's Instructions: Indicate foundation preparation requirements including shear lug and anchor bolt placement.

F. Erection Drawings: Indicate members by label, assembly sequence, and temporary erection bracing.

G. Foundation Load Drawings.

2. PROPOSAL DATA REQUIREMENTS

Specifier – Attachment to be subject to overall Project criteria.

3. PERFORMANCE GUARANTEES

Special Warranties

A. Provide a 20 year warranty to include coverage for exterior pre-finished surfaces and color coat against chipping, cracking or crazing, blistering, peeling, chalking, or fading. Warrant the roof panels will remain free from rupture, structural failure, or perforation due to corrosion under operating atmospheric conditions for a period of 10 years. The pre-engineered building Manufacturer will, during this period and at no additional cost to the Owner, provide labor and materials necessary to replace defective roof and wall panels. The total liability of the pre-engineered building Manufacturer for replacement of defective material shall not be limited during this period of this warranty.

B. Weather Tightness Warranty: Upon final acceptance of the project, the pre-engineered building Manufacturer shall furnish a warranty against defects in materials and workmanship for a period of 10 years. The pre-engineered building Manufacturer will during this period, and at no additional cost, maintain the installed work in a watertight condition and correct any defects which may develop as a result of operating atmospheric conditions in a manner which will restore the work to a leak-proof and/or comparable condition to that at the date of final acceptance of the project. The total liability of the pre-engineered building Manufacturer for replacement of defective materials or correction of defective workmanship shall not be limited during the period of this warranty.

C. A specimen copy of all warranties must accompany the bid, clearly stating the conditions under which the warranties are valid.

4. SITE CONDITIONS AND REFERENCE MATERIALS

PRODUCTS

Manufacturers – Building System

A. Ceco

B. Butler

C. Varco Pruden

D. Other Manufacturer's offering equivalent products subject to approval by the Owner and Owner's Engineer and subject to conformance with the specifications.

Materials - Framing

A. Structural Steel Members: ASTM A36, ASTM A572, ASTM A992 (Grades 42 and 50)

B. Plate or Bar Stock: ASTM A36 or ASTM A283 (Grades D)

C. Anchor Bolts / rods: ASTM F1554 (Grades 36, 55 including S1 supplementary requirements, 105), compatible nuts and washers galvanized to ASTM A153, Class C

D. Steel-to-steel Bolts, Nuts, and Washers: ASTM A325, ASTM A563, Grade DH, ASTM F436, Type 1 respectively, galvanized to ASTM A153, Class C

E. Welding Materials: AWS D1.1; type required for materials being welded

Materials – Wall and Roof System

A. Sheet Steel Stock: ASTM A446 Grade B, with 1 1/4 ounce galvanized coating. Minimum material thickness shall be 24 gauge for roofs and walls. Wall panels shall be approximately 36 inches wide. Configuration of panels shall be Manufacturer's standard nominal 1 1/2 inch deep profile. Wall panels shall be embossed.

B. Liner Panels: Full height liner panels shall be minimum 26 gauge, galvanized, roll formed, modular 16 inch wide units, with factory applied thermosetting enamel finish in standard colors. Panels shall be furnished with all required bases, eave trim, ceiling cove, girt covers, and trim at doors and windows.

C. Roof Panels: Roof panels shall be a standing-seam interlocking design with exposed fasteners at end laps only. Roof panel design shall allow for thermal expansion and contraction through the use of concealed floating clips. Finish shall match wall panels, except that roof panels are non-embossed.

D. Roof Insulation: Insulation at the roof shall be reinforced white vinyl faced glass fiber insulation with a UL label, flame spread rating, of 25 or less. Thermal spacers shall be provided at each purlin. Insulation shall have a minimum R-value of 19.

C. Wall Insulation: Insulation at the walls shall be reinforced white vinyl faced glass fiber insulation with a UL label, flame spread rating, of 25 or less. Insulation to have a minimum R-value of 19.

D. Joint Seal Gaskets: Manufacturer's standard type.

E. Fasteners: Manufacturer's standard type, galvanized to ASTM A153 2.0 ounces per square foot, finish to match adjacent surfaces when exterior exposed. Use neoprene washers at exposed fasteners.

F. Metal Mesh: Galvanized steel wire, woven.

G. Trim, Closure Pieces, Caps, Flashings, Gutters, Downspouts, Corners: Same material, thickness, and finish as exterior sheets; brake formed to required profiles and coated to match existing buildings.

H. Closures: Provide sealing enclosures at top and bottom of all panels and where otherwise indicated or required. Sealing enclosures shall consist of brake formed metal caps and compressible closure strips.

I. Roof Curbs: Provide in size, quantity, and structural capacity as indicated on the drawings. Curbs shall be shop fabricated from materials recommended by the Vendor in a finish compatible with the roof panels.

J. Manufacturer shall provide extra stock sheeting and components for replacement due to damage during construction and for minor design changes.

Doors, Door Frames, Door Hardware

A. Doors, door frames, door hardware to be provided with separate specifications. Doors to conform to with architectural drawings.

B. Overhead doors to be provided with separate specifications. Overhead doors to conform to architectural drawings.

Windows

A. Windows shall be EFCO Corporation Series 2500, thermal break of nominal sizes indicated on the drawings. The thermal barrier shall be poured-in-place two part polyurethane. The depth of frame and sash shall not be less than 2 inches. Frame components shall be mitered, reinforced with an extruded aluminum corner key, hydraulically crimped, and "cold welded" with epoxy adhesive and extruded aluminum sub-sill, No. 1507 with flashing lip shall be furnished and installed. Finish shall be clear anodized to finish Specification AA-M10-C22-A31/41.

B. Aluminum frames and sash members shall be 6063 alloy, minimum 0.062 inch thick extrusions.

C. Glazing shall be 1/2-inch tinted insulating glass. Window manufacturer's extruded aluminum glazing bead with gasket used in conjunction with butyl tape and silicone cap seal (DC 795 or equal) by EFCO. Window may be factory glazed using wet glaze system with silicone backbed compound (GE SCS-2511) or equal.

Plastic Skylights

A. Provide fiberglass reinforced translucent plastic skylight panels to cover a percentage of the roof area indicated by architectural design drawings. Skylights shall form an integral part of the roof system and shall be covered by the same warranty provisions as the remainder of the roof.

Louvers – Manually Adjustable

A. Storm proof design of the sizes indicated on the drawings.

B. Frames: Rectangular, 3 inches deep, from 18 gauge galvanized steel, complete with integral lintel and sill.

C. Slats: Z-shaped, pivoted slats, which are spring loaded through linkage in closed position. Slats shall be fabricated from 20 gauge galvanized steel.

D. Screens: No. 4 galvanized hardware cloth in removable frame fabricated of 24 gauge galvanized steel, mounted on the inside of the louver.

E. Pivot pins, chain link holder, chain, coil spring, fasteners, etc., shall be the Manufacturer's standard hardware.

F. Fabrication and Material: Galvanized steel with 1.25-ounce zinc coating conforming to ASTM A525. Factory paints or anodized louvers and frames to match the building trim.

Fixed Louvers

A. Storm proof design of the sizes as indicated on the drawings.

B. Frames: Rectangular, 3 inches deep, fabricated from 18 gauge galvanized steel with integral lintel and sill.

C. Fixed Louver Blades: Storm-proof design, 20 gauge galvanized steel.

D. Screens: No. 4 galvanized hardware cloth in removable frame of 26 gauge galvanized steel, mounted on inside face of louver.

E. Fabrication and Material: Galvanized steel with 1.25-ounce zinc coating conforming to ASTM A525. Factory paint or anodize louvers and frames to match the building trim.

Fabrication - Framing

A. Fabricate members in accordance with AISC Specification for plate, bar, tube, or rolled structural shapes.

B. Anchor Bolts: Comply with ASTM F1554, fabricated and galvanized for casting into concrete. Sizing requirements, projection, etc. shall be stipulated by the Manufacturer, the foundation anchor bolts will be provided by the General Contractor. Allow adequate clearance beneath base plates for grout bed unless noted otherwise on drawings.

C. Provide framed openings for personnel doors, overhead doors, louvers, roof curbs, and mechanical penetrations. Penetrations for equipment shown on design drawings must be framed to support the vertical and lateral loads induced by the equipment. Flashing and support details shall not void the Manufacturer’s warranties.

Fabrication – Wall and Roof System

A. Girts/Purlins: Rolled formed structural shape to receive siding and roofing.

B. Internal and External Corners: Same material thickness and finish as adjacent material, profile brake formed to required angles.

C. Flashings, Closure Pieces, and misc. trims: Same material and finish as adjacent material, profile to suit system.

D. Fasteners: To maintain load requirements and weather tight installation, same finish as cladding, non-corrosive type, compatible with drift limits of structure.

Fabrication – Gutters and Downspouts

A. Fabricate of prefinished metal, same finish as wall panels.

B. Form gutters and downspouts of Manufacturer's standard profile, sized according to rainfall intensity to collect and remove water. Fabricate with connection pieces.

C. Form sections in maximum possible lengths. Hem exposed edges. Allow for expansion at joints.

D. Fabricate support straps of 16 gauge material, same finish as roofing metal. Attach straps to eave member at a maximum spacing of 3 feet.

Finishes

A. Framing Members - Finish according to architectural design drawings and the following:

1. Clean and prepare to SSPC-SP2 requirements, and prime according to SSPC 15, type 1, red oxide, 2.0 mils DFT requirements for painted members. Apply final coat according to manufacturer's standards.

2. Prepare and galvanize according to ASTM A123 for galvanized members.

B. Exterior surfaces of Wall Panels, Roof Panels, Components and Accessories, shall be baked-on polyvinylidene fluoride with a minimum of 70% Kynar 500 by weight. Finish shall carry a twenty (20) warranty against crazing, chipping, cracking, peeling, and loss of color.

C. Interior Panel Finish: Paint with USDA-approved interior white polyester paint.

5. QA/QC (Including Inspection Test Plans)

Quality Assurance

A. Manufacturer Qualifications: Not less than 5 years experience in the actual production of specified products.

1. Member of the Metal Building manufacturer's Association (MBMA).

2. Primary manufacturer of frames, secondary steel, roof and wall sheeting, and trim.

B. Installer/Erector Qualifications: Firm experienced in application or installation of systems similar in complexity to those required for this project, plus the following:

1. Acceptable to or licensed by manufacturer.

2. 3 year experience with systems.

3. Sucessfully completed not less than 5 comparable scale projects using similar systems.

C. Mock up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship:

1. Finish areas designated by architect.

2. Do not proceed with remaining work until workmanship, color, and sheen are approved by Architect.

3. Refinish mock-up area as required to produce acceptable work.

6. STARTUP, TESTING, AND COMMISSIONING

EXECUTION

Examination

A. Verify that foundation, floor slabs, mechanical and electrical utilities, and placed anchors are in the correct location. Discrepancies in this work shall be corrected before execution of the erection of the building is started. Commencement of erection represents acceptance of existing conditions.

Erection - Framing

A. Erect framing in accordance with AISC Specification.

B. Provide for erection and wind loads. Provide temporary bracing to maintain structure plumb and in alignment until completion of erection and installation of permanent bracing.

C. Set column base plates and shear lugs with non-shrink grout to achieve full plate bearing.

D. Do not field cut or alter structural members without approval of the Manufacturer and the Owner.

E. After erection, prime welds, abrasions, and surfaces not shop primed, and clean all surfaces. Clean galvanized welds and coat with Sherwin-Williams Zinc Clad 5 or approved equal.

Erection – Wall and Roof Systems

A. Install in accordance with Manufacturer's instructions. Install roof and wall insulation with the white vinyl vapor barrier towards the building interior and in accordance with the Manufacturer's recommendations.

B. Exercise care when cutting prefinished material to ensure cuttings do not remain on finish surface. Stained or marred panels will require replacing.

C. Fasten cladding system to structural supports, aligned level and plumb.

D. Roof panels shall be continuous from ridge to eave, except where indicated otherwise. Laps are acceptable only for spans longer than 40 feet.

E. Locate end laps over supports. End laps shall be a minimum 6 inches.

F. Install sealant and gaskets to prevent weather penetration.

Erection – Gutter and Downspout

A. Rigidly support and secure components. Join lengths with formed seams sealed watertight. Flash and seal gutters to downspouts.

B. Apply bituminous paint on surfaces in contact with cementitious materials.

Installation – Accessories

A. Seal wall and roof accessories watertight with metal flashing and sealant.

Cleaning

A. Clean framing members and components of dirt, mud, foreign substances, debris, and other stains before erecting. Finished structure must be clean.

Tolerances

A. Framing Members: 1/4 inch from level; 1/8 inch from plumb

B. Siding and Roofing: 1/8 inch from true position

7. PACKAGING, SHIPPING, AND STORAGE

Delivery, Storage and Handling

A. Scheduling and coordinating of the work specified in this Section and that specified in other Sections shall be the responsibility of the Contractor.

B. Shipping and handling shall be accomplished in a manner which will prevent damage. Materials shall be clearly marked for identification.

C. Materials shall be stored off-the-ground on pallets, and if exposed to the weather, covered with a waterproof material, and shall be protected from damage until ready for use or installation. Surfaces of color coated materials shall be protected from stain.

D. Cut plastic packaging to prevent moisture from accumulating and damaging items prior to installation. Sealants shall remain in the Manufacturer's original unopened containers until ready for use. Sealants shall be protected from freezing.

MASTER SPECIFICTION
FOR

Reinforced Concrete

Revision History

Approved 2013	1.0	New

D.1 CONCRETE FORMWORK

D.1.1 General

D.1.1.1. Section Includes

Formwork for cast-in-place concrete with shoring, bracing, and anchorage.

Openings for other work.

Form accessories.

Form stripping.

D.1.1.2. Design Requirements

Design, engineer, and construct formwork, shoring, and bracing to conform to design and code requirements. Resultant concrete to conform to required shape, line, and dimension.

D.1.1.3. Quality Assurance

Perform Work in accordance with the current ACI 347 standards.

D.1.1.4. Regulatory Requirements

Conform to applicable federal and state codes for design, fabrication, erection, and removal of formwork.

D.1.1.5. Protection

Deliver and install void forms according to instructions proved by Manufacturer.

D.1.2 Products

D.1.2.1. Wood Form Materials

Form Materials: At the discretion of the Contractor.

Forms should produce a clean, uniform, durable finished surface.

D.1.2.2. Prefabricated Forms

Preformed Steel Forms: Minimum 16 gauge matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.

Preformed Plastic Forms: Tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.

Glass Fiber Fabric Reinforced Plastic Forms: Matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished concrete surfaces.

Tubular Column Type: Round, surface treated with release agent, non-reusable, of sizes required.

Void Forms: Manufactured specifically for use as concrete formwork. Moisture resistant treated paper faces, biodegradable, structurally sufficient to support weight of wet concrete mix until initial set, 4 inches minimum thickness or as specified on drawings provided in the contract.

D.1.2.3. Formwork Accessories

Form Ties: Removable type, galvanized metal or plastic, fixed length, cone type, free of defects that could leave holes larger than 1 inch in concrete surface.

Form Release Agent: Colorless mineral oil, which will not stain concrete or absorb moisture.

Corners: Chamfered as shown on project drawings provided by Company.

Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Sized as required, of sufficient strength and character to maintain formwork in place while placing concrete.

Waterstops: Embedded: Polyvinyl chloride (PVC), minimum 1,750 psi tensile strength, minimum 50°F to +175°F working temperature range, 6 inch wide, maximum possible lengths, ribbed profile, preformed corner sections, heat welded jointing.

Adhesive for application to hardened concrete: Single component, self-sealing plastic water stop manufactured by Synko-Flex Products, Inc. Houston, Texas.

D.1.3 Execution

D.1.3.1. Examination

Verify lines, levels, and centers before proceeding with formwork. Ensure that dimensions agree with project drawings provided by Company.

D.1.3.2. Earth Forms

Hand trim sides and bottom of earth forms. Remove loose soil prior to placing concrete.

D.1.3.3. Erection - Formwork

Erect formwork, shoring, and bracing to achieve design requirements, in accordance with requirements of ACI 301.

Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.

Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.

Align joints and make watertight. Keep form joints to a minimum.

Obtain approval from Company before framing openings in structural members which are not indicated on project drawings provided by Company.

Provide chamfer strips on exposed corners. Do not provide chamfer strips at joints, unless required by the project drawings provided by Company.

Install void forms in accordance with Manufacturer's recommendations. Protect forms from moisture or crushing.

Coordinate this Section with other Sections of Work which require attachment of components to formwork.

Ensure formwork provides for adequate concrete coverage over reinforcement.

D.1.3.4. Application - Form Release Agent

Apply form release agent on formwork in accordance with Manufacturer's recommendations.

Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.

Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.

D.1.3.5. Inserts, Embedded Parts, And Openings

Provide formed openings where required for items to be embedded in or passing through concrete work.

Locate and set in place items which will be cast directly into concrete.

Coordinate with Work of other sections in forming and placing openings, slots, reglets, recesses, sleeves, bolts, anchors, other inserts, and components of other Work.

Install accessories in accordance with Manufacturer's instructions, straight, level, and plumb. Ensure items are not disturbed during concrete placement.

Install PVC waterstops in accordance with Manufacturer's instructions, continuous without displacing reinforcement. Heat and seal joints need to be watertight.

Install adhesive waterstops in accordance with Manufacturer’s instructions, using appropriate techniques and materials. Lap ends and corners to form a single, continuous waterstop. Do not remove protective paper from top of waterstop until immediately prior to concrete placement.

Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

D.1.3.6. Form Cleaning

Clean forms as erection proceeds, to remove foreign matter within forms.

Clean formed cavities of debris prior to placing concrete.

Flush with water or use compressed air to remove remaining foreign matter. Ensure that water, debris and mud drain to exterior through clean-out ports prior to concrete pour.

During cold weather, remove ice and snow from within forms. Do not use de-icing salts. Do not use water to clean out forms. Use compressed air or other means to remove foreign matter.

D.1.3.7. Formwork Tolerances

Construct formwork to maintain tolerances required by ACI 301.

D.1.3.8. Field Quality Control

Inspect erected formwork, shoring, and bracing to ensure that Work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and other items are secure. Check that anchor bolts and other embedded anchorages are properly located and securely anchored.

Do not reuse wood formwork more than four (4) times for concrete surfaces to be exposed to view. Do not patch formwork.

D.1.3.9. Form Removal

Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads.

Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.

Store removed forms in manner that surfaces to be in contact with fresh concrete will not be damaged. Discard damaged forms.

D.1.3.10. Schedules

Mats: Form exposed surfaces using plywood or metal forms coated with a form release agent.

Beams, Columns, Pedestals, Slabs and Equipment Pads: Form edges using wood or metal forms coated with a form release agent.

D.2 CONCRETE REINFORCEMENT

D.2.1 General

D.2.1.1. Section Includes

Reinforcing steel bars, wire fabric and accessories for cast-in-place concrete.

D.2.1.2. Quality Assurance

Perform Work in accordance with ACI 318.

D.2.2 Products

D.2.2.1. Reinforcement

Reinforcing Steel: Bent bars, sizes No. 14 and No. 18, shall conform to ASTM A706, grade 60. All other reinforcing steel shall conform to ASTM A615, grade

60, and Supplementary Requirements (S1). All reinforcing steel is to be unfinished unless specified on project drawings.

Welded Steel Wire Fabric: ASTM A185 Plain Type; unfinished.

Dowels: ASTM A615; 60 ksi yield grade, plain steel, unfinished.

D.2.2.2. Accessories

Tie Wire: Minimum 16 gauge annealed type.

Chairs, Bolsters, Bar Supports, Spacers for concrete not exposed to weather or moisture: Sized and shaped for strength and support of reinforcement during concrete placement.

Special Chairs, Bolsters, Bar Supports and Spacers for concrete surfaces exposed to weather: Plastic or plastic coated steel type; size and shape as required.

D.2.2.3. Fabrication

Fabricate concrete reinforcing in accordance with ACI SP-66.

Do not weld reinforcement without approval of Company.

Locate reinforcing splices not indicated on project drawings provided by Company at point of minimum stress, preferably in compression zones of concrete members. Splices should comply with ACI 318 and should develop full strength of reinforcement. Lap splices shall be Class B.

Stagger lap splices and detail as required by ACI 318 and CRSI 63.

D.2.3 Execution

D.2.3.1. Placement

Place, support and secure reinforcement against displacement. Conform to CRSI 63 and CRSI 65. Do not deviate from required position unless approved by company.

Use reinforcement at time of placement of concrete shall be free of mud, oil, ice, loose rust, mill scale, or other coatings that adversely affect bond.

Use metal reinforcement without kinks or non-specified bends. Straighten or repair bars in a manner that will not damage the bars or adjacent construction.

Accommodate placement of formed openings.

Conform to project drawings provided by Company for concrete cover over reinforcement. However, concrete cover must not be less than required by ACI 318.

D.2.3.2. Field Quality Control

Contractor QCI shall inspect for acceptability. Company shall be notified for inspection prior to placement of concrete.

D.2.3.3. Drawing Schedules

Reinforcement for footings, mats, grade beams, foundation walls, drilled piers, pier caps, drainage structures, structural beams and slabs, pedestals, equipment pads, concrete topping slabs over steel deck and slabs-on-grade: All deformed bars and wire fabric, unfinished, of dimensions shown on project drawings provided by Company.

D.3 CAST-IN-PLACE CONCRETE

D.3.1 General

D.3.1.1. Section Includes

All Cast-in-place concrete structures, including but not limited to the following: concrete footings, mats, grade beams, foundation walls, drilled piers, pier caps, drainage structures, structural beams and slabs, pedestals, equipment pads, concrete topping slabs over steel deck and slabs-on-grade.

Control, expansion and contraction joint devices associated with concrete work.

Electrical duct bank and vaults.

Lean concrete.

D.3.1.2. Quality Assurance

Perform Work in accordance with ACI 301.

Acquire cement and aggregate from same source for all Work. Verify and document that mix design is adequate if sources are changed during Work of this Section.

D.3.2 Products

D.3.2.1. Concrete Materials

Cement: ASTM C150, Type II - Portland Cement. (Specifier needs to evaluate the requirement for sulfate resistant concrete normally Type V cement may be required due to contact with high sulfate content soil. Specifier needs to select cement types based on recommendations in Geotechnical Report and other available Engineering Reports for concrete that is in contact with soil.)

Fine and Coarse Aggregates: ASTM C33.

Water shall be clean and free from injurious amount of oil, acids, salts, organic or other deleterious matters.

D.3.2.2. Admixtures

Air-entraining admixtures shall conform to ASTM C260, Darex AEA, or neutralized Vensol resin (NVX).

Water reducing admixture shall conform to ASTM C494, Type AD; WRDA, as manufactured by W.R. Grace and Company, or Pozzolith, manufactured by Master Builders Company.

Set-retarding admixture shall conform to ASTM C494, Type D, PSI-R PLUS or PSI-300R as manufactured by Gifford-Hill & Co. Inc.

Fly Ash: ASTM C618 Class F or Class C.

D.3.2.3. Accessories

Bonding Agent: Acrylic Latex Emulsion.

D.3.2.4. Joint Devices and Filler Materials

Joint Filler: ASTM D994; Asphalt impregnated fiberboard or felt, 1/2 inch thick; tongue and groove profile.

ASTM D1751 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).

ASTM D1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

Concrete Mix (Specifier needs to evaluate the requirement for freeze and thaw resistant concrete, normally due to exposure to wet and freezing conditions. Specifier also need to evaluate the Maximum Fly Ash Content, if higher early strength concrete is needed, the fly ash content may need to be lower than 25%. Slump may also need to be changed due to specific application. For example, 4" ± 1" Footings 6" ± 1" Walls 7" ± 1" Walls Pumped)

D.3.2.5.)

Concrete mix designs shall be approved by the Company and shall not be changed without Company approval.

Air-entraining admixture, set-retarding admixture and water reducing admixture are the only admixtures that may be used.

Mix and deliver concrete in accordance with ASTM C94, Option C.

Select proportions for normal weight concrete in accordance with ACI 301.

Provide concrete to the following criteria except as noted:

Item	**Requirement**
Gradation of coarse aggregate	Size Number 57, 1 inch to No. 4
Compressive Strength (7 day)	3,000 psi
Compressive Strength (28 day)	4,000 psi
Maximum Water/Cement Ratio	0.48 by weight
Air Entrainment	6% ± 2% by volume
Maximum Fly Ash Content	25% of cement content
Slump	3 inches ± 1 inch

Provide concrete to the following criteria for concrete structures exposed to moisture and freezing:

Item	**Requirement**
Gradation of coarse aggregate	Size Number 57, 1 inch to No. 4
Compressive Strength (7 day)	3,000 psi
Compressive Strength (28 day)	4,500 psi
Maximum Water/Cement Ratio	0.45 by weight
Air Entrainment	6% ± 1% by volume
Maximum Fly Ash Content	25% of cement content
Slump	3 inches ± 1 inch

Use accelerating admixtures in cold weather only when approved by Company. Use of admixtures will not relax cold weather placement requirement

Do not use calcium chloride in concrete mixture.

Use set retarding admixtures during hot weather only when approved by Company.

Lean Concrete may be used to fill voids around permanent drilled pier casing, to correct over excavation, build mad matt for foundations, and to construct ductbank. Lean Concrete shall meet the following requirements:

Item	**Requirement**
Coarse Aggregate	“Pea gravel” - 3/8 inch maximum diameter
Compressive Strength (28 day)	2,000 psi
Flowable fill mix design	
Slump	7 inches ± 1 inch
Minimum Cement Content	4 sacks/cubic yard

D.3.3 Execution

D.3.3.1. Examination

Verify requirements for concrete cover over reinforcement.

Verify that anchors, anchor bolts, seats, plates, reinforcement, and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete. Embedments must be supported by formwork or tied to reinforcement. Under no circumstances should embedments be welded to reinforcement.

D.3.3.2. Preparation

Concrete

- Prepare previously placed concrete by cleaning with steel brush or light sandblasting and applying bonding agent in accordance with Manufacturer's instructions.
- In locations where new concrete is doweled to existing Work, drill holes in existing concrete, clean holes, fill with an epoxy adhesive, and insert steel dowels and pack solid with non-shrink grout. The adhesive shall be Hilti HIT C-100 or Company-approved equal. Follow Manufacturer's instructions for details of application and curing.
- Coordinate the placement of joint devices with erection of concrete formwork and placement of form accessories.
- Protect anchor bolts and embedments with tape and plastic wrap.

D.3.3.3. Placing Concrete

Place concrete in accordance with ACI 304.

Place steam turbine generator mat as monolithic mass following the guidelines of ACI 304 Paragraph 5.6 "Mass Concreting." Follow these guidelines for any other foundation more than 3 feet thick in least dimension.

Notify Contractor's QCM and Company a minimum of 24 hours prior to commencement of operations.

Ensure reinforcement, inserts, embedded parts, formed expansion and contraction joints, and water stops are not disturbed during concrete placement.

Separate slabs on grade from vertical surfaces of other structures with 1/2 inch thick joint filler. Locate joints along vertical edges of foundations whenever foundation creates re-entrant corner in paving or slab. If joint location is impractical, install one (1) Number 4 diagonal bar per each 6 inches of slab thickness at the re-entrant corner to prevent open cracks from forming.

Place joint filler in floor slab. Set top to required elevations. Secure to resist movement by wet concrete.

Extend joint filler from bottom of slab to within 1/4 inch of finished slab surface.

Install joint devices in accordance with Manufacturer's instructions.

Install construction joint devices in coordination with floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.

Install joint device anchors. Maintain correct position to allow joint cover to be flush with floor finish.

Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

Place concrete continuously between predetermined expansion, control, and construction joints.

Do not interrupt successive placement; do not permit cold joints to occur.

Place large floor slabs in long strips as described in ACI 302.

Screed slabs level, maintaining surface flatness of maximum 1/4 inch in 10 feet. Floors beneath folding partitions must be within a tolerance of 1/8 inch in 10 feet.

Hot Weather Requirements

- The maximum temperature of mixed concrete prior to and during placement shall be 90°F.
- Recommendations of ACI 305 shall be followed.

Cold Weather Requirements

- Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near freezing weather. All concrete materials and all reinforcements, forms, fillers, and ground with which the concrete is to come in contact shall be free from frost. No frozen materials or materials containing ice shall be used.
- Concrete shall be kept at minimum temperature of 50°F prior to placement and for the required curing period.
- Recommendations of ACI 306 shall be followed.

D.3.3.4. Finishing Concrete

Finish concrete surfaces in accordance with ACI 301.

Footings and other permanently buried structures do not require finishing. Ensure that concrete is level and provides adequate cover for reinforcing.

In areas with floor drains or trenches, maintain floor elevation at walls; pitch surfaces uniformly to drain structures as indicated on project drawings provided by Company.

Clean concrete from anchor bolts and other embedments and protect them from damage.

D.3.3.5. Curing and Protection

Concrete

- Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.

- Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
- Cure concrete in accordance with specified requirements if provided by Company.
- Do not permit traffic over unprotected floor surface during curing period.

D.3.3.6. Field Quality Control

Provide free access to Work and cooperate with appointed testing firm.

D.3.3.7. Patching

Allow Representative Contractor's QCM or QCI to inspect concrete surfaces immediately upon removal of forms.

Imperfections including excessive honeycombs, defects greater than 1 inch in depth and embedded debris in concrete are not acceptable. Notify Company and Contractor's QCM or QCI upon discovery.

After obtaining the approval from the Company, patch imperfections within 24 hours of form removal following the provisions of ACI 301. Cut defective area square to avoid feathering edges. Coat area to be repaired with a latex bonding agent pursuant to Manufacturer's instructions. Fill imperfections with mortar mixture and blend with surrounding concrete.

Patch indentations left by all form ties, including stainless steel ties, according to ACI 301.

D.3.3.8. Defective Concrete

Defective Concrete: Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements.

Repair or replacement of defective concrete will be determined by the Company and Contractor's QCM.

D.3.3.9. Finish Schedule (Specifier to provide Finish Schedule per specific project requirements. Following table is provided as template)

D.3.3.10.

Building Floors

Administration/Maintenance Addition	Steel trowel finish
Water Treatment Building	Steel trowel finish
Equipment Enclosures	Steel trowel finish
Chemical Storage Areas	Steel trowel finish
Containment Areas	Steel trowel finish
Paved Areas	Broom finish
Sidewalks	Broom finish

Equipment Bases Interior	Steel trowel finish
Equipment Bases Exterior	Steel trowel w/ light broom finish

D.4 CONCRETE CURING

D.4.1 General

D.4.1.1. Section Includes

Initial and final curing of all horizontal and vertical surfaces of concrete structures.

D.4.1.2. Quality Assurance

Perform Work in accordance with ACI 301 and ACI 302.

D.4.2 Products

D.4.2.1. Materials

Membrane Curing Compound Type 1-D Class A according to ASTM C309.

D.4.3 Execution

D.4.3.1. Examination

Verify that substrate surfaces are ready to be cured.

D.4.3.2. Execution - Horizontal Surfaces

Cure floor surfaces and large mat surfaces in accordance with ACI 308.

Membrane Curing Compound: Apply curing compound in accordance with Manufacturer's instructions in two (2) coats with second coat applied at right angles to first.

Water Curing: Concrete may be water cured by the continuous or frequent application of water by means of ponding, spraying, sprinkling, or fogging in accordance with ACI 308. Care shall be taken to prevent saturating the supporting soil causing softening and subsequent damage to the concrete.

D.4.3.3. Execution - Vertical Surfaces

Cure surfaces in accordance with ACI 308.

Membrane Curing Compound: Apply compound in accordance with Manufacturer's instructions in one (1) coat.

D.4.3.4. Protection of Finished Work

Do not permit traffic over unprotected floor surface.

APPENDICES

APPENDICES TO SPECIFICATION

Specifier – These appendices should all be considered for inclusion with the technical specification either as attachments to the technical specification for smaller contracts or incorporated into specific schedules as part of a large contract.
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1. PROPOSAL DATA REQUIREMENTS
(To be inserted in the Bid Form may include the following)

- Total estimated concrete volume
- Unit price for additional concrete
- Unit price for additional rebar

2. DOCUMENTATION AFTER AWARD
(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule B)

Seller's Data Submission Schedule

Specifier – Follow are recommended list for submittals and requirements for submittals

1. Rebar shop drawings- Tie the submission to milestone deliverables and milestone payment.
2. Concrete mix design
3. QA/QC procedures at for ready mix concrete plant
4. Allowed minimum 5 days for the Company review and approval of submittals

Documentation

Specifier – Add discussion of options and criteria that must be addressed including format of drawings and delivery

1. All submitted documents shall be electronic and dated.
2. Senders of submittals are obligated to confirm the reception of documents by the intended receivers

PERFORMANCE GUARANTEES

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add performance discussions and criteria that must be addressed, include Acceptance Criteria that is established on the project. Otherwise Xcel Energy standard terms and conditions (1 year warranty) are acceptable, and then this page becomes optional.

3. QUALITY ASSURANCE

(For Base Capital Projects to be attachment to the technical specification, for Major Capital Project to be included in Schedule #)

Specifier – Add discussion and criteria that must be addressed with the following recommended starting points

- Company shall retain inspection and testing agency for concrete sampling and lab cylinder compression tests. Selected bidder shall notify Company and its testing agency minimum 24 hours before any planned concrete pour.
- Cast-in-place concrete shall be sampled at one set of three cylinders per pour, one set of three cylinders per 150 cubic yard, or one set of three cylinders per 1500 square feet surface area of walls or slabs, whichever results in more frequent tests shall apply.

4. REFERENCE DRAWING LIST
(Make sure to include the drawing lists pertain the specified concrete work)

Specifier – This is optional if the general bid package include the drawing list, but it is a good practice to list applicable drawings pertaining the specified work

SECTION 03100

CONCRETE FORMWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. Formwork for cast-in-place concrete, with shoring, bracing, and anchorage.

2. Openings for other work

3. Form accessories

4. Form stripping

B. Related Sections

1. Section 01300 - Submittal

2. Section 01400 - Quality Control

3. Section 01600 - Material and Equipment

4. Section 03200 - Concrete Reinforcement

5. Section 03300 - Cast-In-Place Concrete

1.2 SCOPE OF WORK

Design, engineer, and construct formwork, shoring, and bracing to conform to design and code requirements; resultant concrete to conform to required shape, line, and dimension.

1.3 REFERENCES

A. ACI 301 - Structural Concrete for Buildings

B. ACI 347 - Recommended Practice For Concrete Formwork

1.4 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals Procedures

B. Product Data: Provide data on void form materials.

1.5 QUALITY ASSURANCE

Perform work in accordance with ACI 347 standards.

1.6 REGULATORY REQUIREMENTS

Conform to applicable federal and state codes for design, fabrication, erection, and removal of formwork.

1.7 DELIVERY, STORAGE, AND PROTECTION

A. Transport, handle, store, and protect products in accordance with the provisions of Section 01600.

B. Deliver void forms and installation instructions in Manufacturer's packaging.

C. Store materials off ground in ventilated and protected manner to prevent deterioration from moisture.

PART 2 PRODUCTS

2.1 WOOD FORM MATERIALS

A. Form Materials: At the discretion of the Contractor.

B. Forms should produce a clean, uniform, and durable finished surface.

2.2 PREFABRICATED FORMS

A. Preformed Steel Forms: Minimum 16 gage matched, tight fitting; stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.

B. Preformed Plastic Forms: Tight-fitting; stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.

C. Glass Fiber Fabric Reinforced Plastic Forms: Matched, tight fitting; stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished concrete surfaces.

D. Tubular Column Type: Round; surface treated with release agent; non-reusable; of sizes required.

E. Void Forms: Manufactured specifically for use as concrete formwork. Moisture resistant treated paper faces; biodegradable; structurally sufficient to support weight of wet concrete mix until initial set; 2 inches minimum thickness.

2.3 FORMWORK ACCESSORIES

A. Form Ties: Removable type; galvanized metal or plastic; fixed length; cone type; free of defects that could leave holes larger than 1 inch in concrete surface.

B. Form Release Agent: Colorless mineral oil which will not stain concrete or absorb moisture.

C. Corners: Chamfered as shown on contract drawings.

D. Nails, Spikes, Lag Bolts, Through Bolts, and Anchorages: Sized as required; of sufficient strength and character to maintain formwork in place while placing concrete.

E. Waterstops: Embedded; polyvinyl chloride (PVC); minimum 1,750 pounds per square inch tensile strength; minimum 50°F to plus 175°F working temperature range; 6 inches wide; maximum possible lengths; ribbed profile; preformed corner sections; heat welded jointing.

F. Adhesive Waterstop for Application to Hardened Concrete: Single component, self-sealing plastic water stop manufactured by Synko-Flex Products, Inc. Houston, Texas.

PART 3 EXECUTION

3.1 EXAMINATION

Verify lines, levels and centers before proceeding with formwork. Insure dimensions agree with drawings.

3.2 EARTH FORMS

Hand trim sides and bottom of earth forms. Remove loose soil prior to placing concrete.

3.3 ERECTION - FORMWORK

A. Erect formwork, shoring, and bracing to achieve design requirements, in accordance with requirements of ACI 301.

B. Provide bracing to insure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.

C. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.

D. Align joints and make watertight. Keep form joints to a minimum.

E. Obtain approval from Architect/Engineer before framing openings in structural members which are not indicated on drawings.

F. Provide chamfer strips on exposed corners unless exposed surface is to be used as a cold joint. An expansion joint will abut floor slabs or will provide one edge of a joint that will accept sealants.

G. Install void forms in accordance with Manufacturer's recommendations. Protect forms from moisture or crushing.

H. Coordinate this Section with other Ssections of work which require attachment of components to formwork.

I. If formwork is placed after reinforcement and results in insufficient concrete cover over reinforcement, before proceeding request instructions from Architect/Engineer.

3.4 APPLICATION - FORM RELEASE AGENT

A. Apply form release agent on formwork in accordance with Manufacturer's recommendations.

B. Apply form release agent prior to placement of reinforcing steel, anchoring devices, and embedded items.

C. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.

3.5 INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Provide formed openings where required for items to be embedded in passing through concrete work.

B. Locate and set in place items which will be cast directly into concrete.

C. Coordinate and work with other Sections in forming and placing openings, slots, reglets, recesses, sleeves, bolts, anchors, other inserts, and components of other work.

D. Install accessories straight, level, plumb, and in accordance with Manufacturer's instructions. Insure items are not disturbed during concrete placement.

E. Install PVC waterstops in accordance with Manufacturer's instructions, continuous without displacing reinforcement. Heat seal joints watertight.

F. Install adhesive waterstops in accordance with Manufacturer’s instructions using appropriate techniques and materials. Lap ends and corners to form a single, continuous waterstop. Do not remove protective paper from top of waterstop until immediately prior to concrete placement.

G. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

H. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

3.6 FORM CLEANING

A. Clean forms as erection proceeds to remove foreign matter within forms.

B. Clean formed cavities of debris prior to placing concrete.

C. Flush with water or use compressed air to remove remaining foreign matter. Insure water and debris drain to exterior through clean-out ports.

D. During cold weather, remove ice and snow from within forms. Notify Architect/Engineer of presence of ice or snow. Do not use de-icing salts. Do not use water to clean out forms. Use compressed air or other means to remove foreign matter.

3.7 FORMWORK TOLERANCES

Construct formwork to maintain tolerances required by ACI 301.

3.8 FIELD QUALITY CONTROL

A. Section 01400 - Quality Control: Field inspection

B. Inspect erected formwork, shoring, and bracing to insure work is in accordance with formwork design, and supports, fastenings, wedges, ties, and items are secure. Check that anchor bolts and other anchorages are properly located and securely anchored.

C. Do not reuse wood formwork more than four times for concrete surfaces exposed to view. Do not patch formwork.

D. Protect waterstop during backfill operations or any other operation which may damage the waterstop. Unacceptable or damaged waterstop shall be repaired or replaced.

3.9 FORM REMOVAL

A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads.

B. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.

C. Store removed forms in such manner that surfaces in contact with fresh concrete will not be damaged. Discard damaged forms.

3.10 SCHEDULES

A. Mats: Form exposed surfaces using plywood or metal forms coated with a form release agent.

B. Slabs and Equipment Pads: Form edges using wood or metal forms coated with a form release agent.

END OF SECTION

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

Deformed reinforcing steel bars, wire fabric and accessories for cast-in-place concrete.

B. Related Sections

1. Section 01300 - Submittals
2. Section 01400 - Quality Control
3. Section 02470 - Drilled Concrete Piers and Shafts
4. Section 03100 - Concrete Formwork
5. Section 03300 - Cast-in-Place Concrete

1.2 SCOPE OF WORK

Not used

1.3 REFERENCES

A. ACI 318 - Building Code Requirements for Reinforced Concrete

B. ACI SP-66 - American Concrete Institute - Detailing Manual

C. ASTM A185 - Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement.

D. ASTM A706/A706M - Low-Alloy Steel Deformed Bars for Concrete Reinforcement

E. CRSI 63 - Recommended Practice For Placing Reinforcing Bars

F. CRSI 65 - Recommended Practice For Placing Bar Supports, Specifications and Nomenclature

1.4 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals: Procedures for submittals

B. Shop Drawings: Indicate bar sizes, spacings, locations, and quantities of reinforcing steel bending and cutting schedules, and supporting and spacing devices.

1.5 SUBMITTALS FOR INFORMATION

A. Section 01300 - Submittals: Procedures for submittals

B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

C. Submit certified copies of mill test report of reinforcement materials analysis.

1.6 QUALITY ASSURANCE

A. Perform work in accordance with ACI 318.

B. Provide Architect/Engineer with access to fabrication plant to facilitate inspection of reinforcement. Provide notification of commencement and duration of shop fabrication in sufficient time to allow inspection.

PART 2 PRODUCTS

2.1 REINFORCEMENT

A. Reinforcing Steel: All reinforcing shall conform to ASTM A706/A706M, Grade 60. All reinforcing steel is to be unfinished.

B. Welded Steel Wire Fabric: ASTM A185 Plain Type; unfinished.

C. Dowels: ASTM A706/A706M; 60 ksi yield grade, plain steel, unfinished.

2.2 ACCESSORIES

A. Tie Wire: Minimum 16 gage annealed type.

B. Chairs, Bolsters, Bar Supports, Spacers for concrete not exposed to weather or moisture: Sized and shaped for strength and support of reinforcement during concrete placement.

C. Special Chairs, Bolsters, Bar Supports and Spacers for concrete surfaces exposed to weather: Plastic or plastic coated steel type; size and shape as required

2.3 FABRICATION

A. Fabricate concrete reinforcing in accordance with ACI SP-66.

B. Do not weld reinforcement without approval of Architect/Engineer.

C. Locate reinforcing splices not indicated on drawings at point of minimum stress, preferably in compression zones of concrete members. Splices should comply with ACI 318 and should develop full strength of reinforcement. Lap splices shall be Class B.

D. Stagger lap splices and detail as required by ACI 318 and CRSI 63.

PART 3 EXECUTION

3.1 PLACEMENT

A. Place, support, and secure reinforcement against displacement. Conform to CRSI 63 and CRSI 65; do not deviate from required position.

B. Use reinforcement at time of placement which is free of mud, oil, ice, loose rust, mill scale, or other coatings that adversely affect bond.

C. Use metal reinforcement without kinks or nonspecified bends. Straighten or repair bars in a manner that will not damage the bars or adjacent construction.

D. Accommodate placement of formed openings.

E. Conform to Contract Drawings for concrete cover over reinforcement. However, concrete cover must not be less than required by ACI 318.

3.2 FIELD QUALITY CONTROL

A. Section 01400 - Quality Control: Field inspection

B. Architect/Engineer will inspect for acceptability.

3.3 SCHEDULES

Deformed bars and wire fabric, unfinished, of dimensions shown on design drawings

END OF SECTION

SECTION 03390

CONCRETE CURING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

Initial and final curing of horizontal and vertical concrete surfaces.

B. Related Sections

1. Section 01300 - Submittals
2. Section 01400 - Quality Control
3. Section 01600 - Materials & Equipment
4. Section 03300 - Cast-In-Place Concrete

1.2 SCOPE OF WORK

Not used

1.3 REFERENCES

A. ACI 301 - Structural Concrete for Buildings

B. ACI 302 - Recommended Practice for Concrete Floor and Slab Construction

C. ACI 308 - Standard Practice for Curing Concrete

D. ASTM C309 - Liquid Membrane-Forming Compounds for Curing Concrete

1.4 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Product Data: Provide data on curing compounds, compatibilities, and limitations.

1.5 QUALITY ASSURANCE

A. Perform work in accordance with ACI 301 and ACI 302.

B. Insure compatibility between curing methods and hardeners or finishing agents.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products under provisions of Section 01600.

B. Deliver curing materials in Vendor's packaging including application instructions.

PART 2 PRODUCTS

2.1 MATERIALS

Membrane Curing Compound Type 1-D Class A according to ASTM C309

PART 3 EXECUTION

3.1 EXAMINATION

Verify that substrate surfaces are ready to be cured.

3.2 EXECUTION - HORIZONTAL SURFACES

A. Cure floor surfaces and large mat surfaces in accordance with ACI 308.

B. Membrane Curing Compound: Apply curing compound in accordance with Vendor's instructions in two coats, with second coat applied at right angles to first.

C. Water Curing - Concrete may be water cured by the continuous or frequent application of water by means of ponding, spraying, sprinkling, or fogging in accordance with ACI 308. Care shall be taken to prevent saturating the supporting soil causing softening and subsequent damage to the concrete.

3.3 EXECUTION - VERTICAL SURFACES

A. Cure surfaces in accordance with ACI 308.

C. Membrane Curing Compound: Apply compound in accordance with Vendor's instructions in one coat.

3.4 PROTECTION OF FINISHED WORK

Do not permit traffic over unprotected floor surface.

END OF SECTION

SECTION 05120

STRUCTURAL STEEL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. Structural steel framing members, support members and sag rods
2. Base plates

B. Related Sections

1. Section 01300 - Submittals
2. Section 01400 - Quality Control
3. Section 01600 - Materials and Equipment
4. Section 03300 - Cast-In-Place Concrete
5. Section 05510 - Metal Stairs and Handrail

1.2 SCOPE OF WORK

Not used

1.3 REFERENCES

A. AISC - Manual of Steel Construction, Allowable Stress Design (ASD), Ninth Edition

B. AISC - Manual of Steel Construction, Load and Resistance Factor Design (LRFD), Second Edition

C. AISC - Code of Standard Practice for Steel Buildings and Bridges, Adopted September 1, 1986

D. AISC - Structural Joints Using ASTM A325 or A490 Bolts, Approved November 13, 1985

E. ASTM A6 - General Requirements for Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use

F. ASTM A36 - Structural Steel

G. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

H. ASTM A123 - Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

I. ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware

J. ASTM A307 - Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

K. ASTM A325 - High Strength Bolts for Structural Steel Joints

L. ASTM A490 - Heat Treated Steel Structural Bolts, Classes 150 ksi (1035 Mpa) Tensile Strength

M. ASTM A500 - Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

N. ASTM A563 - Carbon and Alloy Steel Nuts

O. ASTM F436 – Hardened Steel Washers

P. ASTM F1554 – Anchor Bolts, Steel, 36, 55, And 105 ksi Yield Strength

Q. AWS A2.0 - Welding Symbols

R. AWS D1.1 - Structural Welding Code

S. CBC – 1998 California Building Code (comment-Building code is project specific. JAK)

T. RCSE – Research Council on Structural Connections

U. SDI - Steel Deck Institute, "Design Manual for Composite Decks, Form Decks and Roof Decks."

V. SJI – Steel Joist Institute, "Recommended Code of Standard Practice for Steel Joists and Joist Girders."

W. SSPC (Steel Structures Painting Council) – Painting Manual

1.4 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals Procedures

B. Shop Drawings

1. Indicate profiles, sizes, spacing, locations of structural members, openings, attachments, and fasteners.

2. Connections detailed

3. Indicate welded connections with AWS A2.0 welding symbols.

C. Calculation Package for Structural Steel Connections:

1. Indicate that finished connections have adequate strength and stiffness to function according to project requirements.

2. Indicate that connection design complies with appropriate codes.

3. Calculations must be properly sealed by a Professional Engineer licensed to practice in the State of California.

1.5 SUBMITTALS FOR INFORMATION

A. Section 01300 - Submittals Procedures

B. Manufacturer's Mill Certificate: Certify that Products meet or exceed specified requirements.

C. Mill Test Reports: Indicating structural strength, destructive, and non-destructive test analysis.

1.6 QUALITY ASSURANCE

A. Materials and fabrication for structural steel shall be in accordance with AISC "Manual of Steel Construction." Steel plates and rolled shapes are to be from domestic mills only. Foreign materials may be used with written permission to the Engineer.

B. Fabricator: Company specializing in performing the work of this Section with minimum five (5) years documented experience. Fabricator is expected to adhere to quality control procedures that require material tracking and visual weld inspection.

C. Design and fabricate connections not detailed on design drawings per the requirements of AISC Code of Standard Practice. Shop drawings to include piece marks for steel erection.

D. Design structural details and connections under direct supervision of a Professional Structural Engineer experienced in design of the work and licensed to practice in the State of California. Submit calculation package sealed by a Professional Structural Engineer when submitting fabrication drawings to Engineer for review of compliance to drawings and specifications. A review of the submitted documentation is required by the California Energy Commission Chief Building Official (CBO). Utility Engineering Corporation will pass said documentation on to the CBO via submittal packets, which require approval prior to construction.

E. Approval of shop drawings by Engineer and CBO does not alleviate Fabricator from the responsibility for accurate fabrication and tolerances. Engineer will check drawings for engineering content only.

F. Certify welders employed for the work, verifying AWS qualification within the previous 12 months.

G. Welding Inspectors: Certify that personnel responsible for the inspection and acceptance of welds are currently certified as Certified Welding Inspectors (CWI) in accordance with AWS QC1.

PART 2 PRODUCTS

2.1 MATERIALS

The following materials shall conform to the requirements in ASTM as listed below:

Structural Steel Material

Material	Specification
Structural Steel	ASTM: A36
Structural Steel Plates, Shapes and Bars	ASTM: A36
Sag Rods	ASTM: A36
Structural Tubing	ASTM: A500, Grade B
Structural Pipe	ASTM: A53, Type E or S, Grade B
Components of high-strength steel fastener assemblies for use in structural steel joints.	
Bolts	ASTM: A325 [1], Type 1, Zinc Coated [2]
Nuts	ASTM: A563, Grade DH [3], Zinc Coated [2]

Hardened Washers	ASTM: F436, Type 1, Circular, Zinc Coated [2], including S1 supplementary requirements
Components of anchor rod assemblies for use in anchoring structural supports to concrete foundations [4]	
Hooked, headed, threaded and nutted anchor rods	ASTM: F1554; Grades: 36, 55 including S1 supplementary requirements, 105; Zinc Coated [5]
Nuts	ASTM: A563, including Appendix X1 [3], Zinc Coated [5]
Washers	ASTM: F436, Type 1, Circular, Zinc Coated [5], including S1 supplementary requirements

1 Certified Manufacturer's test reports required.
2 Hot-dipped galvanized per ASTM: A153, Class C. Obtain all fasteners from North American manufacturers only.
3 Zinc-coated nuts shall be furnished with a dry lubricant conforming to Supplementary Requirement S2 in ASTM Designation: A563
4 Other grades may be required for anchoring specific equipment
5 Hot-dipped galvanized per ASTM: A153, Class C
6 Welding Materials: AWS D1.1; type required for materials being welded

2.2 FABRICATION

A. Conform to AISC Manual of Steel Construction, AISC Code of Standard Practice, and ASTM A6.

B. Connection material shall be the same material as the member to which it attaches.

C. Fabricate and assemble structural steel members in the shop to the greatest extent practicable.

D. Cut surfaces shall be smooth and neat, without ragged edges, notches, or cracks.

E. Continuously seal joined members by continuous welds. Grind exposed welds smooth as required by drawings.

F. Fabricate connections for bolt, nut, washer connectors, and welded connections as shown on drawings. Unless otherwise noted, the minimum shear beam reaction for connection design shall be taken as one-half the total uniform load capacity determined from the tables of allowable

Uniform Load, Part 2 of the AISC "ASD Manual of Steel Construction."(comment-this criteria must be understood by the designer as well as the fabricator. JAK)

G. Steel beams used for monorails or crane rails shall be straight and level with no gaps or unevenness in splices. Stops made from angles shall be bolted in place on each end of each monorail beam to limit travel of the hoist.

H. Furnish bolts, nuts, and washers for all field connections with a 2% overage of each size and length of bolt.

2.3 FINISH

A. Prepare structural component surfaces to be coated in accordance with SSPC SP 6, commercial sandblast, according to schedule.

B. Hot-dip galvanize structural steel according to ASTM A123 as required by schedule. Provide minimum 1.25 ounces per square foot galvanized coating for shapes not covered by ASTM A123.

C. Shop coat structural steel members with 1 coat of Carbo Zinc 11 (CZ-11) as manufactured by Carboline, at 2.5 to 3.5 mils. DFT according to schedule.

D. Apply coating in accordance with SSPC-PA1 and Manufacturer's instructions.

E. Securely affix piece marks to steel members and assemblies for purposes of erection. Marking may be with paint, metal tags, adhesive labels, or with other approved means. Piece marks should be durable enough to remain legible after shipping, handling, and weather exposure.

2.4 SOURCE QUALITY CONTROL AND TESTS

Fabricator to provide shop testing and analysis of structural steel sections and welds.

PART 3 EXECUTION

3.1 ERECTION

A. Allow for erection loads and sufficient temporary bracing to maintain structure safe, plumb, and in true alignment until completion of erection and installation of permanent bracing.

B. Field weld components indicated on contract drawings and shop drawings.

C. Field connect members with threaded fasteners. Threaded fasteners shall be installed in accordance with the AISC Specification for Structural Joints using ASTM A325 or A490 Bolts. Tighten bolts using a method approved by the AISC Specification, the Engineer, and the Owner. The Contractor is responsible for insuring that all fasteners are properly tightened through an ongoing Quality Assurance and Quality Control program.(comment-method of verifying tightening should be determined prior submittal of RFP documents. JAK)

D. Do not field cut or alter structural members without approval from the Engineer.

E. Thoroughly clean members and connections of dirt, mud, debris, and other foreign substances prior to erecting.

F. After erection, paint welds, abrasions, and surfaces to match shop painting. Surfaces to be in contact with concrete or surfaces to be covered with insulation do not require surface preparation or painting.

G. Grout under base plates in accordance with Section 03600 and the design drawings. Trowel grouted surface smooth. Splay edges neatly to 45 degrees.

3.2 ERECTION TOLERANCES

A. Maximum Variation From Plumb: 1/4 inch per level, non-cumulative except that the displacement of any column center line from the established column line shall be no more than 1 inch at any point in the total height of the column.

B. Maximum Offset From True Alignment: 1/4 inch

C. Comply with tolerances specified in AISC Code of Standard Practice for Steel Buildings and Bridges.

3.3 FIELD QUALITY CONTROL

Section 01400 - Quality Control

3.4 FINISH SCHEDULE

ITEM	SURFACE PREPARATION	SURFACE FINISH	COLOR
PIPE RACK	CLEAN	GALVANIZE	NONE
EXTERIOR PLATFORMS	CLEAN	GALVANIZE	NONE

(note: schedule is project specific. JAK)

END OF SECTION

SECTION 05540

STEEL H-PILES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. This Specification covers the requirements for material, installation, quality control, testing, and reporting for the steel piling.
2. Unless otherwise specified, the Contractor shall furnish all labor materials, equipment transportation, supervision, and facilities necessary to perform all work scoped and defined in construction drawings and this Specification.
3. All materials used and work performed by the Contractor shall be subject to approval by the Engineer inspector to ensure compliance with drawings and this Specification.
4. Unless otherwise specified, the acquisition of all required permits is the responsibility of the Contractor.
5. All applicable local, city or other required codes shall be adhered to by the Contractor. Any Conflicts between the requirements of such codes and these documents shall be brought to the attention of the Engineer for clarification or resolution.
6. Piles shall be driven to a pile cut-off elevation as shown on the design drawings.
7. The Contractor shall provide H-pile accessories such as H-pile points/splices. Uplift connectors shall be provided and installed by the foundation mat contractors.
8. Removal of existing above ground and below ground obstructions as required for the installation of piling will be by others.

1.2 SCOPE OF WORK

Not Used.

1.3 REFERENCES

A. American Society for Testing and Materials

1. ASTM A36-1988 - Structural Steel
2. ASTM D1143-87 - Piles Under Static “Axial Compressive Load”
3. ASTM D3689-83 - “Individual Piles Under Static Axial Tension Loads”
4. ASTM D3966-81 - “Method for Testing Piles Under Lateral Loads”

B. American Institute of Steel Construction

1. AISC-1989 - Specification for Structural Steel Buildings
2. AISC-1986 - Code of Standard Practice for Steel Buildings and Bridges
3. AISC-1989 - Manual of Steel Construction, Ninth Edition

C. American Welding Society

1. AWS A5.1-1981 - Specification for Mild Steel Covered Arc-Welding Electrodes
2. AWS A5.5-1981 - Specification for Low-Alloy Steel Covered Arc-Welding Electrodes
3. AWS D1.1-2002 - Structural Welding Code

1.4 DESIGN CRITERIA

A. Steel H-Piles - General

1. Location shown on the drawing, H-Type steel (ASTM A-36) bearing piles, shall be used to support the foundation mat.
2. H-piles shall be sized as shown on the drawings.
3. Splices in steel piles are to be welded. Welds to be as per AWS D1.1.
4. When the pile shall be spliced to develop adequate embedment length, all the necessary equipment shall be standing by so that when hammer is shutoff the splice can be quickly made.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 Pile Driving

A. Pile driving shall be accomplished using a hammer rated at 40,000 ft/lbs or greater. The size and capacity of the pile hammer is typically determined during the geotechnical investigation of the project. A description of the pile driving equipment shall be submitted to the Engineer for approval prior to the start of pile driving. Piles are to be driven to refusal. All piles shall employ rock shoes for protection when driving to bedrock.

B. After completion of driving, each pile shall be inspected to verify that the in-place pile is sound and without injury. Piles shall be driven continuously to the required penetration the same day they are started.

C. Where penetration of the pile is suddenly resisted by underground obstructions, the Contractor shall bring this condition to the attention of the Engineer for resolution.

D. When piles in large groups are to be driven, the Contractor must be alert to the danger of heaving and lateral displacement and select the proper driving sequence in order to minimize heaving and displacement.

E. As far as practicable, piles in large groups should be driven from the inside toward the outside. Piles, which drift off position and exceed the location tolerance criteria given in this Specification may be subject to rejection.

F. The Contractor shall measure and record heave and displacement of each pile after all piles in the group have been driven. Piles showing more than 1/2 inch of heave shall be re-driven until refusal and piles have been driven to or below the original pile tip elevation. Driving shall be done with fixed leads, which will hold the pile firmly in position and in axial alignment with the hammers. During driving, all precautions shall be taken to ensure that the piles are driven in their required positions. Any pile so out of position as to impair its intended usefulness shall be pulled and re-driven or an additional pile driven, as directed and at the expense of the Contractor.

G. Accurate driving records for each pile shall be maintained on a reproducible form by the Contractor and submitted to the Engineer on a daily basis. The driving record for each pile shall include the number of blows per foot used to drive the pile for its entire length.

H. The records shall also include the following information:

Pile Data

Number: ____________________

Location; ____________________

Type: ____________________

Dimensions of:
 Butt
 Tip ____________________

Length: ____________________

Elevation of:
 Tip
 Cutoff
 Grade ____________________

Time and Date of Reason: ____________________

Equipment Data

Make and Model of Rig: ______________________

Weight of Striker ______________________

Weight of Hammer ______________________

Height of Fall or Stroke ______________________

Rated Energy ______________________

Cushion Type ______________________

Driving Interruption

Time: ______________________

Duration: ______________________

Tip Elevation: ______________________

3.2 Acceptance Criteria

A. The acceptance criteria for the position of driven piles is as follows:

1. Cut off elevation, ± 1 inch
2. Horizontal location, ± 3 inches
3. Alignment (vertical or batter), 2%

B. Suitable anvils, cushions, caps, mandrels, or containment bands shall be employed as necessary to protect the structural integrity of the pile tops against the impact forces of driving. Any pile damage, in the judgment of the Engineer, so as to impair the structural integrity of the pile with respect to its intended use shall be remedied by the Contractor at its expense. The remedy shall be as directed by the Engineer.

C. All piles shall be driven to bedrock. Extreme care should be taken during pile driving operations not to overstress the piles upon encountering bedrock

(Comment – Driven piles utilize a know energy input to determine the design depth of the foundation. The objective is to avoid pile damage or foundation cost overruns due to excessive driving. This can be achieved through wave equation analysis, dynamic monitoring of pile driving, and static load testing. It is incorrect to state that pile will be driven to bedrock. The piles resist vertical loads through friction forces as well as end bearing.)

END OF SECTION

CIVIL/STRUCTURAL

D.1 Anchor Bolts

Shop Drawings:

- Indicate profiles, sizes, spacing, locations of structural members, openings, attachments, and fasteners.
- Connections detailed by Supplier.
- Indicate welded connections with American Welding Society (AWS) A2.4 welding symbols. Supplier's shop detail and erection drawings will clearly distinguish between shop and field welding.
- Approval of shop drawings by Company does not alleviate Fabricator from the responsibility for accurate fabrication and tolerances. Company will check drawings for engineering content only.

D.1.1 Quality Assurance

Materials and fabrication for structural steel shall be in accordance with American Institute of Steel Construction (AISC) "Manual of Steel Construction."

Manufacturer: Company specializing in performing the Work of this Section with minimum 5 years documented experience. Contractor shall ensure that Manufacturer adheres to quality control procedures that require material tracking and visual weld inspection.

Design and fabricate connections not detailed on the design drawings provided by Company, if applicable, to meet requirements of AISC Code of Standard Practice. Shop drawings are to include piece marks for steel erection.

For welding requirements see Attachment B.

Design structural details and connections under direct supervision of a Professional Civil Engineer experienced in design work and licensed to practice in the State of Colorado. When submitting fabrication drawings to Company for review of compliance to drawings and specifications, include calculation package signed and sealed by a Professional Civil Engineer licensed to practice in the State of Colorado

D.1.2 Materials

Anchor Bolts:

- ASTM F1554, grade as noted on design drawings. ASTM A563, Grade A, heavy hexagon nuts, ASTM F436 hardened steel washers.

- Other grades may be required for anchoring specific equipment.
- ASTM A36 Plate washers as required and noted on design drawings.

Welding Materials: AWS D1.1; type required for materials being welded.

Used or repaired materials shall not be used without the explicit approval of the Company.

D.1.3 Fabrication

Conform to AISC Manual of Steel Construction and ASTM A6M, and IBC.

Fabricate and assemble structural steel members in the shop to the greatest extent practical.

Cut surfaces shall be smooth and neat without ragged edges, notches or cracks.

Seal joined members by continuous welds where air-tight connection is required. Grind exposed welds smooth as required by design drawings provided by Company.

Fabricate connections for bolt, nut, and washer connectors or for welded connections as shown on design drawings provided by Company. Unless otherwise noted, the minimum shear beam reaction for connection design shall be taken as one-half the total uniform load capacity determined from the tables of Uniform Load Constants, Part 2 of the AISC "Manual of Steel Construction, Allowable Stress Design (ASD), Ninth Edition" (or later editions).

Steel beams used for monorails or for crane rails shall be straight and level with no gaps or unevenness in splices. Stops made from angles shall be bolted in place on each end of each monorail beam to limit the travel of the hoist.

Furnish bolts, nuts and washers for all field connections with a 2% overage of each size and length of bolt.

D.1.4 Bolting

High strength bolts shall conform to the requirements of this Section and to the requirements of the RCSC "Specification for Structural Joints Using ASTM A325 or A490 Bolts".

Except as otherwise specified in this Section, the methods, conditions, materials, and products specified herein apply to work whether performed in the shop or in the field.
Include an additional 2% overage for bolts, nuts and washers to be installed in the field.

Shoulder Bolts, fabricated from ASTM A325 material, shall be used for slotted sliding connections.

Erection Bolts: Use ASTM A307.

Bolt holes shall be 1/l6 in. larger than the nominal diameter of the bolt.

Oversized or slotted holes will not be permitted, unless shown on Company Drawings.

Contractor shall insure the proper faying surface is provided at all connections for the class and type of connection specified in the design.

Nuts shall be fully engaged with the end of the bolt at least flush with the face of the nut.

The threaded part of the installed bolt shall not be in the shear plane.

For a slotted sliding connection using shoulder bolts, two nuts are required. Each nut shall be installed using an impact wrench. The first nut shall be installed up to the shank of the bolt, followed by the second nut. Both nuts shall be installed to a "snug-tight" condition.

Washers shall be used in accordance with the RCSC Specification.

Location of Bolt Heads:

- Columns: On outside faces of flanges.
- Beams and Girders: On upper sides of flanges.

Snug-tight bolt tensioning of bearing connections are preferred and will be utilized to the maximum extent possible unless other bolt tightening requirements are specified by Supplier using method approved by the AISC specification. Bolts in bearing type connections not requiring fully tensioned bolts need only be tightened to the snug tight condition as defined in Section 4.1 and 8.1 of the AISC “RCSC” Specification for Structural Joint Using ASTM A325 or A490 Bolts.

When pre-tensioned bolts are required for bearing or slip critical connections, the Fabricator and Erector may utilize their preference of any of the four AISC approved installation methods when properly used in accordance with RCSC requirements: 1) the turn-of-nut method, 2) the calibrated wrench method, 3) the twist-off type tension control bolt, and 4) the direct tension indicator method. Fabricator and Erector shall demonstrate compliance of preferred method to Company.

Inspection, examination and “Special Inspections” indicated in Chapter 17 of IBC, if required, shall be performed by the Contractor’s independent Testing and Inspection Agency.

Contractor’s Work is subject to inspection and examination by Company and the testing and inspection agency for full compliance with all the requirements specified herein.

Contractor shall provide, and pay for, access and all rigging required for the examinations performed by Company or the testing and inspection agency. Contractor shall also provide personnel required to assist Company or the testing and inspection agency at no additional cost to Company.

Company's inspection will not relieve Contractor of its obligation for inspection. Company's testing and inspection agency will not be available for Contractor’s use.

Inspection of High-Strength Bolting:

- Contractor shall furnish and install a tension calibrating device, such as a Skidmore-Wilhelm calibrator. The device furnished shall bear a certification as to the accuracy of the device. Such certification shall be dated not more than 30 days prior to the first actual use of the device for inspection of the Work.

- Inspection procedures shall be in accordance with Section 9 of the RCSC "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts", including the provisions for arbitration inspection specified therein. The Contractor shall provide a procedure and associated documentation, signed by Contractor’s QA/QC Manager, to indicate that the inspection requirements of the RCSC specification have been performed.

- When alternative washer-type indicating devices, squirter type DTIs, are used, detailed installation and inspection instructions shall be prepared by the Contractor, per RCSC requirements and approved by Company prior to installation. The instructions shall be augmented by the test procedures performed to establish the volume and appearance of the orange silicone liquid squirted out from the collapsed bumps on the face of the DTI.

SITE GRADING

D.1 ROUGH GRADING

Cutting, grading and filling the site to establish subgrade contours.

Prior to placement of fill, any vegetation and organics in areas to be graded shall be removed. Coal shall be removed underlying proposed structures. Exposed ground shall be scarified to a depth of 8 inches, moisture conditioned and compacted.

D.1.1 Project Record Documents

Accurately record actual locations of remaining utilities by horizontal dimensions, elevations of inverts, and slope gradients.

D.1.2 Examination

Verify that survey benchmark and intended elevations for the Work are as indicated.

D.1.3 Preparation

Identify required lines, levels, contours and datum plane.

Identify known underground, above ground, and aerial utilities. Stake and flag locations.

Protect above and below grade utilities which are to remain.

Protect benchmarks, existing structures, and paving to remain from excavation equipment and vehicular traffic.

Install erosion and sediment control per the Storm Water Management Plan (SWMP) prepared by others.

Proof roll subgrade with pneumatic-tired roller (20-ton minimum weight) with at least four (4) equally loaded tires after clearing site. Proof roll the entire site in perpendicular passes to expose soft or weak areas of soil. Over-excavate areas of the subgrade that are determined to be inferior due to softness, pumping or excessive deflection. Excessive deflection is defined as rutting of more than 1 inch measured from the top of the construction grade to the bottom of the rut. Replace excavated material with structural fill and compact according to the provisions of these Specifications to attain a firm, uniform surface. Final density of the reworked area must equal or exceed density of adjacent material.

Permanent slopes constructed at the site shall have a maximum inclination of 3:1 (horizontal to vertical).

D.1.4 Subsoil Excavation

Excavate subsoil form areas to be further excavated or re-graded for building pads or paving.

Remove excess subsoil from the site to an area designated by the Company.

Do not excavate saturated topsoil.

D.1.5 Filling

Fill placed at the site, other than structural fill, shall be compacted to a minimum 95% of the standard Proctor (ASTM D698) density at a moisture content within 2% of optimum. Fill may consist of on-site materials. Excavated claystone shall be broken down prior to use as fill. Fill shall not contain particles greater than 4 inches in maximum dimension in the upper 6 feet. Excavated claystone shall not be placed as fill beneath foundations or pavements. Fill areas to contours and elevations with unfrozen materials.

Subsoil Fill: Place and compact fill material in continuous layers not exceeding 8 inches loose. Inaccessible areas should be compacted using hand equipment in 3-inch loose lifts.

Maintain optimum moisture content of fill materials per test requirements to attain required compaction density.

If subgrade material or previously placed subsoil fill has deteriorated due to weather exposure, scarify the top 6 inches of material to establish an acceptable interface for the materials prior to placing any additional fill.

Slope grade away from buildings a minimum of 6 inches in 10 feet, unless noted otherwise. Grade site to promote drainage for surfaces that are to remain exposed for an extended period of time to prevent water accumulation and subsequent softening.

Make grade changes gradual. Blend slope into level areas and match existing paving that will remain.

All graded areas, slopes, and ditches which will not be paved or otherwise surfaced shall be provided with permanent seeding.

Remove surplus fill materials from site, or dispose of in designated disposal areas.

D.1.6 Tolerances

Top Surface of Subgrade: ± 1/10 foot.

D.1.7 Field Inspection and Testing

Field inspection and testing of soils will be performed by independent Testing Service hired by Supplier.

D.2 EXCAVATION AND FILL

D.2.1 Design Criteria

Foundations shall conform to the requirements provided in the Geotechnical Report provided in Appendix H. Earthwork shall be coordinated in an effort to support foundation design and construction.

Supplier shall provide to the Company, for approval, a Production Sequencing Plan which coordinates earthwork and foundation construction efforts. The plan shall address foundation design requirements as provided by the Geotechnical Report.

D.2.2 Field Measurements

Verify that survey benchmark and intended elevations for the Work are as indicated.

D.2.3 Preparation

Identify known underground, above ground, and aerial utilities. Stake and flag locations.

Protect above and below grade utilities that are to remain.

Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.

Recent geotechnical investigation efforts encountered groundwater at varying elevations and are likely to impact underground excavations and drilled pier construction. Supplier shall use existing soil borings in his area of excavation as part of his excavation plan.

Install erosion and sediment control per the SWPP prepared by others.

Review geotechnical investigation for groundwater conditions that may impact foundation construction and fill placement.

D.2.4 Excavation

Construction excavations in fill and natural soil should be inclined not steeper than two (2) horizontal to one (1) vertical or as recommended by OSHA 1926 Subpart P, App. B. These soils will classify as Type C soils. Weathered claystone and claystone bedrock classify as Type A soils and may slope 1:1 or steeper if determined appropriate by Supplier's safety personnel. Excavators into bedrock shall require ripper teeth, hoerams, and extra effort.

Take special precautions as required preserving condition and integrity of existing structures.

Blasting shall not be allowed.

Excavate subsoil required to accommodate building foundations, slabs-on-grade, and paving.

Use precaution during final excavation to subgrade level to prevent disturbance and remolding of subgrade material. Hand trim excavation as required. Remove loose material.

Remove lumped subsoil, boulders, and rock up to 1/3 cubic yard measured by volume.

Grade top perimeter of excavation to prevent surface water from draining into excavation.

Notify the Company of unexpected subsurface conditions or hazardous materials encountered and discontinue affected Work in area until notified to resume work.

Correct unauthorized excavation.

Correct areas over-excavated by error.

It is the Supplier’s responsibility to comply with applicable state and federal regulations on excavation, shoring, and trenching.

D.2.5 Fill Course Placement

Fill areas to contours and elevations with unfrozen materials. Temporary and permanent cut and fill slopes shall be constructed no steeper than three (3) horizontal to one (1) vertical.

Maintain optimum moisture content of all fill materials at test requirements to attain required compaction density.

Do not mix fill types beneath foundations.

If subgrade material or previously placed subsoil fill has deteriorated due to weather exposure, scarify the top 6 inches of material to establish an acceptable surface prior to placing any additional fill.

Slope grades away from building a minimum of 2 inches in 10 feet, unless noted otherwise. Grade site to promote drainage for surfaces that are to remain exposed for an extended period of time to prevent water accumulation and subsequent softening.

Make grade changes gradual. Blend slope into level areas and match existing paving that will remain.

All graded areas, slopes, and ditches which will not be paved or otherwise surfaced shall be provided with permanent seeding.

Remove surplus fill materials from site or dispose of in designated disposal areas.

D.2.6 General

Blading and rolling shall be done alternately, as necessary, to obtain a smooth, even, and uniformly compacted course.

The final surface should be smooth and uniform and should conform to the required cross section and established grade. Tolerance for the finished surface: ± 1/10 foot.

Provide for visual inspection of bearing surfaces.

D.2.7 Protection

Protect excavations by methods required preventing cave-in or loose soil from falling into excavation.

Remove water which enters excavations.

Protect soil adjacent to and beneath existing foundation from freezing.

It is the Supplier's responsibility to comply with applicable state and federal regulations in protecting open excavations.

D.3 BACKFILL

D.3.1 Fill Materials

Sand: Natural river or bank sand; washed, free of silt, clay, loam, friable, or soluble materials, or organic matter; graded in accordance with ANSI/ASTM C136, within the following limits:

Sieve Size	Percent Passing
No. 4	100
No. 40	30 to 50

Excavated Subsoil: On-site low density clay soils, if any, are not acceptable as structural fill material. Areas not requiring structural fill may accept excavated site material. This material shall be compacted to a minimum 95% of standard Proctor density at a moisture content within 2% of optimum. The excavated claystone, if any, shall be broken down prior to use as fill material. Fill shall not contain particles greater than 4 inches in maximum dimension in the upper 6 feet.

Structural Fill: Free of loam, friable, or soluble materials. Non-swelling, impervious engineered (structural) fill shall be constructed of soil with 100% finer than 4 inches, 15% minimum of minus No. 200 sieve sizes, and a plasticity index of 15% or less. Bottom Ash material shall not be considered Structural Fill.

Coarse Aggregate Fill: Washed stone: Free of shale, clay, friable material and debris; graded in accordance with ASTM D2487 Group Symbol “GW.”

Fly Ash: Class C Fly Ash.

Final fill course in unpaved or unsurfaced areas shall be topsoil capable of establishing vegetative groundcover.

Controlled Low-Strength Materials (CLSM) as defined by, and in accordance with, ACI-229R-99 may be used in place of fill materials in certain situations with prior approval of the Company.

D.3.2 Examination

Verify fill materials to be used are acceptable to Company.

D.3.3 Preparation

Subgrade soils beneath foundations, floor slabs, and pavements shall be scarified to a minimum depth of 8 inches, moisture conditioned to within 3% of optimum moisture content, and compacted. The moisture and compaction shall be maintained until construction of the foundation, slab, or pavement.

Cut out soft areas of subgrade not capable of in-situ compaction that are determined to be inferior due to excessive deflection defined as rutting of more than 1 inch measured from the top of the construction grade to the bottom of the rut. Backfill with fill and compact to density equal to or greater than requirements for subsequent backfill material.

Prior to placement of aggregate base course material at paved areas, compact subsoil to 95% of its maximum dry density within ± 3% of optimum moisture content determined in accordance with ASTM D698.

D.3.4 Filling and Backfilling

Backfill areas to contours and elevations with unfrozen materials. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

Granular Fill: Place and compact materials in continuous loose layers not exceeding 8 inches loose depth.

Engineered (structural) fill shall be placed and compacted in horizontal lifts not exceeding 8 inches in loose thickness, using equipment and procedures that will produce recommended moisture contents and density throughout the cross section of the fill area. Required compaction criteria for structural fill materials and scarified subgrade soils are as follows:

Materials	Minimum Percentage (ASTM D698)
Scarified Subgrade Soils	
Beneath floor slabs and pavement	95
Beneath foundations	95
Structural Fill Soils	
Beneath floor slabs, pavement, and rail	100
Beneath mat/spread foundations	100
Other	95

Structural fill shall be compacted within a moisture content within 2% of optimum moisture content.

Building Pad: Movement sensitive floors shall be designed as structural floors with a minimum 6-inch void space between the underlying soil and floor. Building loads are to be transferred to drilled piers.

Comply with ASTM D2321 for backfill around High Density Poly-Ethylene (HDPE) and other flexible piping in trenches.

Employ a placement and compaction method that does not disturb or damage utilities in trenches.

Maintain optimum moisture content of backfill materials to attain required compaction density.

Slope grade away from building a minimum of 2 inches in 10 feet, unless noted otherwise.

Make grade changes gradual. Blend slope into level areas.

All graded areas, slopes, and ditches which will not be paved or otherwise surfaced shall be provided with permanent seeding.

Remove surplus backfill materials from site or dispose of in designated disposal areas.

Fill to restore over-excavation/unauthorized excavation shall be placed and compacted in continuous layers not exceeding 8 inches loose depth. Compact to 95% standard Proctor density.

D.3.5 Tolerances

Top Surface of Backfilling Under Paved Areas: ± 1/2 inch from required elevations.

D.3.6 Compaction

Proof roll compacted fill surfaces under slabs-on-grade and site paving with pneumatic-tired roller (20 ton minimum) with at least four (4) equally loaded tires. Rework loose or soft areas to attain firm, uniform surface. Final density of reworked areas must equal or exceed density of adjacent material. Any clay and claystone encountered at the site will provide poor pavement support. The expansive properties of the subsurface material shall be verified in case treatment is required to prevent pavement or railroad distress.

D.3.7 Protection of Finished Work

Protect finished Work.

Scarify and recompact fills subjected to vehicular traffic.

D.4 TRENCHING

D.4.1 General

D.4.1.1 Field Measurements

Verify that survey benchmark and intended elevations for the Work are as shown on project drawings provided by Company.

D.4.2 Execution

D.4.2.1 Examination

Verify fill materials to be reused are acceptable by Supplier's QCM.

D.4.2.2 Preparation

Identify required lines, levels, contours, and datum plane.

Protect bench marks, existing structures, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.

Protect above and below grade utilities which are to remain.

Install erosion and sediment control features per SWMP prepared by others.

Cut out soft areas of subgrade not capable of in situ compaction. Backfill and compact to density equal to or greater than requirements for subsequent backfill material.

D.4.2.3 Excavation

Excavate subsoil required for connection to existing utilities.

Cut trenches sufficiently wide to enable installation of utilities and allow inspection.

Excavation shall not interfere with normal 45 degree bearing splay of foundations.

Remove rocks to a minimum clearance of 8 inches around the bottom and sides of pipe, conduit, and duct.

Hand trim excavation. Remove loose matter.

Keep trenches dewatered.

Correct unauthorized excavation and areas over-excavated by error.

Stockpile excavated material in area designated on site.

D.4.2.4 Bedding

Support pipe and conduit, if necessary, during placement and compaction of bedding fill, according to design drawings. Compact to 95% Standard proctor density at $\pm$ 2% of optimum moisture content.

Bedding material shall provide continuous support for pipe between joints

.D.4.2.5 Backfilling

Backfill trenches to proper contours and elevations with unfrozen materials.

Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

Sheeting, forms, and bracing may not be left in place unless written permission has been received from the Company.

Employ a placement method that does not disturb or damage conduit or pipe in trench.

Comply with ASTM D2321 for backfill around HDPE piping. Work fill material underneath haunches of pipe with a shovel and hand tamp under haunches to provide firm, uniform support of pipe.

Place remaining backfill in continuous

layers not exceeding 8 inch loose lifts and compact to 95% Standard

Proctor Density at ± 2% of optimum moisture content.

Backfill around sides and top of rigid pipe with fill, tamped in place in 8 inch loose lifts and compacted to 95% Standard Proctor density at ± 2% of optimum moisture content.

Allow 24 hours minimum cure time for concrete encasements prior to backfilling.

D.4.2.6 Tolerances

Top surface of backfilling under paved areas: ± 1/2 inch from required elevations.

Top Surface of General Backfilling: ± 1 inch from required elevations.

D.4.2.7 Field Inspection and Testing

Field inspection and testing of soils will be performed by independent Testing Service hired by Supplier.

D.4.2.8 Protection of Finished Work

Protect finished Work.

Recompact fill disturbed by vehicular traffic.

SECTION 05501

METAL STAIRS, HANDRAILS, RAILINGS, AND GRATING

PART 1: GENERAL

1.01 DESCRIPTION

A. Work included in this section shall be performed in accordance with the following paragraphs and the provisions of the other Agreement Documents.

B. Work covered under this section includes providing all materials, equipment, and labor for miscellaneous stair, ladder, handrails, and grating as shown on drawings.

1.02 REFERENCES

A. The following are complete titles of references cited in this section:

1. American Society for Testing and Materials (ASTM) A36, "Specification for Structural Steel"
2. ASTM A53, "Specification for Hot-Dipped, Zinc-Coated Welded and Seamless Steel Pipe"
3. ASTM A123, "Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products"
4. ASTM A153, "Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware"
5. ASTM A283, "Specification for Carbon Steel Plates, Shapes, and Bars"
6. ASTM A307, "Specification for Carbon Steel Externally Threaded Standard Fasteners"
7. ASTM A500, "Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes"
8. ASTM E985, "Standard Specification for Permanent Metal Railing Systems and Rails for Buildings"
9. ASTM F593, "Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs"
10. American Welding Society (AWS) A2.0, Standard Welding Symbols
11. AWS D1.1, Structural Welding Code

1.03 SUBMITTALS

A. Shop Drawings. Shop drawings showing fabrication and installation of handrails and railing systems including plans, elevations, sections, details of components, and attachments to other units of Work. Shop drawings shall be submitted to the Company two weeks prior to start of Work. Review will be for general design and arrangement only, and fabricator shall be responsible for correctness of sizes, details, dimensions, and quantities

B. Product data for formed metal bar grating, metal stairs, manufacturer's clips and anchorage devices for gratings.

C. Shop drawings detailing fabrication and erection of gratings. Include plans, sections, and details of connections. Show anchorage and accessory items.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Care shall be utilized throughout the delivery, storage, and handling so as to not scratch, bend, wrap, or otherwise damage the components.

B. Metal chokers, cable, or straps likely to damage the surface shall not be used.

C. Components shall be stored aboveground on level timbers or other material which will not stain, corrode, scratch, or otherwise damage the components.

PART 2: PRODUCTS

2.01 MATERIALS

A. Structural Steel Shapes and Plates. Steel shapes and plates shall be the size and shape shown on the drawings and shall conform to the latest ASTM Designation A36. Components shall be hot-dipped galvanized.

B. Rectangular Hollow Steel Sections. Rectangular hollow steel sections shall be the size and shape shown on the drawings and shall conform to the latest ASTM Designation A500 Grade B with a minimum yield stress of 46 ksi. Components shall be hot-dipped galvanized.

C. Bolts. Bolts shall be the size and shape shown on the drawings and shall conform to the latest ASTM Designation A307, except as otherwise specified on the drawings, and shall be hot-dipped galvanized.

D. Fasteners into Concrete. Hilti HVA capsule adhesive anchoring system with a stainless HAS rod which meets the requirements of ASTM F593 (304/316).

E. Stair Treads. Stair treads shall be serrated grating with checkered plate nosing and hot-dipped galvanized.

F. Heavy Duty Serrated Grating. W-22-4 (1½ x ¼) hot-dipped galvanized steel: 1½-by-¼-inch bearing bars at 1-3/8 inches o.c., and crossbars at 4 inches.

2.02 FABRICATION

A. General. Structural and architectural metal shall be fabricated in accordance with the Drawings and in a neat workmanship manner.

B. Structural Steel. Structural steel components shall be fabricated and erected in accordance with the applicable requirements set forth by the American Institute of Steel Construction (AISC) publications, "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings," Section 1.23 entitled "Fabrication," and "Code of Standard Practice for Steel Buildings and Bridges," and Section 6 entitled "Fabrication and Delivery."

1. Members shall be straight with no bends or kinks. Steel shall be accurately cut with shears, mechanically-guided torches capable of forming smooth cut, or hand-guided torches. Hand-guided cuts or other rough surfaces, which are exposed or visible, shall be ground smooth. Exposed sharp edges and corners shall be machine filleted or chamfered. Bolt holes shall be accurately located and orientated normal to the bolting surfaces.

C. Handrails and Guards

1. Cut, reinforce, drill, and tap components, as indicated, to receive finish hardware, screws, and similar items.

2. Provide weepholes, or another means to evacuate entrapped water, in hollow sections of railing members that are exposed to exterior or to moisture from condensation or other sources.

3. Fabricate joints that will be exposed to weather in a manner to exclude water.

4. Provide wall returns at ends of wall-mounted handrails, unless otherwise indicated.

5. Where indicated, provide toe boards at railings around openings and at the edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

6. Shear and punch metals cleanly and accurately. Remove burrs from exposed cut edges.

D. Grating

1. Provide for anchorage per manufacturer's recommendations. Fabricate and space anchoring devices to secure gratings, frames, and supports rigidly in place and to support loads.

2. Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes.

E. Welds. Welds for the structural components shall conform to the applicable standard specifications set forth by the American Welding Society (AWS) publication "Structural Welding." Welds shall be of the type and size shown on the drawings.

F. Handrails, guards, base plates, bolts, rods, studs, nuts, washers, ladders, platform, cages, grating and other miscellaneous angles and plates shall be hot-dipped galvanized, as set forth in ASTM A123 after cut and fabricated.

G. Damage caused to galvanized surfaces by transport, erection, welding, or other operations shall be field repaired using a cold galvanizing process. Galvanizing Repair Paint: high-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.

H. Quality Control

1. The manufacturer or fabricator shall maintain a documented quality control program. The quality control program shall conform to the AISC Specifications and Code of Standard Practice.

2. Welders shall conform to the requirements set forth in AWS 01.1, Section 5 for the work performed. Welds shall be inspected in accordance with AWS D1.1, Section 6.

PART 3: EXECUTION

3.01 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Care shall be utilized throughout the delivery, storage, and handling so as to not scratch, bend, warp, or otherwise damage the components.

B. Metal chords, cable, or straps likely to damage the galvanized coating shall not be used.

C. Components shall be stored aboveground on level timbers or other materials.

3.02 ERECTION

A. General. Metal components shall be erected in a neat workmanship-like manner. Components shall be plumb, horizontal at the designated slope, and square, as appropriate.

B. Structural Steel. Structural steel shall be erected in accordance with the AISC Specifications, Section 1.25 entitled “Erection,” the Code of Standard Practice Section 7 entitled “Erection,” and commentaries. This includes the tolerance requirements.

C. Field Connections. Field connections shall be performed in a neat workmanship-like manner. Applicable welding requirements set forth in Part 2 of this section for fabrication shall also pertain to the erection.

D. Anchor Bolts. Hilti HVA anchor bolt system shall be drilled into hardened concrete and fastened in accordance with manufacturer’s recommendations.

E. Handrails and Guards. Handrails and guards shall be installed in accordance with the details shown on the Construction Drawings. Vertical components of handrails and guards shall be plumb and all horizontal components shall be parallel to the walls.

F. Gratings

1. Install gratings to comply with recommendations of NAAMM grating standard referenced under Part 2 that apply to grating types and bar sizes indicated, including installation clearances and standard anchoring details.

2. Secure non-removable and removable units to supporting members with type and size of clips and fasteners indicated, or, if not indicated, as recommended by grating manufacturer for type of installation conditions shown.

3. All removable grating panels shall be outlined in yellow paint.

G. Touch up surfaces and finishes after erection.

1. Galvanized Surfaces: clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780

H. Handrail and Guard Connections

1. Use fully welded joints for permanently connecting steel railing components.

2. Install expansion joints not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond the joint on each side, fasten internal sleeve securely to 1 side and locate joint within 6 inches of post.

3.03 FIELD CONTROL QUALITY

A. Contractor shall establish and maintain quality control for work under this section to assure compliance with Agreement requirements and maintain records of his quality control for all construction operations.

3.04 PROTECTION

A. Protect finishes of handrails and railing systems from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of completion.

B. Restore finishes damaged during installation and construction period so that no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05501

Schedule A

Minimum Requirements for Solar Generation Facility Build-Own-Transfer Proposals

TABLE OF CONTENTS

TABLE OF FIGURES

APPENDICES

Appendix A- EEC 7.970W01 Drawing Deliverables Standard
Appendix A1 - NSP Titleblock Standard2
Appendix B - XCEL ENERGY PHYSICAL DESIGN CRITERIA FOR SUBSTATIONS
Appendix C - XCEL ENGINEERING AND DESIGN MANUAL (ED)
Appendix D - SUBSTATION PHYSICAL DETAIL MANUAL
Appendix E - STD-CRITERIA FOR ENG DESIGN OF CIVIL AND STRUCTURAL PERFORMANCE
Appendix F - XEL-STD-DESIGN GUIDE FOR TRANSMISSION LINE CONDUCTOR
Appendix G - XEL-STD-SPECIFICATION FOR PROCUREMENT OF ROUND WOOD POLES
Appendix H-STD-SPECIFICATION FOR PROCUREMENT OF TUBULAR STEEL POLES

1. Introduction

1.1. Definitions

1.1.1. Owner / Buyer: Xcel Energy

1.1.2. Contractor: EPC (Engineer, Procure, Construct) Contractor

1.1.3. Seller: Developer or EPC Contractor

1.1.4. Engineer / Engineer of Record: (EOR) EPC Contractor

1.1.5. Quality Assurance Representative (QAR): The Owner reserves the right to engage an individual, partnership or corporation, to perform independent testing, inspection, and analysis to verify the Contractor is supplying a product in compliance with all contractual requirements, including this specification. The QAR shall be qualified by training and experience and hold certifications or documentation of their qualifications. The QAR shall be selected by the Owner and be fully independent of the contractor.

1.1.6. Testing Agency: The Contractor shall employ an independent, accredited testing agency. The testing agency shall be employed by the Contractor, at no cost to the Owner. The testing agency shall complete all testing as documented in contract documents, including this specification.

1.1.7. Geotechnical Engineer: A qualified person licensed to perform geotechnical engineering and investigate, employed by the Contractor, at no cost to the Owner. The Geotechnical Engineer must be a licensed, professional engineer in the state where the project is located.

1.1.8. Utility: Owner of the transmission line for the interconnection agreement.

1.2. Project Description

Contractor to provide all engineering, labor, procurement of materials and equipment, and supervision required for the complete design and installation of a fully functional, and operational solar photovoltaic (PV) facility with an O&M building as described in Appendix S, that is in full compliance with Owner's requirements, applicable codes, standards, laws and regulations. The described facility, as further detailed in the solar technical specifications, shall be designed for a 30-year operating life based on normal operation, and the performance of maintenance, repairs, and the replacement of parts according to manufacturers' recommendations and standard industry practices.

Contractor shall provide all materials (unless provided by Owner), and full system installation of all components, including photovoltaic modules, DC electrical systems including inverters, DC combiner boxes, mounting systems, weather station, remote monitored security cameras, Data Acquisition System (DAS) and electrical interconnection to the local Utility.

Contractor shall commission the component systems of the facility and coordinate interconnection and start-up with Utility. Contractor shall provide comprehensive on-site construction management at all times for the facility when work is conducted.

The facility shall be designed and arranged to make maximum use of the available space as defined in the documents and drawings provided in Attachment 7. The design of the facilities shall be to maximize the annual megawatt hours (MWh) over a 30-year operating life based on measured actual site conditions, and adjusted for evaluated operating, maintenance, and replacement costs.

It is anticipated that the sites will require grading modification for storm water collection and runoff features. Installations shall be pile supported design with direct buried electrical cabling below grade. The transition from PVC raceway above grade to direct buried cables shall include PVC conduit extending below grade to a PVC conduit sweep where the cable transitions to direct buried.

The base design capacity range of the facilities considered shall be capable of a 0.95 lead/lag power factor at the interconnect, unless otherwise indicated by the site interconnect agreement. See Section 9 for base design facilities greater than 75 MVA connecting at high-voltage (HV) transmission voltage levels. The facility will interconnect with the point of interconnection specified voltage distribution lines/substation or transmission lines/substation adjoining or on the facility property. The PV Solar installation shall be single axis tracker design, as dictated by Owner requirements. The module racking foundations shall be adequate for the wind and snow loading specified in Attachment 3. Medium voltage collection lines from each module shall be direct buried as described in this specification.

1.3. Engineering

In all cases, installed components shall carry a Nationally Recognized Testing Laboratories (NRTL) listing for their intended use and application (e.g. – UL, CSA, ETL) and shall be appropriate for the local climate and exposure. All components shall be installed per manufacturer guidelines and in a manner that upholds the manufacturer's warranty.

1.3.1. Transformers shall meet or exceed current US Department of Energy transformer efficiency standards.

1.3.2. Contractor shall consider existing site conditions (including any wetland, waterway, habitat, endangered/threatened species, flood, cultural) with respect to soil characteristics, site clearing, grubbing, grading and drainage to minimize site disturbance.

1.3.3. Contractor shall review the geotechnical evaluation report and shall take all relevant construction measures to accommodate the site conditions provided in the report, based on their professional experience. The geotechnical evaluation report is provided in the contract documents for information purposes only. Specifications provided in the geotechnical evaluation report shall be incorporated into the contract documents under the direction of the EOR. The Facility shall meet all applicable seismic requirements.

1.3.4. Contractor shall install power and communications infrastructure within the system to service the Owner DAS (Data Acquisition System). Layout of this infrastructure shall be in accordance with DAS specification and subject to Owner review and approval.

1.3.5. Contractor shall be responsible for coordinating telecommunications service to the system with telecommunications provider, where such coordination is allowed. Where such coordination is prohibited by the telecommunications provider, Contractor shall assist Owner in their coordination efforts with the telecommunications provider. Contractor is responsible for providing Owner with remote access to data (and physical access to the extent provided herein) to the revenue grade meter and DAS, and weather stations (as applicable). The PV system operation shall be monitored by measurement and data acquisition equipment that conforms to the standards set forth in IEC-61724, PV System Performance, sections 1, 2 and 3. Contractor may use the performance data solely to validate the system integrity and production performance.

1.3.6. Contractor shall review and comply with all environmental studies, glare/glint study, flood studies, cultural resource studies, habitat/species studies, wetlands studies, geotechnical data, and surveys for the project. Contractor shall verify all designs incorporated all results, conclusions, and recommendations from those reports, including all permit conditions and order points.

1.4. Standards

At a minimum, Contractor shall confirm that the facility is constructed in accordance with the most current, locally adopted version of the following standards, as applicable. In the case where standards have conflicting requirements, Contractor must notify the Owner.

All codes and standards required by the local Authority Having Jurisdiction (AHJ), including but not limited to:

1.4.1. ACI - American Concrete Institute

- ACI 318 latest edition, Building Code Requirements for Structural Concrete and Commentary.
- ACI 117, Specification for Tolerances for Concrete Construction and Materials.
- ACI 306, Cold Weather Concreting.

- ACI 305, Hot Weather Concreting.
- ACI 301, Standard Specifications for Structural Concrete.
- ACI 351.1R Grouting between Foundation and Support of Equipment and Machinery

1.4.2.AISC - American Institute of Steel Construction:

- AISC Steel Construction Manual
- AISC Specification for Structural Steel Buildings.
- AISC Code of Standard Practice for Steel Buildings and Bridges.

1.4.3.ASTM - American Society for Testing and Materials

- ASTM A36 Specification for Structural Steel.
- ASTM A992 Standard Specification for Structural Steel Shapes
- ASTM A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- ASTM A325 Specification for High-Strength Bolts for Structural Steel Joints.
- ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
- ASTM C 94 Standard Specification for Ready-Mixed Concrete
- ASTM F959 Specification for Compressible-Washer-Type Direct Tension Indicators for use With Structural Fasteners.
- ASTM E94 Guide for Radiographic Testing.
- ASTM E142 Methods for Controlling Quality of Radiographic Testing.
- ASTM E164 Practice for Ultrasonic Contact Examination of Weldments.
- ASTM E165 Practice for Liquid Penetrant Inspection Method.
- ASTM E709 Practice for Magnetic Particle Examination.
- ASTM E1799 – Standard Practice for Visual Inspections of Photovoltaic Modules
- ASTM E1802 – Standard Test Methods for Wet Insulation Integrity Testing of Photovoltaic Modules
- ASTM E1830 – Standard Test Methods for Determining Mechanical Integrity of Photovoltaic Modules
- ASTM E2047 – Standard Test Method for Wet Insulation Integrity Testing of Photovoltaic Arrays
- ASTM E2848 – Standard Test Method for Reporting Photovoltaic Non- Concentrator System Performance

1.4.4.AWS - American Welding Society:

- AWS D1.1 Structural Welding Code – Steel
- AWS D-1.2Structural Welding Code-Aluminum
- Welding Handbook RP69
- Research Council on Structural Connections:
  - Specification for Structural Joints Using ASTM A325 or A490 Bolts

1.4.5.ANSI - American National Standards Institute

- ANSI C37.90 – IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus
- ANSI Z21.83 – Solar Photovoltaic Performance Safety

1.4.6.ASCE - American Society of Civil Engineers

- ASCE 7 – Minimum Design Loads for Buildings and Other Structures ASTM -

1.4.7. ASHRAE – American Society of Heating, Refrigerating, and Air Conditioning Engineers

1.4.8. IBC - International Building Code

1.4.9. ICEA – Insulated Cable Engineers Association

1.4.10. IEC - International Electrotechnical Commission –

- IEC 61646 – Thin-film Terrestrial Photovoltaic (PV) modules Design Qualification and Type Approval
- IEC 61683 – Photovoltaic Systems Power Conditioners – Procedure for Measuring Efficiency
- IEC 61727 – Photovoltaic (PV) Systems – Characteristics of the Utility Interface
- IEC 61829 – Crystalline Silicon Photovoltaic (PV) Array – On site Measurement of I-V characteristics
- IEC TS 61836 – Solar Photovoltaic Energy Systems Terms and Symbols
- IEC 61215 – Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules
- IEC 61724-1,2,3 - Photovoltaic System Performance Monitoring – Guidelines for Measurement, Data Exchange and Analysis
- IEC 62446-1 - Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection
- IEC-62804 - Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation

1.4.11. IEEE - Institute of Electrical and Electronics Engineers

- IEEE 928 – Recommended Criteria for Terrestrial PV Power Systems
- IEEE 1374 – Guide for Terrestrial PV Power System Safety
- IEEE 1547 – Standards for Interconnecting Distributed Resources with Electric Power Systems

1.4.12. IFC – International Fire Code, with local amendments

1.4.13. ISA - Instrumentation Society of America

1.4.14. NEC - National Electrical Code

1.4.15. NEMA - National Electrical Manufacturers Association

1.4.16. NESC – National Electrical Safety Code (if required by AHJ, Incentives, or other governing authorities)

1.4.17. NETA - National Electrical Testing Association

1.4.18. NFPA – National Fire Protection Agency

- NFPA 1 – National Fire Code

1.4.19. OSHA - Occupational Safety and Health Act

1.4.20. UL - Underwriters Laboratories

- UL – Underwriter’s Laboratories for all equipment when such standards exist
    - UL 1703 – Flat Plate Photovoltaic Modules and Panels
    - UL 1741 - Inverters, Converters, Controllers and interconnection System Equipment for Use with Distributed Energy Resources
    - UL 2703 –Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels
    - UL 3703 – Standard for Solar Trackers
    - UL 61730 – Photovoltaic (PV) Module Certification

System electrical design shall be NEC compliant to the greatest extend possible and in accordance with all applicable legal requirements.

1.5. Interconnection Agreement

The Contractor shall be responsible for obtaining the interconnection agreement from the Utility. Contractor will coordinate with the Utility and provide all necessary work, support, and materials for interconnection of the facility on the Owner side of the Point of Common Coupling (POCC) as defined in the Owner scope in the Interconnection Agreement, and as defined in the electrical drawings and site plan.

1.5.1. Contractor shall coordinate facility construction and interconnection with the Utility.

1.5.2. Contractor shall support and accommodate all necessary work for interconnection of the facility by the Utility.

1.5.3. Contractor shall be responsible for all work associated with the interconnection to the Utility on the Owner side of the POCC as defined in the Owner scope in the Interconnection Agreement, and as defined in the electrical drawings and site plan attached to this specification. If interconnection utilizes existing equipment, Contractor to determine suitable point of interconnection that complies with all Applicable Permits, the Interconnection Agreement and Utility requirements. The facility shall include switchgear (if applicable), circuit breakers, disconnect switches, surge arrestors, relay and protective systems, recloser/pad- mounted breaker (as applicable), revenue grade metering, supports, foundations, grounding systems, auxiliary control power, access roads (if applicable), utilities, and other related equipment for a complete and functioning system as required by the Utility and/or independent system operator.

1.6. General Site Work

All work performed must be in accordance with the most stringent requirements of this specification, and the applicable Authority Having Jurisdiction (AHJ).

1.6.1. Site Preparation

1.6.1.1. Contractor shall provide a plot plan identifying access, egress, laydown and storage areas, and turn-around ratios required for deliveries.

1.6.1.2. Contractor shall provide lay down area that meets relevant codes and standards.

1.6.1.3. Contractor shall be responsible for traffic control, when applicable, stabilized construction entrances, secure entrance gate.

1.6.1.4. The system, laydown, and storage shall consider existing site conditions (including any wetland, waterway, habitat, endangered/threatened species, flood, cultural) with respect to soil characteristics, site clearing, grubbing, grading and drainage to minimize site disturbance.

In areas with field drain tile all tile shall be located prior to construction and re-routed as needed to avoid all underground structures such as solar mounting pilings, fence posts, collection cable, and substation footings. All tile breaks or re-routes shall be documented by GPS and photos showing the location. All repairs shall be of equal capacity or greater and completed to the satisfaction of the landowner and warranted for 5 years.

1.6.1.5. A preconstruction visual survey documenting the conditions of the facility property will be performed, documented with appropriate images and delivered to Owner no later than five days prior to construction mobilization.

1.6.1.6. Site Maintenance During Construction

1.6.1.7. All temporary access roadways used by Contractor shall be constructed and maintained by Contractor in serviceable condition.

1.6.1.8. The Contractor shall maintain all Stormwater Pollution Prevention Plan (SWPPP) Best Management Practices during the entire course of the construction period, and until the construction stormwater permit, and/or local erosion control permit, is terminated.

1.6.1.9. Contractor shall be responsible for temporary erosion and sediment control requirements above and beyond those developed in the SWPPP that are deemed necessary by site conditions or AHJ.

1.6.1.10. The Contractor shall coordinate all activities with any adjacent property owners and local authorities to the satisfaction of the owner and local authorizes.

1.6.1.11. A post-construction survey documenting the conditions of the facility's property will be performed, documented with appropriate images and submitted to Owner within five days after the last heavy truck has traversed the road.

1.6.1.12. A final post-construction survey documenting the condition of the facility property after all construction trucking activity for the project will be delivered to Owner within ten days after the last heavy truck has traversed the road.

1.6.1.13. Contractor shall be responsible for design and implementation of dust suppression and erosion control measures at the facility.

1.6.1.14. Contractor shall supply and be responsible for the delivery and drainage of water necessary for Contractor's performance of the work, including dust suppression. Consumption costs shall be paid by Contractor.

1.6.1.15. Excavating, Trenching, Boring, Filling and Backfilling

1.6.1.16. Excavation, trenching, boring and backfill activities shall be completed as recommended in the contract documents.

1.6.1.17. Contractor shall be responsible for performing all operations in connection with underground (or above ground) DC and AC cabling and equipment pads.

1.6.1.18. Contractor shall be responsible for performing all excavation, filling, and backfilling operations for the equipment pads and buildings.

1.6.1.19. Contractor shall be responsible for the collection and containment of spoils during excavation activities. Spoils not used for backfill upon completion of construction are to be disposed of by the Contractor in compliance with all applicable laws, regulations, and codes.

1.6.1.20. Spoils from any source shall not be placed in or near ditches, swales, canals, or impoundments, or any location susceptible to erosion from high water, flooding, or storm water runoff.

1.6.2. Site Restoration

1.6.2.1. All site development areas disturbed during construction, including laydown, parking, temporary roadways and temporary office trailers shall be restored and stabilized with a pollinator friendly native plant community in accordance with the approved grading plan, SWPPP, and/or erosion control plans.

Contractor shall be responsible for compliance with the site's construction stormwater permit requirements, and local erosion control requirements, if applicable, until permit(s) can be closed out or terminated.

1.6.2.2. Post-Construction Soil Stabilization (as applicable)

1.6.2.3. A soil stabilization plan utilizing a regionally appropriate native seed mix shall be reviewed and approved by Owner and AHJ prior to implementation by Contractor.

1.6.2.4. The soil stabilization plan shall define the seed mix to be utilized in the areas to be stabilized along with data sheets describing the materials planting and methods to be used.

1.6.2.5. Materials shall be installed per manufacturer's recommendations. An as-built report should be prepared indicating final seed mix, installation methods, date performed and photographic documentation of conditions after planting

1.6.2.6. Materials shall be installed suitable to seasonal conditions.

Areas inside of the arrays will employ native low growth, organic vegetative ground cover as approved by the AHJ, where and when local conditions would support its growth. Contractor shall maintain for a period sufficient to facilitate self-sustaining vegetation in accordance with the SWPPP requirements.

To facilitate successful native plant establishment, contractor shall perform yearly maintenance for the first three years. Maintenance will consist of monitoring weed growth and soil moisture during the first growing season and mow any weedy growth higher than 18 inches to a height of 4 to 6 inches and/or provide water if droughty conditions are present. Contractor shall mow the site in early spring for the second and third years after planting. Contractor shall leave the site in the same or better condition that what was found at the commencement of **construction. Areas affected by construction will be cleaned of all construction materials and stabilized in accordance with the SWPPP and/or erosion control plan. Contractor shall repair and replace any affected irrigation systems and leave them fully operational to the satisfaction of the Owner's representative. Trees and stumps shall be removed for all solar arrays.**

1.6.3. General and Temporary Construction Facilities

1.6.3.1. Contractor shall be responsible for establishing and maintaining all restroom, office and meeting areas for the duration of the construction and commissioning portion of the project. Contractor shall provide a workspace for the Owner's representatives.

1.6.3.2. Contractor shall provide temporary facilities consisting of washing stations and sanitary facilities.

1.6.3.3. Contractor shall maintain on-site dumpsters and personnel to maintain a clean and rubbish-free work site.

1.6.3.4. Contractor shall provide temporary electrical and network/internet services for its use during construction and consumption costs shall be paid by Contractor.

1.6.3.5. Contractor shall be responsible for supplying or connecting to existing site water source for its use during construction for drinking, personal/equipment washing and dust suppression.

1.6.3.6. Contractor shall fix, at his/her own expense all damaged pavement, utility lines, concrete, and landscape that is damaged as a result of construction activities at an equal or better condition than existed prior to operations.

2. Solar Equipment

2.1. Solar PV Field

2.1.1. All equipment specified by Contractor shall be approved by Owner.

2.1.2. The area available for the solar PV arrays is limited by a Contractor-provided geotechnical evaluation, landscape, protected areas, and other site constraints specified in a Contractor-provided American Land Title Association (ALTA) Survey or equivalent.

2.1.3. Design parameters other than those specified in this document shall be defined by Contractor and approved by the Owner.

2.1.4. PV module row pitch (post-to-post) shall be adequate to allow access for customary maintenance vehicles, such as a pick-up truck, equipment, and personnel.

2.1.5. PV module tilt angle shall be adequate to allow proper water/snow shedding.

2.1.6. PV module strings – groups of PV modules electrically connected in series – shall be designed in accordance with the inverter manufacturer's maximum DC voltage input specifications and applicable code requirements for maximum operating DC voltage.

2.1.7. PV module arrays – groups of PV arrays electrically connected in parallel – shall be designed in accordance with the inverter manufacturer's maximum DC current and power input specifications and applicable code requirements for maximum operating DC current and power.

2.2. Photovoltaic Modules

2.2.1. PV modules shall be designed to produce electricity for a minimum of 30 years under the environmental conditions of the site.

2.2.2. The electricity generation capabilities of the modules shall meet or exceed the capabilities defined by the module electrical data sheet of the product.

2.2.3. Annual degradation shall be specified by the manufacturer.

2.2.4. PV modules shall comply with the following parameters to ensure maximum quality and performance.

2.2.4.1. The module manufacturer shall be as agreed upon by Contractor, Owner or Owner's representative per Attachment 9**.**

2.2.4.2. Specification Sheet

a. The manufacturer/supplier shall provide detailed electrical and mechanical specification sheets for the module.

b. The manufacturer shall provide the estimated annual degradation of their module and justify the value provided with historical production data.

c. The maximum allowable annual degradation for modules used on this Facility shall be 0.55 percent per year.

d. Minimum Load Capacity (Snow Load) shall be 5400 Pa or greater.

2.3. Technology

2.3.1.1. The cell technology for the PV module shall be either monocrystalline or polycrystalline silicon, or thin film.

2.3.2. Codes and Standards

2.3.2.1. Modules shall either be UL listed or certified by an OSHA-approved testing agency to meet the UL 1703 specification.

2.3.2.2. The certificates of factory/laboratories tests and compliance to the codes and standards referenced by the manufacturer shall be provided to Owner.

2.3.2.3. The modules shall be provided with a permanent label indicating, at a minimum, the following information:

2.3.2.3.1. Make/model

2.3.2.3.2. Electrical characteristics, including open circuit voltage (Voc); short circuit current (Isc); maximum power point voltage (Vmpp); maximum power point current (Impp); nameplate power (W), and maximum series fuse size

2.3.2.3.3. Temperature coefficients of Isc, Voc and nameplate power

2.3.2.3.4. Nominal power conditions (STC, NOCT, etc.)

2.3.2.3.5. Environmental operating conditions

2.3.2.3.6. Compliance with applicable standards (UL, IEC, CE, etc.)

2.3.2.3.7. Warnings of electrical hazard

2.3.2.3.8. Maximum system voltage

2.3.2.3.9. Maximum Load Capacity

2.3.2.3.10. Date and location of manufacture, manufacturing code

2.3.2.3.11. Serial number

2.4. Module Design and Construction

2.4.1. All modules shall be new and unused. In order to maintain the homogeneity of the system, all cells and modules used throughout the facility shall be supplied by the same manufacturer, be of the same make and model types, and shall have the same nameplate power rating.

2.4.2. The modules shall include factory installed power conductors at least No.12 American Wire Gauge (AWG), rated at 1500 VDC, with clearly defined polarities, weather-proofed, UV resistant/outdoor rated and with locking-type plug-in connectors of single polarity and with same environmental and electrical ratings as the power conductors.

2.4.3. All modules shall be of the same type shall have the same connectors.

2.4.4. The modules shall include a grounding lug, grounding hole, or some other tested grounding attachment mechanism (applicable for framed modules only).

2.4.5. Grounding attachment must specifically be approved by the AHJ.

2.4.6. The module framing, where provided, shall be corrosion-resistant, resistant to damage from snow, wind, hail and windblown dust and sand.

2.4.7. PV modules, at minimum, shall be supplied with a 10-year defects warranty and a minimum 25-year performance degradation warranty.

2.4.8. PV modules damaged during shipping and construction shall be replaced by the Contractor.

2.4.9. Contractor shall provide reports on PV panel delivery at site. The report shall include inspection and acceptance of the panels along with serial numbers for tracking.

2.4.10. Required Spare Parts

2.4.11. Contractor shall provide 0.25 percent of the modules installed to be kept as spares at a minimum with an option to purchase up to 1.0% of the modules installed to be kept as spares.

Unless the O&M building is large enough, Contractor shall provide storage on site for the spare panels in weather- tight shipping containers or Owner-approved equivalent.

2.5. PV Module Mounting System

2.5.1. The PV module mounting systems for typical single axis tracking (SAT) arrays shall meet the following specifications:

2.5.1.1. The design specifications for the foundations of the module mounting system ("mounting system") shall be provided by Contractor as part of the mounting system design specifications for either fixed or SAT systems.

2.5.1.2. The mounting system foundation shall be designed to withstand the site-specific constraints provided in the contract documents, (ground-mounted system) without replacement or compromising its structural integrity for a minimum of 25 years.

2.5.1.3. The foundation shall be designed to comply with all the environmental conditions of the site.

2.5.1.4. The mounting system shall be designed to withstand wind speeds up to the maximums specified by applicable codes, over its specified operating lifetime, without compromising its structural integrity.

2.5.1.5. The mounting system and modules shall have provisions to be continuously bonded and grounded to the ground grid system of the array.

2.5.1.6. The mounting system shall be certified by UL or another approved testing agency to meet the requirements of UL Subject 2703.

2.5.1.7. If a SAT system is provided, it shall be certified by UL or another approved testing agency to meet the requirements of UL Subject 3703.

2.5.1.8. If a SAT system is provided, it must satisfy minimum site requirements for mechanical and electrical equipment ground clearances.

2.5.2. In addition to meeting the requirements of the mounting system, Contractor shall:

2.5.2.1. Provide detailed information on the materials and design of the mounting system.

2.5.2.2. Provide a detailed structural analysis of the foundations and demonstrate that the design conforms to the applicable standards and codes and the contract documents.

2.5.2.3. Demonstrate that the modules will stay attached to the mounting structure under all environmental conditions specified by applicable codes.

2.5.2.4. Ensure that the design of the mounting structure specifies the attachment of the PV modules to mounting structure in accordance with the mounting specifications provided by the PV module manufacturer.

2.5.2.5. Submit all structural designs and calculations for the mounting system to Owner for review prior to purchase of any mounting system equipment.

2.5.2.6. Prepare a design to mitigate the effects of corrosive soils on the structural support system for the design life, which includes concreting around posts, adding a sacrificial layer to the structural steel members, galvanizing, and/or coating the structural steel members with epoxy coating.

2.5.2.7. Provide a detailed description of the method of installation for the mounting system.

2.5.2.8. Tracking actuators shall be locally controllable either using selector switches or buttons, or a laptop or handheld controller connection.

2.5.3. Required Manufacturer's Warranties- Single Axis Tracker Mounting System

2.5.3.1. The module mounting manufacturer shall provide a product warranty of at least 10 years on structural components.

2.5.3.2. Tracker drive and control system shall be warrantied a minimum 5 years, with options for extension.

2.5.4. Required Spare Parts- Single Axis Tracker Mounting System

2.5.4.1. All necessary hardware for at least two PV module racks shall be provided as spare parts.

2.6. Combiner Boxes

2.6.1. Each combiner box shall include a fused connection between all underground DC circuit wiring from PV strings to provide over-current and short-circuit protection.

2.6.2. The ungrounded DC circuit wiring from PV strings (if any) shall be connected to a terminal block and bus bar.

2.6.3. The combiner box output circuit (homerun) shall be provided with a load-break disconnect switch with exterior lockable handle, rated for the voltage and current of the combined PV strings.

2.6.4. The string fuses and fuse holders shall be finger-safe and rated according to the string DC current and voltage, and environmental conditions.

2.6.5. The power terminal blocks shall be rated for use with copper conductors and rated for continuous duty at 1500 VDC and 90°C conductor and terminal temperature ratings.

2.6.6. The combiner box shall be equipped with a mechanical ground lug and bus, rated for terminations with copper grounding conductors.

2.6.7. The combiner enclosure shall be outdoor-rated, weatherproof, NEMA 3R or NEMA 4 or NEMA 4X, and the doors shall be easily interchangeable.

2.6.8. The manufacturer shall supply a fully assembled combiner box and shall provide detailed drawings, specifications sheets, mounting instructions, and maintenance requirements of its product.

2.6.9. Each combiner box shall provide “touch-safe” power circuit terminations and include provisions for bolted terminations of the output power circuit to the inverter.

2.6.10. Surge protective devices, per UL 1449, shall be installed at the line side of the main disconnect switch.

2.6.11. Conduit entries into the combiner box shall be from the side or bottom to prevent water ingress.

2.6.12. Each combiner box shall include a provision for a padlock, including a padlock and key.

2.6.13. All padlocks shall be keyed the same. Tags and zip ties may be used as an alternate.

2.6.14. The combiner box door shall be interlocked with a load-break disconnect switch in such a manner that the door cannot be opened when the switch is “closed.” In addition, the switch shall not be capable of being placed in the “closed” position unless the combiner box door is fully closed.

2.6.15. An external door interlock defeat mechanism shall be provided to allow authorized personnel access to the interior of the combiner box while the switch is in the closed position for periodic inspection, troubleshooting, and electrical field measurements.

2.6.16. The combiner box shall be listed to UL 1741 to 1500 VDC, and rated for an operating temperature range of -40°C to +50°C.

2.6.17. Each combiner box shall be suitable for application of permanent labels in the field and shall include electrical warning labels.

2.6.18. All information and warnings required by the National Electrical Code sections 690 and 705 shall be provided on a permanent label attached to each combiner.

2.6.19. Arc Flash PPE requirements shall be provided on a permanent label attached to each combiner.

2.6.20. As an alternate, provide monitoring of string circuit currents.

2.6.21. Required Manufacturer’s Warranties:

2.6.21.1. Combiner boxes shall have a manufacturer’s warranty of at least 5 years.

2.6.22. Required Spare Parts:

2.6.22.1. Contractor shall provide at least 1 spare combiner box for every 2 MW AC of installed capacity.

2.6.22.2. Each combiner box shall include 10% spare fuses of each size and type.

2.7. Recombiner Boxes (if required)

2.7.1. Recombiner boxes shall provide a main DC disconnecting means.

2.7.2. Recombiner boxes shall be connected directly before the inverter input via throat connection.

2.7.3. Recombiner boxes shall also meet the following requirements:

2.7.3.1. Rated for 1500 VDC

2.7.3.2. Up to 24 input circuits with configurations up to 1200 A

2.7.3.3. Overcurrent protection (fuses or breakers)

2.7.3.4. If fuses are used, load break disconnects shall be provided that meet the provisions of NFPA-70-2011 (NEC) 690.16(A) and (B) (fuses: disconnecting means and fuse servicing).

2.7.3.5. 90°C rated terminals

2.7.3.6. Continuous duty rated

2.7.3.7. NEMA 3R or NEMA 4 or NEMA 4X

2.7.3.8. Each recombiner box shall include a provision for a padlock, including a padlock and key.

2.7.3.9. All padlocks shall be keyed the same. Tags and zip ties may be used as an alternate with permission of owner.

2.7.3.10. Ground bus

2.7.3.11. As an alternate, provide monitoring of PV output circuit currents.

2.7.4. Each recombiner box shall be suitable for application of permanent labels in the field and shall include electrical warning labels.

2.7.5. All information and warnings required by the National Electrical Code sections 690 and 705 shall be provided on a permanent label attached to each combiner.

2.7.6. Required Manufacturer's Warranties

2.7.6.1. Recombiner boxes shall have a manufacturer's warranty of at least 5 years.

2.7.7. Required Spare Parts

2.7.7.1. Each recombiner shall include 10% spare fuses of each size and type.

2.8. Solar PV Inverters

2.8.1. Inverters shall meet the following requirements:

2.8.1.1. The inverters shall include the necessary DC circuit breakers/disconnect switches, AC circuit breakers/disconnect switches, local controls, remote SCADA system interface (or web-based interface if Owner approved), grid operator control interfaces, and accessories necessary for the inverter to meet all code requirements and function properly as part of a power generation facility.

2.8.1.2. Environmental ratings: -40° to +50°C (-40° to 122°F), Humidity: 15 % - 95%, non-condensing, 6,500 feet elevation.

2.8.1.3. Power factor capability at the point of interconnection shall be at least 0.95 and able to be actively controlled.

2.8.1.4. Power factor capability shall be compliant with the interconnection requirements.

2.8.1.5. Inverters shall include flicker mitigation.

2.8.1.6. Central inverters shall have a nameplate rating greater than or equal to 1 MW AC, unless otherwise approved by Owner.

2.8.1.7. Upon preliminary selection of the inverter make and model, Contractor shall deliver to Owner a location where this inverter in operation.

2.8.1.7.1. Inverter manufacturer shall provide access for a site visit at this location by Owner or Owner's representative to perform sound level testing. (If required)

2.8.1.7.2. Inverter must meet sound level requirements prior to proceeding with this equipment selection.

2.8.1.8. Inverter maximum input voltage shall be 1500 Vdc, unless otherwise approved by Owner.

2.8.1.9. Inverters shall be IEEE 1547 compliant except for anti-islanding and grid disturbance behavior.

2.8.1.10. Output current harmonics shall contain <3% total harmonic distortion (THD) at rated power output, per IEEE 519, utilizing site check meter. The site check meter shall be capable of providing voltage and harmonic data to the 50th harmonic.

2.8.1.11. Inverter shall have the capability of a local connection to view the software and/or controller.

2.8.1.12. Inverter California Energy Commission (CEC) efficiency shall be >97% without medium voltage step-up transformer.

2.8.1.13. Inverters located outdoors shall be enclosed in lockable, NEMA 3R enclosures, at a minimum.

2.8.1.14. The Contractor's design shall include an analysis of the maximum anticipated operating temperature to ensure that the manufacturer's recommended operating temperature is not exceeded.

2.8.1.15. Enclosure shall have a door interlock system to prohibit the door(s) from being opened while energized.

2.8.1.16. Inverters shall incorporate a non-load-break, two (2)-pole, lockable disconnect switch for main DC power disconnect for maintenance personnel safety, or other Owner approved method.

2.8.1.17. Inverter output shall be protected by an AC output circuit breaker with short and long time adjustable over current protection.

2.8.1.17.1. This circuit breaker shall be externally operated, or Contractor shall furnish an external on/off (start/stop) switch. (If required by Owner, or per local requirements.) 115 VAC electrical outlets at all work locations

2.8.1.18. Inverters shall be capable of rated output at 50ºC (122ºF) ambient or higher without derating.

2.8.1.19. Inverters shall employ a maximum power point tracking scheme to optimize inverter efficiency over the entire range of PV panel output for the given site design conditions.

2.8.1.20. Inverters shall be equipped with all hardware for data collection and communication to the central SCADA server, including the ability to write to the control registers to reset inverter and modify AC output parameters, including power factor and maximum power.

2.8.1.21. Data collection points shall be integrated into the inverter monitoring and communications package.

2.8.1.22. Inverter Data collection points included shall be (at a minimum):

- AC Voltage
- DC Voltage
- AC Current
- DC Current
- Real Power (kW)
- Reactive Power (kvar)
- Apparent Power (kVA)
- Energy (kWh)
- Alarms
- Inverter status and faults (including ground fault interrupts)

2.8.2. Required Manufacturer's Warranties

2.8.2.1. The inverter manufacturer shall provide a warranty of at least 10 years, with Owner option to extend.

2.8.3. Required Spare Parts

2.8.3.1. The manufacturer shall provide the necessary spare parts for the first two years of operation.

2.8.4. Disconnect Switches

2.8.4.1. Disconnect switches shall meet the following requirements:

- 600 VAC
- Continuous current rating as specified on the drawings (minimum 30 A)
- Three-pole
- NEMA 3R enclosure
- High conductivity copper
- Visible blades
- Positive, quick-make, quick-break mechanisms
- Operating handle whose position is easily recognizable, and which can be locked in the OFF position with multiple padlocks.
- The ON and OFF positions shall be clearly marked.
- Door interlock that prevents the door from being opened while the operating handle is in the ON position.
- All AC service disconnects shall include integrated or compatible adjacent surge protection.
- Conform to NEMA KS1
- UL listed.

Manufacturer's Standard Warranties shall apply

2.9. Meteorological Monitoring Station(s)

2.9.1. Contractor shall supply and install one stand-alone central meteorological monitoring station (met station) at the site for each 25 MWAC of generation. The met station for each 25 MWAC block shall be spaced to provide accurate data for the site.

2.9.2. The met station shall include all instrumentation and sensors necessary to comply with the requirements set forth below in Attachment 2,12, 16, and 17..

2.9.3. The met station shall include a datalogger that can record data from all required instruments and sensors.

2.9.4. The met station datalogger shall include a backup power system, which may or may not be connected to the SCADA System UPS system, to allow for stand-alone operation for at least fifteen days.

2.9.5. The met station datalogger shall have at least a fifteen-day on-board non-volatile data storage capacity.

2.9.6. The met station datalogger shall be capable of sampling data at a rate of at least once per minute.

2.9.7. Five-minute averages of the one-minute data samples shall be recorded every five minutes.

2.9.8. The access to the datalogger shall be password protected and Contractor shall provide the required software, cables and instruction manual to connect to the port and access the data.

2.9.9. The meteorological monitoring station shall be connected to the SCADA system and shall include a communications port compatible with a standard laptop computer running Windows OS or Owner approved operating system to be able to read and download data on site.

2.9.10. The pyranometers used shall be Class A pyranometer and shall be a Hukseflux SR-30 or equivalent.

2.9.11. Weather station items shall be as listed:

2.9.11.1. Datalogger with battery backup and Modbus TCP/IP communications

2.9.11.2. Ambient Air Temperature and Relative Humidity

2.9.11.3. Global Horizontal Irradiance Pyranometer

2.9.11.4. Plane of Array Pyranometer (2 minimum)

2.9.11.5. Back of Monitor Temperature Sensors (minimum 10, site size dependent)

2.9.11.6. Precipitation Gauge and Meter

2.9.11.7. Anemometer, Wind Speed and Direction

2.9.11.8. Panel Auxiliaries – Lighting and Receptacle

2.9.12. Optional Solar Resource Monitoring Equipment**:**

2.9.12.1. RaZON+ All in One Solar Monitoring System and Mounting Tripod

2.10. Grounding Systems

2.10.1. All grounding systems shall be designed and provided as required by NEC, NESC, IEEE, and local code requirements.

2.10.2. All grounding systems shall comply with the following:

2.10.2.1. Ground loops shall be provided under/around major electrical equipment.

2.10.2.2. The grounding system shall consist of bare copper conductor and copper-clad steel or stainless-steel ground rods.

2.10.2.3. The system shall be designed to protect personnel and equipment at the facility from the hazards that occur during power system faults and lightning strikes.

2.10.2.4. For ground grids below grade, each junction of the grid shall be bonded with either exothermic welds or irreversible compression connections.

2.10.2.5. Major items of equipment such as inverters and transformers shall have integral ground buses connected to the grounding electrode system.

2.10.2.6. Contractor shall route a grounding conductor parallel to all power conductors operating above 50 volts.

2.10.2.7. The module DC system grounding electrode(s) shall be common with, or bonded to, the AC grounding electrode as indicated in NEC Article 690.4

2.10.2.8. Module grounding shall follow module manufacturer recommendations for grounding.

2.11. Power and Control Wiring

2.11.1. Cables shall be selected with an insulation level applicable to the system voltage for which they are used and ampacities suitable for the load being served.

2.11.2. The type of cable used shall be determined by individual circuit requirements, temperature, and individual equipment manufacturer’s recommendations.

2.11.3. Current carrying conductors shall be copper only.

2.11.4. All exposed wiring shall be clearly indicated as sunlight or UV resistant.

2.11.5. DC Cables – Type I

2.11.6. Type I DC cables shall include those used for: Interconnecting PV modules

2.11.6.1.1. Connecting PV module strings to combiner boxes

2.11.6.1.2. Type I DC cables shall be sized in accordance with the NEC requirements for “Solar Photovoltaic Systems” (Article 690) and shall be rated according to the maximum system voltage.

2.11.6.2. Copper conductor is required for all cables from module to module or combiner.

2.11.6.3. Conductors shall be sized accordingly considering any ambient temperature or ampacity de-rate factors and voltage drop considerations.

2.11.6.4. DC cabling shall be sized to not exceed a maximum voltage drop of 2 percent total from PV to module to inverter at Standard Test Conditions.

2.11.6.5. PV Wire is recommended for DC string cables, Owner approval required for alternative DC cable types or PV wire harnesses.

2.11.6.6. If the DC system is ungrounded, PV Wire is required for all conductors that are not enclosed in raceway.

2.11.6.7. DC cable may be direct buried and shall have a minimum insulation that meets the NEC requirement for “Wet Locations.” If the DC system is ungrounded, PV Wire is required for all direct buried DC cable.

2.11.6.8. Schedule 80 PVC conduit shall be used for transitions “entering” and “exiting” the cable trench to meet NEC 300.5(D) requirements.

2.11.6.9. DC conductors installed underground or in concrete slabs in PVC conduit are acceptable.

2.11.6.10. Schedule 80 PVC conduit shall only be used above ground to allow immediate transition to metallic raceway.

2.11.6.11. Schedule 40 PVC shall only be used below ground or in concrete slabs.

2.11.6.12. Cable insulation levels shall be rated according to the maximum system voltage.

2.11.6.13. Insulation and jacket materials on all DC conductors, regardless of location, shall be made from thermoset materials such as XLP.

2.11.6.14. No thermoplastic insulation or jacket materials are permitted for DC conductors.

2.11.6.15. Cable insulation type shall be sunlight resistant, rated for wet locations, and have a temperature rating of 90°C or better.

2.11.6.16. Exposed DC string wiring shall be secured at intervals of approximately 24 inches, on center, maximum.

2.11.7. DC Cables – Type II

2.11.7.1. Type II DC cables shall include those used for:

- Connecting combiner boxes to recombiner boxes or inverters
- Connecting recombiner boxes to inverters

2.11.7.2. Conductors shall be sized accordingly considering any ambient temperature or ampacity de-rate factors and voltage drop considerations.

2.11.7.3. DC cabling shall be sized to not exceed a maximum voltage drop of 2 percent total from PV module to inverter at Standard Test Conditions.

2.11.7.4. Aluminum conductor may be used for conductors from combiner to inverter if the conductor is AWG 1/0 or larger. Otherwise copper conductor is required.

2.11.7.5. DC cable may be direct buried and shall have a minimum insulation that meets the NEC requirement for "Wet Locations." If the DC system is ungrounded, PV Wire is required for all direct buried DC cable.

2.11.7.6. Schedule 80 PVC conduit shall be used for transitions "entering" and "exiting" the cable trench to meet NEC 300.5(D) requirements.

2.11.7.7. DC conductors installed underground or in concrete slabs in PVC conduit are acceptable.

2.11.7.8. Schedule 80 PVC conduit shall only be used above ground to allow immediate transition to metallic raceway.

2.11.7.9. Schedule 40 PVC shall only be used below ground or in concrete slabs.

2.11.7.10. Cable insulation levels shall be rated according to the maximum system voltage.

2.11.7.11. Insulation and jacket materials on all DC conductors, regardless of location, shall be made from thermoset materials such as XLP.

2.11.7.12. Thermoplastic insulation or jacket materials shall not be permitted for DC conductors.

2.11.7.13. Cable insulation type shall be rated for wet locations and have a temperature rating of 90°C or better.

2.11.8. Low Voltage AC Power Cables

2.11.8.1. Low Voltage (LV) AC Power Cables shall include those used for connecting inverter output terminals to step-up transformer input terminals

2.11.8.2. Aluminum conductor may be used for conductors for LV AC Power Cable if the conductor is AWG 1/0 or larger.

2.11.8.3. Otherwise copper conductor is required.

2.11.8.4. All power and control cables shall be UL listed.

2.11.8.5. Cables shall be routed in UL listed wireway, conduit, direct buried PVC conduit, or underground duct banks.

2.11.8.6. A maximum of 1 percent AC voltage drop is acceptable between inverter AC output and step-up transformer LV AC input.

2.11.8.7. A maximum of 3 percent AC voltage drop is acceptable in other AC circuits not associated with solar power production.

2.11.8.8. Less than 600 V AC applications

2.11.8.9. Cable insulation levels shall be rated 600 V.

2.11.8.10. Conductors installed in PVC conduit are acceptable.

2.11.8.11. Low voltage power cables for loads up to 480 volts AC and control cables (i.e., 120 volts ac) shall have copper conductor with 600-volt class insulation.

2.11.8.12. Power cables shall be Type XHHW-2 with concentric-lay, uncoated copper, strand B conductor, rated for normal maximum operating temperature of 90°C in wet and dry applications, cross-linked thermosetting polyethylene insulation, and conforming to ICEA S-95-658 (NEMA WC 70).

2.11.9. Auxiliary Power Cables

2.11.9.1. Auxiliary power cables shall include those used for Lighting, electrical receptacles, computers, programmable logic controllers (PLCs), and heating/ventilation.

2.11.9.2. Auxiliary power cables for loads up to 480 volts AC and control cables (i.e., 120 volts ac) shall have copper conductor with 600-volt class insulation.

2.11.9.3. All power and control cables shall be UL listed.

2.11.9.4. Cables shall be routed in UL listed wireway, conduit, direct buried PVC conduit, or underground duct banks, as required.

2.11.9.5. A maximum of 3 percent AC voltage drop is acceptable in AC circuits not associated with solar power production.

2.11.9.6. Power cables shall be Type XHHW-2 with concentric-lay, uncoated copper, strand B conductor, rated for normal maximum operating temperature of 90°C in wet and dry applications, cross-linked thermosetting polyethylene insulation, and conforming to ICEA S-95-658 (NEMA WC 70).

2.11.10. Control System Cables

2.11.10.1. Control cables shall include those used for system control, alarms, contacts, etc.

2.11.11. Shall be type XHHW-2 with concentric-lay, uncoated copper, strand B conductor, rated for normal maximum operating temperature of 90°C in wet and dry applications, cross-linked thermosetting polyethylene insulation, and conforming to ICEA S-95-658 (NEMA WC 70). Multi conductor cable assemblies with XLPE insulation and an overall CPE jacket, 600V. Tray rated, suitable for direct burial. Analog Instrumentation Cables

2.11.11.1. Analog instrumentation cables shall meet the following requirements:

2.11.11.1.1. Twisted Shielded Pair type

2.11.11.1.2. No less than 16 AWG seven-strand

2.11.11.1.3. Concentric-lay

2.11.11.1.4. Uncoated copper conductor

2.11.11.1.5. Rated for normal maximum operating temperature of 90°C dry and 75°C wet applications

2.11.11.1.6. Polyvinyl chloride insulation not less 15 mils average thickness

2.11.11.1.7. Twisted pair of 1-1/2 inch to 2-1/2 inch (38.10 mm - 63.5 mm) lay

2.11.11.1.8. Shield consisting of combination aluminum-polyester tape and seven-strand

2.11.11.1.9. 20 AWG minimum tinned copper drain wire

2.11.11.1.10. With shield applied to achieve 100 percent cover over insulated conductors

2.11.11.1.11. Jacket thickness of 4 mils minimum

2.11.11.1.12. Conductor color identification with one black conductor and one white conductor

2.11.11.1.13. Conforming to UL 62 for Type TFN, and UL 1277 for vertical-tray flame test requirements.

2.11.12. Fiber Optic Cables

2.11.12.1. Fiber optic cable shall meet the following requirements:

2.11.12.1.1. Multi-mode or single-mode (per Owner's requirement)

2.11.12.1.2. 6 strand minimum

2.11.12.1.3. Double armor (corrugated steel tape), double jacket, when direct buried

2.11.12.1.4. Single armor (corrugated steel tape), single jacket when installed in conduit

2.11.12.1.5. Black polyethylene inner and outer jacket.

2.11.12.1.6. Nominal wall thickness of 0.06 inches.

2.11.12.1.7. Gel filled

2.11.12.1.8. Overall water swellable barrier tape with 25 percent overlap

2.11.12.1.9. Tensile load (installation) of 600 lbs.

2.11.12.1.10. Minimum bending radius 20 times cable diameter Operating temperature -40°C to 70°C

2.11.13. Category 5e or Category 6 Cables

2.11.13.1. Category 5e or Category 6 cable shall meet the following requirements:

2.11.13.1.1. Sunlight, oil, and gas resistant

2.11.13.1.2. Industrial grade

2.11.13.1.3. 4 bonded pairs, 22 AWG

2.11.13.1.4. Solid copper conductor

2.11.13.1.5. Polyolefin insulation

2.11.13.1.6. Black PVC jacket, 0.03 inches

2.11.13.1.7. UL listed Operating temperature of -25°C to 75°C

2.12. Testing

2.12.1. PV STRING OPEN-CIRCUIT VOLTAGE TESTING

2.12.1.1. Open-circuit voltage (Voc) string testing shall be conducted in order to assess overall module and string performance.

2.12.1.2. The Contractor shall perform a follow up infrared scan with a drone 90 days after energization.

2.12.1.3. The test shall be conducted and witnessed by at least two qualified technicians using best practices and the following procedure:

2.12.1.4. The test shall be conducted during periods of irradiance greater than $\mathbf{400}\ \frac{W}{m^2}$

2.12.1.5. Inspect string fuses for appropriate use and correct sizing

2.12.1.6. Measure and record the following for every string:

2.12.1.6.1. String number and combiner box location (or similar relevant string identification)

2.12.1.6.2. Measurements made every five (5) or fifteen (15) minutes

2.12.1.6.3. Time of test and weather conditions

2.12.1.6.4. Module back sheet temperature at a location representative of the strings being tested

2.12.1.6.5. Plane-of-Array (POA) irradiance measurement for area of strings being tested

2.12.1.6.6. Open-circuit voltage (Voc) measurement of every string within each combiner box.

2.12.1.6.7. Measurement shall be made using a voltmeter with the suitable voltage rating and accuracy of at least 0.5%

2.12.1.6.8. Each measured string Voc shall be within 5% from the expected Voc (Voc- expected) and within 5% of adjacent strings under identical temperature and irradiance conditions.

2.12.1.7. The expected Voc shall be calculated using the following equation:

$$Voc - expected = r \cdot Voc - ref \cdot [1 + (J \cdot (Tmod - Tmod - ref)]$$

Where:

$Voc - expected$	= expected open-circuit voltage of the string
$Voc - ref$	= module open-circuit voltage at reference conditions
r	= number of modules in series in tested string
J	= module open-circuit temperature coefficient $(°\mathrm{C} - 1)$
$Tmod$	= measured module backsheet temperature $(°\mathrm{C})$
$Tmod - ref$	= back of module temperature at reference conditions

2.12.2. Comparisons between all measured and expected Voc shall be analyzed in a spreadsheet which shall include the following PASS/FAIL tests for each string:

2.12.2.1. String Voc-measured is within 5% of Voc-expected

2.12.2.2. String Voc-measured is within 5% of the Voc-measured of adjacent strings

2.12.2.3. Strings that fail either test shall be investigated for module defects, loose connections, disconnected modules, or other possible defects tested)

2.12.2.4. Ambient temperature

2.12.2.5. Wind speed

2.12.2.6. Weather conditions

2.12.2.7. Correct polarity shall be verified

2.12.3. Using an IV curve tracer, perform the curve trace using the manufacturer's instructions.

2.12.4. The curve tracer shall be configured to record at least 10 current-voltage data points and record the following values:

2.12.4.1.1. Maximum power (Pmax)

2.12.4.1.2. Voltage at maximum power (Vmp)

2.12.4.1.3. Current at maximum power (Imp)

2.12.4.1.4. Open circuit voltage (Voc)

2.12.4.1.5. Short circuit current (Isc)

2.12.4.1.6. Fill Factor (FF)

2.12.5. Short-circuit current test: Each measured string short-circuit current shall be greater than the expected short-circuit current (Isc-expected) derived using the following equation:

$$Isc - expected = K \cdot Isc - ref \cdot (GGref)$$

Where:

$ISC - expected$	= Expected short-circuit current of the string
$ISC - ref$	= Short-circuit current at Standard Test Conditions (STC) as shown on module datasheet
K	= 0.95 (uncertainty and soiling factor)
G	= Measured Irradiance $\frac{W}{m^2}$
$Gref$	= $1000\ \frac{W}{m^2}$

2.12.6. LOW VOLTAGE INSULATION RESISTANCE TESTING

2.12.6.1. All low voltage (LV) direct current (DC) and alternating current (AC) cables shall be tested for insulation resistance in accordance with the NETA-ATS.

2.12.6.2. Measured insulation resistance values shall be adjusted to a 20°C reference in order to determine acceptance with NETA-ATS.]

2.12.6.3. All insulation resistance acceptance criteria shall be proposed by Contractor for approval by Owner.

2.12.6.4. Any test results that fail to be in accordance with the NETA-ATS, or do not meet the accepted criteria, shall be documented as a deficiency on the test report.

2.12.6.5. Corrective action shall follow the identification of a failed test, followed by re-testing.

2.12.7. LOW VOLTAGE CABLE TESTING

2.12.7.1. Low voltage cables shall include only those designed to operate at or below 1500 V.

2.12.7.2. All low voltage cables shall be inspected and tested in accordance with NETA-ATS, Section 7.3.

2.12.7.3. Test Values shall be in accordance with NETA-ATS, Section 7.3.2.

2.12.7.4. Note: NETA-ATS, states that Section 7.3.2 is for low-voltage cables up to a 600 Volt Maximum.

2.12.7.5. This Section shall also be used for cables with voltages up to 1000 Volts

2.12.7.6. Test voltages applied in the field shall not exceed the maximum test voltage of NETA- ATS, Table 100.1

2.12.7.7. Verify uniform resistance for all parallel conductors

2.12.8. POLARITY VERIFICATION

2.12.8.1. All circuits shall be verified to have the correct polarity according to the design drawings.

2.12.9. INVERTER COMMISSIONING

2.12.9.1. Inverters shall be commissioned by the inverter manufacturer, or an authorized representative of the manufacturer, using the manufacturer's specified procedures.

2.12.9.2. Commissioning reports shall be in a format provided by the manufacturer.

2.12.9.3. At a minimum, inverter commissioning shall meet the following requirements:

2.12.9.3.1. Inverters shall be fully operational after commissioning completion

2.12.9.3.2. All shipping and packing materials shall be removed from inverter cabinets

2.12.9.3.3. Fuses and air filters shall be checked, verified as correct and in place

2.12.9.3.4. Torque wrench marks shall be recorded

2.12.9.3.5. Software updates and data acquisition communication shall be tested and functional

2.12.9.3.6. Noise level study shall indicate inverter meets the manufacturer's specifications.

2.12.9.3.7. Confirm glycol mixture is adequate for the ambient design conditions if required.

2.12.10. METEOROLOGICAL MONITORING STATION TESTING

2.12.10.1. All meteorological monitoring station equipment shall be commissioned, calibrated and tested using the manufacturer's specified procedures with accuracy being compared to the manufacturer's specifications.

2.12.10.2. Current calibration certificates for each installed instrument shall be provided to Owner.

2.12.10.3. Test reports shall be in a manufacturer provided format if available.

2.12.10.4. The following instrumentation, if it is part of the metrology equipment specified by Owner, shall be tested, at a minimum:

2.12.10.5. Solar irradiance measurement device, as applicable, e.g.:

2.12.10.5.1. Global horizontal irradiance (GHI)

2.12.10.5.2. Plane of array (POA) irradiance

2.12.10.5.3. RaZON solar monitor system, as applicable

2.12.10.6. Anemometer (wind speed), as applicable

2.12.10.7. Module temperature, as applicable

2.12.10.8. Ambient temperature, as applicable

2.12.10.9. Precipitation gauge, as applicable

2.12.10.10. Data-logger and communications equipment, as applicable

2.13. Data Acquisition System - (Data Logger Monitoring System)

An overall data acquisition site monitoring system shall be provided separately, or shall be integrated into the Weather Station referenced herein for Meteorological Monitoring Station(s)

2.13.1. The manufacturer of the system shall be included in Attachment 9 PV Solar Equipment Suppliers List or approved by the Owner. Each inverter will be equipped with a condition-based monitoring system. The inverter monitoring system shall connect to the site data logger. Power metering data shall be provided to the data logger to provide revenue grade accuracy metering data and provide alerts for discrepancies with inverter readings. The data logger shall provide wireless communication to allow for secure remote access of the information via the internet, or Owner approved equivalent method.

2.13.2. Hardware

2.13.2.1. The data collection / signal processing unit shall be installed in a serviceable location in the inverter and connected.

2.13.2.2. All cables shall be oil and grease resistant, cold weather flexible, and routed in trays, conduit or raceways that provide protection to the cable.

2.13.3. Data logger and software shall meet the following requirements:

2.13.3.1. Ability to communicate with other devices via Modbus TCP, OPC, PI, or similar protocols

2.13.3.2. Capable of quickly running the provided analysis software

2.13.3.3. Capable of storing 1 year of data

2.13.3.4. Unrestricted access without user count based licensing

2.13.3.5. Analysis software shall be preinstalled and meet the following requirements:

a. Unrestricted access without individual user licensing
b. High level display to view all status on 1 page
c. Record data at least once per day
d. Local alarm function with remote notification
e. Access to all raw data

2.13.4. Minimum Features

2.13.4.1. Solar operation and control from a secure, web-based monitoring system.

2.13.4.2. Main control server with 1-year minimum data storage

2.13.4.3. Secure remote access server

2.13.4.4. Backup power supply

2.13.4.5. All applicable software licenses

2.13.4.6. Automatic backup software

2.13.4.7. Software to modify screens

2.13.4.8. System monitoring screen(s) including the display of all alarms and statuses along with a 1-line overview of breaker position and MWs, volts, amps, and VARs at all metered locations

2.13.4.9. Remote Alarm Notification

2.13.4.10. Power curtailment at the substation level

2.13.4.11. Actual possible power signal the value of which is based on actual on-site solar speed

2.13.4.12. Power ramp rate control

2.13.4.13. System VAR

2.13.4.14. System voltage

2.13.5. Products

2.13.5.1. The solar and associated equipment provided by the manufacturer shall be new and shipped directly from the factory to the project site and shall comply with all Occupational Safety and Health Administration (OSHA) regulations

2.13.6. Execution

2.13.6.1. The solar panels shall be assembled and commissioned in strict compliance with the solar panel manufactures requirements and procedures.

2.13.6.2. All panels and associated array components shall be cleaned internally and externally and free of surface coating scratches, chips, etc. and the subject scratches, chips, etc. repaired prior to being lifted into place. All damage shall be repaired in strict compliance with manufacturer requirements.

2.13.7. Testing and Inspection

2.13.7.1. All facility components will be commissioned and tested in strict compliance with manufactures requirements and procedures

2.13.8. Submittals

2.13.8.1. All supplier commissioning and testing procedures, checklists, inspection reports, punch lists and other records related to solar facility assembly, inspection, commissioning and testing shall be submitted to Owner

2.13.8.2. Contractor and Subcontractor(s) commissioning and testing procedures, checklists, inspection reports, punch lists and other records related to solar panel assembly, inspection, commissioning and testing shall be submitted to Owner

3. Civil Technical

Work under this specification applies to the construction of the roadways, foundations, and drainage.

3.1. Road and Foundation Grading Specifications

3.1.1. All grading shall conform to county grading ordinances, storm water permit requirements, and other applicable laws and applicable standards pertaining thereof.

3.1.2. The Contractor shall perform the grading work, including the exercise of supervisory control during construction, to ensure compliance with all plans, specifications, and codes. Subject to soil conditions, the Contractor shall install geotextile membrane at the discretion of the geotechnical engineer of record on the compacted subgrade prior to placement of road material. The road base course material thickness shall be a minimum of 12 inches and adjusted to accommodate construction traffic and to meet all other requirements as specified in this agreement if geotextile membrane is not used.

3.1.3. Structural fill shall be defined as any fill area receiving permanent loading from an external source, i.e. equipment foundation. Structural fill shall be compacted to a minimum of 95% of the maximum dry density per ASTM D698. Fill materials designated as structural fill shall be placed in lifts not exceeding 6 to 8 inches thick for cohesive soils (containing silts and clays) and 12 inches for cohesionless soils. In-place moisture content of compacted structural fill shall be at or above the optimum moisture content for cohesive soils and plus or minus 3 percentage points of the optimum moisture content for cohesionless soils as per ASTM D698.

3.1.4. Prior to placing structural fill, the existing ground shall be cleared of brush, roots/organic matter, debris and standing water. All unsuitable material shall be placed in non-structural fill areas. Granular fill soil (soils with less than 10 percent passing the No. 200 sieve) is suitable for imported structural fill material and shall be approved by the Engineer prior to use.

3.1.5. Borrow source for structural fill shall be approved by Owner. Structural fill shall be granular soil, free of deleterious material including expansive and organic material, rocks greater than 3 inches in diameter, debris, ice, and frozen soil, and shall be approved by the engineer prior to transport. Structural fill shall be placed on compacted native soil. Depth of the structural fill and compaction requirements shall be according to the contract documents.

3.1.6. Compaction tests shall be taken as required by contract documents. In the event of failed tests, the affected lift of material shall be reworked, recompacted and retested. Contractor shall not place additional fill until acceptable test results are obtained.

3.1.7. Positive drainage is required to drain water away from all footing or load-bearing structures. Drainage shall be directed to natural drainage ways and shall be graded according to the contract documents.

3.1.8. Access and Maintenance Road locations shown on maps may be altered to avoid sensitive vegetation. “AS BUILT” drawings conforming to Owner drawing standards shall be provided upon completion to reflect road and equipment foundation pad modifications made during construction.

3.1.9. Access roads shall be restricted from use by the general public. Signs at all entrances shall indicate “NO TRESPASSING, AUTHORIZED PERSONNEL ONLY. DANGER – HIGH VOLTAGE”. Sign size, content, location, etc. shall be approved by Owner prior to installation. The integrity of the sign shall be designed to withstand all seasonal and earthly elements including but not limited to sun, wind, snow, ice, rain, acidic soils, etc.

3.1.10. All work will be constructed, tested and inspected in compliance with the Project Quality Assurance Plan outlined in Attachment 4.

3.1.11. Site Access Roads shall be designed and constructed such that all uses during operations produce a maximum rut depth of 1.5 inches. Site Maintenance Roads shall be designed and constructed such that all uses during construction produce a maximum rut depth of 3 inches. Roadways shall also be maintained by the Contractor in acceptable condition for a standard 2-wheel drive ½ ton class truck to safely navigate the entire road to perform site inspections.

3.1.12. Contractor shall meet or exceed all recommendations in the contract documents.

3.1.13. Roads damaged during construction shall be repaired to reflect their condition prior to construction.

3.1.14. Road design shall consider water runoff patterns that will exist after construction is complete such that road material will not wash into fields or block, restrict, or divert water flow during heavy rains.

3.1.15. Access roads shall extend to the inverter access door. The road surface area shall be sufficient for a maintenance truck to complete a 3-point turn.

3.1.16. Access roads shall be designed for emergency vehicle access.

3.2. Definition Key

3.2.1. "Site Access Road" is defined as a road used to access the solar facility from a state or county road or an existing access road and extends from the state or county road to immediately within the perimeter fencing to inverters. This shall also include the access road to the substation.

3.2.2. "Site Maintenance Road" is defined as a road/access corridor within the solar facility perimeter fence and between solar arrays used to maintain the solar panels, arrays, etc. Site Maintenance Roads may be compacted native soil roads.

3.2.3. Contractor shall submit to the Owner all QA/QC plan records, all testing and inspection results, compaction test results for road base material, including location, dry density and moisture content.

3.2.4. Contractor shall submit to the Owner grain size analysis test results for road base material, including location and moisture content.

3.2.5. Contractor shall submit to the Owner copies of all completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan, the design documents, and testing and inspection requirements included in this document.

3.3. Products

3.3.1. Aggregate base course and cap material: Shall be as specified in the contract documents or otherwise approved by owner. At a minimum, road base material shall consist of an aggregate base course material with less than 10 percent particles passing the No. 200 sieve with a nominal maximum aggregate size of 1 ½ inches, free of deleterious, frozen and debris-laden materials.

3.3.2. Geotextile Membrane: Shall meet the requirements of the design documents. The engineer of record shall follow the manufacturer's recommendations for aggregate base thickness to be used during construction.

3.3.3. Culvert: Those located in State or County road Right-of-Ways shall be PVC or corrugated metal pipe and shall meet the requirements as directed by the State Department of Transportation and/or the County Engineer in which the project is located. Culverts on project property shall be PVC or corrugated metal pipe and shall meet the required specifications of the construction drawings.

3.4. Execution

3.4.1. Where new Site Access Roads are planned for agricultural areas, all topsoil shall be stripped through the root zone.

3.4.2. The entire Site Access Road subgrade shall be proof-rolled prior to placement of the aggregate base to identify unsuitable areas of subgrade and observed and documented by the QAR. The method to scarify, dry and recompact subgrade will not be allowed unless the material is proven not to contain organic material and/or material unable to remain compacted during or after a rain event.

3.4.3. All trees, stumps, brush, and debris within the grading areas shown in the design document shall be removed. Tree branches overhanging the drive zone of the Site Access Road shall be trimmed back to the edge of the Site Access Road.

3.4.4. Permanent Culverts: Shall be installed per the manufacturer's recommendations. The area where culverts are to be installed shall be cleared and grubbed. Organic materials shall be removed and replaced with recommended bed material. Provide a minimum cover over culverts of 12 inches.

3.4.5. Compaction of the sub-grade for roads, crane pads and foundations shall be the more stringent of the design documents or 95% of Modified Proctor (ASTM D1557).

3.4.6. Compaction of the road base and top course shall be as required by the design documents or to a minimum of 95% of Modified Proctor (ASTM D1557).

3.4.7. Road base course material shall be placed in layers not exceeding 6 inches in loose depth.

3.5. Testing and Inspection

3.5.1. All testing and inspections shall be performed as required by the design documents but at a minimum as indicated and described in this section.

3.5.2. All testing and inspection records shall be sent to the engineer of record for review. A copy of all testing and inspection records and any recommendations made by the engineer shall be sent to the Owner. Review of testing and inspection records does not alleviate the Contractor from the responsibility of correcting defective areas or work.

3.5.3. Soils used for Fill Material shall be tested for Grain Size Analysis and classification (ASTM D6913 and D2487), Atterberg Limits (ASTM D4318), Moisture Content (ASTM D2216), Standard Proctor Tests (ASTM D698), and Modified Proctor Tests (ASTM D1557).

3.5.4. Compacted Subgrade: Site access road shall be proof-rolled the full length in the presence of a geotechnical engineer or qualified and approved representative with a loaded tandem axle dump truck having a minimum gross weight of 25 tons. Subgrade shall be corrected if rutting greater than 1.5 inches and/or "pumping" of the subgrade occurs. Site Maintenance roads shall be recompacted if rutting greater than 3.0 inches occurs. Aggregate Base and Top Course: Shall be proof-rolled the entire road length.

4. Fencing

4.1. Site Fencing – For Solar Facilities Not Located Within Existing Security Fences

4.1.1. Chain link fence is the Owner standard. This type of fence is covered by the following standard and is considered a protective barrier for unattended facilities, a security barrier for the public and the first line of defense as a wildlife deterrent.

4.1.2. Manual entrance gates shall be two 8-feet wide gates that latch and lock at the center.

4.1.3. The solar array fence height is 8-foot-high (7-foot fence plus height of outrigger barbed wire), anti-climb, chain link, perimeter fencing with 2-inch diamond mesh. The substation fence shall be 10 feet high without barbed wire.

4.1.4. Contractor shall provide and install the fence to the configuration and details as shown on the permit set of plans.

4.1.5. Contractor shall provide fencing for construction equipment, laydown, and storage as necessary and according to applicable AHJ requirements.

4.1.6. The site fencing shall be grounded.

4.2. Security

4.2.1. 2” diamond chain link fence for the solar arrays and 1" diamond chain link fence for the substation shall be used to deny good toe hold and make climbing over the fence more difficult for unauthorized access from the public.

4.2.2. 45° outrigger with three stands of barbed wire to make climbing over the fence more difficult for the public and to legally declare the facility fences as security barriers.

4.2.3. A 7-foot fence height is the security requirement for the solar array. The substation fence height shall be 10 feet in total height.

4.2.4. Two eight -foot manual swing gates shall be installed at the access road. A personnel gate shall be located near the access road.

4.3. Fencing Material and Application

4.3.1. The height of a standard fence including the barbed wire shall be 7 feet above the rough grade.

4.3.2. The fence fabric shall be 1" or 2” diamond mesh chain link style as required, galvanized as follows:

4.3.2.1. Galvanized - Number 9 AWG (American Wire Gauge), galvanized after weaving, Class II, Conforming to ASTM A392, “Zinc-Coated Steel Chain-Link Fence Fabric”.

4.3.2.2. Barbed wire top guards, consisting of 3 or 4 strands of barbed wire, shall be mounted on outriggers directed outward at a 45-degree angle. The barbed wire should be equally spaced about 6” inches apart. Outriggers should be at least 18” or 24” long to insure 1’-0” vertical height over the top rail of the fence. Wire material to be either galvanized as follows:

4.3.2.2.1. Galvanized - 12 1/2 gauge with 14-gauge 4 barb, 5-inch spacing, conforming to ASTM A121, Class 3 “Zinc-Coated Steel Barb Wire.”

4.4. Fence Framework

4.4.1. Fence posts, top rail, and braces shall be compliant with ASTM F1043 or ASTM F1083.

4.4.2. Intermediate line posts shall be a minimum of 2 1/2” galvanized Schedule 40 pipe (2 7/8” O.D.)

4.4.3. 5.79 lbs. per foot with sufficient length to be driven into the ground a minimum of 4 feet deep.

4.4.4. Corner and terminal posts shall be a minimum of 2 1/2” galvanized Schedule 40 pipe (2 7/8” O.D.) standard pipe, 5.79 lbs. per foot. Posts shall be of sufficient length to be set in concrete at a minimum of 5 feet deep.

4.4.5. Gate posts shall be galvanized standard weight pipe of the following size for single swing gates or one leaf of the double gate. Posts shall be of sufficient length to be set in concrete at a minimum of 5 feet of depth.

Up to 6' wide	2 7/8" O.D.	5.79 lbs. per foot.
Over 6' to 13'	4" O.D.	9.11 lbs. per foot.
Over 13' to 18'	6 5/8" O.D.	18.97 lbs. per foot

4.4.6. Top rail and braces shall be 1 5/8" O.D. 2.27 lbs. per foot. All pipe shall be galvanized to conform to ASTM A120 covering "Black and Hot-Dipped Zinc-Coated (galvanized) Welded and Seamless Steel Pipe for Ordinary Uses."

4.4.7. Gates shall be galvanized 1.90-inch O.D. pipe, 2.72 lbs. per foot, complete with hinges, stops, rests, and latching devices of a type to accommodate a padlock.

4.4.8. Fittings and latches shall be of appropriate specifications for their functions.

4.4.9. All pipe shall be galvanized to conform to ASTM A120 covering "Black and Hot-Dipped Zinc-Coated (galvanized) Welded and Seamless Steel Pipe for Ordinary Uses."

4.4.10. Latch for double gate shall allow opening one half of the gate without disturbing anchorage of the second half.

4.4.11. Hardware fittings and braces shall be in compliance with applicable industry standards for complete and proper installation of the fence standard. Galvanizing shall conform to ASTM A153 "Zinc-Coating Hot-Dip Iron and Steel Hardware."

4.4.12. Each shipment of fence shall be inspected by the Contractor and the Owner to determine whether the galvanizing meets the specifications under which it was purchased.

4.5. Installation of Chain Link Fencing

4.5.1. Installation shall be made in a professional manner by skilled persons experienced in the erection of this type of fence and comply with ASTM F 567 Standard Practice for Installation of Chain-Link Fence. The fence shall be erected on lines and to grades as provided in the design documents. Fence shall follow the ground line unless otherwise specified. Line posts shall be spaced not more than 10 feet apart and shall be driven into the ground, 4 feet minimum, without concrete. All gate, corner and terminal posts shall be set in concrete foundations to a minimum depth of 60 inches. The diameter of the foundation is to be a minimum of 9 inches, except for gate posts, on which the minimum diameter shall be three times the outside diameter of the post. The foundation shall be 3000 P.S.I. concrete or greater.

4.5.2. All foundations shall extend to the finished grade and shall slope away from the post to assure proper drainage. The top shall be the same diameter as the remainder of the foundation and shall be neat in appearance. The fabric and the barbed wire shall be stretched to proper tension between the terminal posts and securely fastened to the framework members as covered in the material specifications. The bottom of the fabric shall be held uniformly to the existing grade elevation.

5. Electrical System

5.1. Design Requirements

5.1.1. All construction work and the completed electrical system shall be in accordance with and conform to applicable provisions of Schedule A.

5.1.2. All equipment shall be new materials and free of defects shall be installed and appropriately listed and NEMA rated. Where applicable, utility-grade equipment shall be used. All new equipment shall have identification tags installed.

5.1.3. Array must be sized to operate within the current, voltage and power limits approved and warranted by the inverter manufacturer. The temperature-adjusted voltage must remain within the inverter limits at historical record low temperature for the location in which it is installed.

5.1.4. Wires must be sized to keep the total voltage drop below 2 percent on the DC conductors from the array to the inverter including existing wire whips on the PC modules, and 2 percent on the AC conductors from the inverter to the point of interconnection. Total drop not to exceed 4 percent.

5.1.5. Electrical design shall include the design of equipment grounding and lightning and sure protection for the entire PV facility.

5.1.6. Design and specify all communications hardware and software required for system protection and remote monitoring and control, and facility security system. The security cameras shall be remotely monitored and controlled.

5.1.7. The electrical system shall be designed to minimize power losses from nameplate generation at the panel through the inverter, and switchgear to the substation or distribution line breaker.

5.1.8. The latest adopted edition of the National Electric Code (NFPA 70, NEC), and National Electric Safety Code (NESC), ANSI C2-1997 shall be followed except where the Utility standards and/or local regulations are more stringent, in which case the most stringent requirement shall govern. Intermediate grounds-4 per mile will not be provided.

5.1.9. All work shall be constructed, tested and inspected in compliance with the Project Quality Assurance requirements.

5.2. AC System

5.2.1. AC Cabling - Cabling for AC systems should be designed to provide a safe and cost-effective means of transmitting power from the inverters to the transformers and beyond. Cables shall be rated for the correct voltage and have conductors sized, considering the operating currents and short-circuit currents. Design shall consider as follows:

0.1.1.1 Cable must be rated for the maximum expected voltage

0.1.1.2 Conductor shall be able to pass the operating and short circuit safely.

0.1.1.3 Cabling sized to avoid voltage drop

0.1.1.4 Insulation should be adequate for the environment of installation

0.1.1.5 Earthing and bonding

0.1.1.6 Installation methods and mechanical protection of the cable

5.2.2. Step-up Transformers

0.1.1.7 Transformer shall be sized based on the output power from the PV arrays with sufficient capacity.

0.1.1.8 Transformer efficiency standards set forth in the Department of Energy “Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule”.

0.1.1.9 Transformers shall be supplied with a no-load tap changer with high voltage taps capable of operating at 2, 2.5% above and below nominal voltage at full rating.

0.1.1.10 Transformers shall be either dry-type or less-flammable oil insulating liquid.

0.1.1.11 Enclosure finish shall be a powder coat designed for a 25-year service life.

0.1.1.12 Accessories to include liquid level and pressure/vacuum gauges, dial-type thermometer with SPDT alarm contacts, pressure relief valve, and a drain valve with sampler.

5.2.3. Switchgear – Switchgear and protection systems shall be included to provide disconnection isolation, earthing and protection. On the output side of the inverters, provision of a switch disconnector shall be provided to isolate the PV array.

5.2.3.1. Switchgear shall be located outdoors; Enclosure shall be NEMA 4 and lockable.

5.2.3.2. Switchgear shall include an auxiliary compartment containing all instrument transformers associated with the protective relays and 120/240V control power transformer (CPT).

5.2.3.3. Communication hardware shall be included.

5.2.3.4. Relay current transformers shall be C400 accuracy class.

5.2.3.5. Medium voltage protective device and relaying shall be provided.

5.2.4. Grounding and Surge Protection – Grounding should be provided to protect against electric shock, fire hazard and lightning. The grounding of a solar PV system shall include array frames, inverters, lightning and surge protection. Design guidelines should be considered:

5.2.4.1. Ground rods should be placed close to junction boxes.

5.2.4.2. A continuous earth path is to be maintained throughout the PV array.

5.2.4.3. Cable runs should be kept as short as possible.

5.2.4.4. Surge suppression devices can be installed at the inverter end of the DC cable and at the array junction box.

5.2.4.5. Inverter models may include internal surge arrestors.

5.3. DC System

5.3.1. DC components shall be rated to allow for thermal and voltage limits. DC system comprises the following constituents:

5.3.1.1. Array of PV modules

5.3.1.2. DC cabling (module, string, and main cable)

5.3.1.3. DC connectors (plugs and sockets)

5.3.1.4. Junction boxes/combiner boxes

5.3.1.5. Disconnect/switches

5.3.1.6. Protection devices

5.3.1.7. Earthing

5.3.2. PV Array Design – Multiple PV modules shall be installed in sufficient quantity to form a complete PV solar array generating system to generate the projected mega-watts, alternating current (MWac). Design of the arrays should optimize efficiency and should consider the following:

5.3.2.1. Minimize ohmic losses

5.3.2.2. Inverter voltage limits

5.3.2.3. Minimize string voltage drops

5.3.2.4. Maximum number of strings shall not lead to yield loss

5.3.3. Combiner Boxes – Combiner boxes are needed at the point where the individual strings forming an array are marshalled and connected in parallel before leaving for the inverter through the main DC cable. Junctions should be made with screw terminals and must be of high quality to ensure lower losses and prevent overheating.

5.3.4. Fuses/Miniature Circuit Breakers – String fuses or miniature circuit breakers are required for over-current protection. They must be rated for DC operation.

5.3.5. DC Switching – DC switches provide a manual means of electrically isolating entire PV arrays, which is required during installation and maintenance. DC switches must be:

5.3.5.1. Double-pole to isolate both the positive and negative PV array cables

5.3.5.2. Rated for DC operation

5.3.5.3. Capable of breaking under full load

5.3.5.4. Rated for system voltage maximum current

5.3.5.5. Equipped with safety signs.

5.3.6. Inverter – Sizing of the inverter should range within limits of $\mathbf{0.9} < \boldsymbol{Power\ ratio} < \mathbf{1}$. Sizing should be obtained from the inverter manufacturers.

5.3.7. DC Cabling – The selection and sizing of DC cables shall be designed for solar PV installations

5.3.7.1. Module and string cables – single conductor, double-insulated cables are preferable for module connections. Using such cables helps protect against short circuits.

5.3.7.2. Cables shall be resistant to ultraviolet (UV) radiation and weather if laid outdoors without protection.

5.3.7.3. Cables should be rated to the highest temperature they may experience.

5.3.7.4. Appropriate de-rating factors for temperature, installation method and cable configuration should also be applied.

5.3.7.5. Main DC cable – the overall voltage drop between the PV array and the inverter should be minimized and reduce losses. A benchmark voltage drop of less than 2 percent (at STC) shall be used.

5.3.8. Cable management

5.3.8.1. Over-ground cables such as module cables and string cables need to be properly routed and secured to the mounting structure, either using dedicated cable trays or cable ties. Cables should be protected from direct sunshine, standing water and abrasion by the sharp edges of support structures. Split loom shall be installed to protect the cable against sharp edges. They should be kept as short as possible.

5.3.8.2. Plug cable connectors to be touch-proof.

5.3.8.3. The laying of DC cables in trenches must comply with national code and consider specific ground conditions.

5.3.8.4. Cables shall be listed and identified as PV wire per NEC.

5.4. Communication System:

5.4.1. The facility monitoring system and the security system shall require a communications medium with remote access. Contractor shall provide a cellular or DSL link for remote monitoring.

5.4.2. Contractor shall procure and install all materials and equipment necessary to complete the communication (data collection) cable installation. This includes, but is not limited to fiber optic cable, conduit, pull boxes, terminations, connectors, and panels.

5.4.3. Communication tests shall be performed to demonstrate its ability to meet the requirements of its intended use. Fiber loops shall also be tested and provide loop functional check sheets for each communication circuit.

5.4.4. Documentation shall include test results and materials provided.

5.5. Meteorological Stations

5.5.1. Sufficient number of meteorological stations shall be provided to measure meteorological data to evaluate facility performance. The stations shall be capable of collecting the data points and sample frequency. Station shall have capability of recording and storing environmental conditions without AC power for two (2) days.

5.6. Supervisory Control and Data Acquisition (SCADA)

5.6.1. Contractor shall provide engineering workstation providing local control.

5.6.2. A single customizable SCADA system composed of integral operator human-machine interface (HMI), input/output (I/O) and remote telemetry units (RTU) hardware, firmware, and software, internal control/communications devices designed to industry standards shall provide for remote monitoring, alarm management, control and historical trending of the monitored equipment in a single software package.

5.6.3. Communication shall be transmitted via ANSI compliant optic or wireless communications infrastructure for web and client interface.

5.6.4. Points to be monitored by the SCADA system shall include, at a minimum:

5.6.4.1. Meteorological stations

a. Reference cell temperature
b. Reference cell Irradiance
c. Ambient Air Temperature
d. Wind Speed
e. Wind Direction
f. Global Horizontal Irradiation
g. Rain
h. Module Temperature

5.6.4.2. Inverters

a. AC Voltage
b. DC Voltage
c. AC Current
d. DC Current
e. kW
f. kWh

5.6.4.3. Metering – System shall monitor and store data from the facility site meter on an interval from between five (5) to twenty (20) seconds.

5.6.4.4. Trackers (if applicable) remote monitoring and control

5.6.4.5. Facility switchgear

5.7. Underground Power Distribution Installation

5.7.1. High voltage cables shall be pulled to the distribution line and tied off to the termination structure with a Kellems grip, or equivalent.

5.7.2. Contractor shall use a minimum cable insulation rated 133% of distribution voltage.

5.7.3. Contractor shall obtain all necessary permits for road bores or trench crossings.

5.8. Underground Power Distribution Feeder Grounding

5.8.1. Grounding transformers are to be supplied on the collection system. Each feeder shall contain at least one grounding transformer, and each grounding transformer shall be interchangeable with another. Grounding transformers shall be sized per Owner distribution standards, and to keep the collection feeder voltage rise during a fault on the feeder to less than 1.39 pu voltage as per IEEE C62.92.1-2000.

5.8.2. An analysis of the maximum transient overvoltage along the feeder collection circuits under a fault shall be performed to determine the appropriate ratings and placement of the grounding transformers on the collection circuits. The analysis shall be provided to Xcel for review.

5.8.3. Arrestors shall be placed on each feeder at the substation, and along the collection circuit at the end of each string, and as needed between to limit the voltage rise during fault conditions, or other events that can cause transient over-voltages.

5.9. Conduit and Wire

5.9.1. Contractor shall keep phasing and color-coding of phases consistent throughout the project.

5.9.1.1. The minimum bending radius of primary cable is twelve (12) times the overall diameter of the cable. The minimum bending radius of secondary and service cable is eight (8) times the overall diameter of the cable. In all cases the minimum radius specified is measured to the surface of the cable on the inside of the bend. No cable bend shall be made within six (6) inches of a terminal base.

5.9.1.2. A pull rope shall be installed in all empty conduits All exposed ends of conduit shall be plugged during construction to prevent the entrance of foreign matter and moisture into the conduit. Burrs or sharp projections, which might damage the cable, shall be removed. Riser shield or conduit shall extend at least eighteen (18) Inches below grade at all riser poles or as shown on the drawings. If full round conduit is used as a riser shield, an end bell shall be installed on the lower end to prevent damage to the cable.

5.9.1.3. Each cable in a switch, sectionalizing cabinet, transformer, etc. shall be identified by circuit number, phase and location of the opposite end with permanent plastic or corrosion resistant metal tags. Close to each cable termination, Contractor shall also mark the cable termination phase designation on the cabinet.

5.9.1.4. At each medium voltage junction box or inverter foundation, a minimum of 10 feet of slack cable shall be coiled in the transformer vault or buried as close as possible if a vault is not used

5.9.1.5. Conduit duct seal shall be used to prevent rodent infestation. Spray foam insulation shall not be used.

5.10. Direct Burial Installation of Cables

5.10.1. The bottom of the trench receiving conduit or direct-buried cable should be smooth, undisturbed, well-tamped earth without exposed rocks. When excavation is in rock or rocky soils, the conduit or cable should be laid on a protective layer of well-tamped backfill. Backfill should be compacted to 95% standard proctor per ASTM D698.

5.10.2. All cables shall be buried a minimum depth of 3 feet to the top of cable/conduit, or as specified by the design engineer, local code requirement, whichever is greater. Communication cable shall be buried at the same depth as the power cable, except in the case when the manufacturer requires that ground cable be buried above power cable. In that case the communication cable shall be buried at the same level as the ground cable.

5.10.3. A minimum bend radius of twelve (12) times the outside diameter of the cable shall be followed.

5.10.4. Cable separation distance shall always be maintained as specified by the product documentation and engineered drawings.

5.10.5. Sufficient slack shall be left at all risers, transformer pads, pedestals and terminal points so that movement of cable after backfilling shall not cause damaging strain on the cable or terminals.

5.10.6. All debris shall be removed from the fill before placing it back in the trench. Cable trenches shall be mechanically compacted six (6) feet minimum from all riser poles, pads, pedestals and terminal points. All disturbed area shall be restored as to not cause ground settling greater than 1” below the undisturbed elevation.

5.10.7. Cable caps (3M) shall be supplied when cables are waiting to be terminated in the field after installation.

5.11. Medium Voltage Splices/Terminations/Connections

5.11.1. Splices

5.11.1.1. Cable splices shall be of the pre-molded rubber, cold-shrink type, of the correct voltage rating and shall be installed in accordance with the splice manufacturer's instructions. Splices that depend solely on tape for a moisture barrier shall not be used.

5.11.1.2. Electrical works design shall minimize the number of splices required.

5.11.1.3. No bends shall be permitted within twenty-four (24) inches of the end of a splice.

5.11.1.4. The cable or circuit numbers and the exact location of all splices shall be noted on the As-Built Drawings and Documentation shall include GPS locations of each splice.

5.11.1.5. Splicing in ducts is not allowed.

5.11.1.6. The location of each splice shall be marked with single or stacked locating marker balls depending upon the depth of cable burial.

5.11.1.7. A marker ball detection device compatible with the marking balls installed shall be provided.

5.11.2. Primary Cable Terminations and Stress Cones: Prefabricated stress cones or terminations shall be installed in accordance with the manufacturer's instructions at all primary cable terminals. They shall be suitable for the size and type of cable that they are used with and for the environment in which they will operate. Any indication of misfit, such as a loose or exceptionally tight fit, shall be called to the attention of the Owner. The outer conductive surface of the termination shall be bonded to the system neutral. A heat-shrink or cold-shrink sleeve shall be installed to seal between the body if the termination and the cable jacket.

5.11.3. Special Precautions for Cable Splices and Terminations: A portable covering or shelter shall be used when splices or terminations are being prepared and when prefabricated terminations are being switched. Since cleanliness is essential in the preparation and installation of primary cable fittings, care shall be exercised to prevent the transfer of conducting particles from the hands to insulating surfaces. Mating surfaces shall be wiped with a solvent such as denatured alcohol to remove any possible accumulation of dirt, moisture or other conducting materials. A silicone grease or similar lubricant shall be applied afterwards in accordance with the manufacturer's recommendations. Whenever prefabricated cable devices are opened, the un-energized mating surfaces shall be lubricated with silicone grease before the fittings are reconnected.

5.11.4. Secondary and Service Connections:

5.11.4.1. A suitable inhibiting compound shall be used with all secondary and service connections.

5.11.4.2. All secondary cable connections located below grade or in secondary pedestals shall be made with pre-insulated secondary connector blocks. Diving bells with open terminals, insulating boots or moisture barriers that depend solely on tape are not acceptable.

5.11.4.3. If the secondary phase terminals are threaded studs, the connection shall be made with a pre-insulated secondary transformer connection block. If the transformer secondary phase terminals are insulated cable leads, connection shall be made with a pre-insulated secondary connector block or with a secondary prefabricated splice when the transformer leads continue directly to the service.

5.11.4.4. Transformer secondary spades shall be taped or otherwise insulated. Boots used for insulation shall be taped so that they cannot be readily slipped off.

5.11.4.5. The secondary connections and insulation shall have accommodations for all future and existing service as shown on the plans and specifications

5.12. Pedestals

5.12.1. Where required, pedestals stakes shall be driven vertically into the bottom of the trench before cables are placed and shall be located as shown on the drawings. Pedestal posts and supporting stakes shall be in place before the cable is installed. All pedestals should be approximately at the same height above finish grade.

5.13. Equipment Pads

5.13.1. The site for the pad shall be adjacent to but not over the trench backfill zone. The site shall be cleared of all debris and excavated to the specified depth. Native soil excavation bottoms shall be observed for cleanliness and suitability by a licensed, geotechnical engineer or designated representative prior to Structural Fill placement. Structural Fill, as defined in this specification, shall be added per plans and compacted to 95% of the maximum dry density of a standard Proctor (ASTM D698). The pad shall be installed level at the specified elevation.

5.13.2. As an alternative, the inverter skids can be mounted on driven pile foundations designed per the site conditions.

5.14. Transformers

5.14.1. Transformers shall be handled carefully to avoid damage to the finish and shall be positioned in accordance with the plans and specifications. Only qualified and experienced personnel shall be allowed to make connections and cable terminations.

5.15. Grounding

5.15.1. All neutral conductors, ground electrodes, and groundable parts of equipment shall be interconnected. All interconnections shall be made as shown on the design documents. Ground rods shall be installed at all equipment locations as shown in the design documents. All underground ground connections shall be exothermically welded. Clamps shall not be used to make underground ground connections.

5.16. Equipment Enclosures

5.16.1. Excavations for sleeve-type sectionalizing cabinet pads and other below grade enclosures shall be made so as to disturb the surrounding earth as little as practical. Enclosures shall be installed with side walls plumb and without any panel distortion. When installation is complete, the cover of the enclosure shall not be lower than and not more than two (2) inches higher than specified grade. Soil in the immediate vicinity shall be tamped and sloped away from the enclosure. The excess soil shall be spread evenly over the surface of the ground to the design requirements.

5.17. Warning Signs

5.17.1. Each equipment enclosure shall display a “Caution” sign placed so that it is visible to anyone attempting entry to the enclosure. Also, the equipment inside the enclosure shall display a “Danger” sign so that it is visible when the enclosure is open. Cable markers which indicate the presence of underground electrical facilities shall be installed at all road crossing locations.

5.18. Cleanup, Disposal and Restoration

5.18.1. All excess excavated material debris, such as boulders, broken concrete, trees, shrubs, roots, lumber, and any other items resulting from the construction operation, shall be removed and the site restored to its original appearance.

5.18.2. All areas in which trenching takes place shall be restored to the original condition. This includes gravel, concrete and asphalt surfaces.

5.18.3. Construction areas shall be de-compacted to a workable condition for farming to the extent practicable and vegetation cover re-established where disturbed by the work.

5.19. Underground Power Distribution Testing

5.19.1. Power Cable Acceptance Testing

5.19.1.1. Installations of power cable including terminations are to be acceptance tested using DC or low frequency AC high potential (Hipot) testing, and at a minimum to include the following tests:

5.19.1.1.1. Continuity: After installation of the cable and prior to the high potential test specified below, a simple continuity test shall be conducted on the system. This can be accomplished by grounding the conductor at the source and checking for continuity from the end of each tap with an ohmmeter.

5.19.1.1.2. High Potential: After successful continuity tests of the distribution voltage collection system, high potential tests on each length of cable, with terminations in place but disconnected from the system. The installation shall withstand a minimum of fifteen (15) minutes DC test potential or as recommended by the cable and connector manufacturers. The voltage may either be increased continuously or in steps to the maximum test value.

5.19.1.1.3. If increased continuously, the rate of increase of test voltage should be approximately uniform and increasing to maximum voltage in not less than ten (10) seconds or more than sixty (60) seconds.

5.19.1.1.4. If applied in steps, the rate of test voltage increase from one step to the next should be approximately uniform. The duration at each step shall be long enough for the absorption current to attain reasonable stabilization (one minute minimum). Current and voltage readings should be taken at the end of each step duration. The number of steps should be from five to eight.

5.19.1.1.5. Cable sheath testing shall be included for medium voltage cable.

5.19.1.2. If more than three failures of any component occur within six months of commercial operation, then partial discharge shall be performed on all similar components.

5.19.1.3. Other Test and Inspections: All other tests and inspections described in the Project Quality Assurance Plan.

5.19.1.4. After completion of a test and before handling the cable, the conductor shall be grounded to permit any charge to drain to earth.

5.19.2. Ground Loop Testing

5.19.2.1. Measure ground loop resistance to remote earth using the three-point method and verify the measured results conform to the requirements of the inverter supplier and the design documents.

5.19.3. Pad – Mount Transformer Testing

5.19.3.1. The following transformer checks and tests shall be completed on all units:

5.19.3.1.1. Inspection of satisfactory mechanical installation including proper torque on bolts, labeling and grounding.

5.19.3.1.2. Insulation resistance test between windings and from each winding to ground.

5.19.3.1.3. Calculate Polarization Index

5.19.3.1.4. Field test of transformer turns ratio test on all taps

5.19.3.1.5. Routine and Design tests specified for Class I power transformers identified in IEEE C57.12.00 2010 table 18.

5.19.3.1.6. Oil analysis for visual inspection, gas, liquid screen, and Karl Fischer moisture at minimum.

5.19.3.1.7. All other test and inspections described in the Project Quality Assurance Plan.

5.20. Submittals

5.20.1. Contractor shall submit to the Owner copies of all completed forms and documentation of all tests, studies, and inspections. Submittals required in the sections that refer to this section shall conform to the requirements of the definitive project agreement and to the following additional requirements:

5.20.1.1. Project Schedule

5.20.1.2. Interface Matrix

5.20.1.3. Construction Plan

5.20.1.4. Design Drawings shall include but not limited to:

5.20.1.4.1. Site plan showing infrastructure layouts, PV arrays locations.

5.20.1.4.2. Overall single line diagrams

5.20.1.4.3. Schematics Diagram

5.20.1.4.4. Wiring Diagram

5.20.1.4.5. Medium voltage and low voltage switch gear line diagrams

5.20.1.4.6. Riser diagrams showing connection to utility AC disconnects and main electrical switchboard

5.20.1.4.7. Indicate conduits, power and communication wires, and combiners, disconnects, inverters, meter, etc.

5.20.1.4.8. Provide PV system(s) power production calculations and total system(s) rating.

5.20.1.4.9. Complete point to point PV System interconnection diagram identifying all DC and AC components.

5.20.1.4.10. Combiner box schedule

5.20.1.4.11. Bill of materials.

5.20.1.4.12. Cable Schedule

5.20.1.4.13. Mounting frame and module layout

5.20.1.4.14. Inverter locations and foundation/housing

5.20.1.5. Control Systems

5.20.1.6. Protection Systems

5.20.1.7. Auxiliary power requirements

5.20.1.8. System Performance Reports: System study shall use software modeling program such as PVsyst for the sizing, simulation, and data analysis of complete PV systems. Output reports shall provide yearly energy production, performance, and energy gains and losses.

5.20.1.9. Medium voltage ampacity report: The purpose of the cable ampacity study is to determine if the calculated cable ampacity is greater than the load on any given cable in the collection system.

5.20.1.10. Low voltage ampacity report: The purpose of the low voltage cable ampacity study is to determine a safe operating ampacity the system can maintain.

5.20.1.11. Insulation coordination study: The purpose of the insulation coordination study is to ensure the insulation coordination requirements have been met per IEEE Std. C62.22-2009.

5.20.1.12. Effective grounding report: The purpose of the effectively grounded system study is to determine if the collection system is effectively grounded as defined by IEEE Standard C62.92.1-2000.

5.20.1.13. Ground grid analysis report: The purpose of the ground grid analysis study is to calculate the touch and step potential and certify that the proposed ground grid will meet or exceed IEEE Std. 80 safety requirements and the inverter manufactures touch potential requirements.

5.20.1.14. Fault current report: The purpose of the fault current analysis and coordination study is to determine the maximum fault current on each section of cable or conductor in the collection system and determine the maximum amount of time the conductor can withstand the fault before the cable is damaged.

5.20.1.15. Power factor report: The purpose of the power factor study is to calculate the power factor over a range of plant outputs to ensure the power factor of the solar facility meets Utility's required power factor range while staying within the power factor limitations of the installation.

5.20.1.16. Energy loss report: The purpose of the energy loss evaluation is to calculate the annual energy loss as a percentage of solar facility production to the distribution voltage bus at the solar facility substation/switching station.

5.20.1.17. Arc flash report: The purpose of the arc flash hazard assessment is to calculate the arc flash incident energy at various points of the solar facility and switchyard under all operating configurations to ensure the worst possible set of results is captured at each location. Applicable standards include IEEE 1584 NFPA 70E.

5.20.1.18. Harmonics report: The purpose of this report is to confirm the solar facility will meet interconnection harmonic requirements under all configurations of the solar facility and interconnection substation.

5.20.1.19. Oil sample analysis report for each padmount transformer

5.20.1.20. Manufacturer's Catalog Data: Submittals for each manufactured item shall include current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts. Handwritten and typed modifications and other notations not part of the manufacturer's preprinted data will result in the rejection of the submittal. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified for certificates of compliance.

5.20.1.21. Bill of Materials: for major equipment

5.20.1.22. Instructions: Where installation procedures or part of the installation procedures are required to be in accordance with manufacturer's instructions, submit printed copies of those instructions prior to installation. Installation of the item shall not proceed until manufacturer's instructions are received. Failure to submit manufacturer's instructions shall be cause for rejection of the equipment or material.

5.20.1.23. Operation and Maintenance Manuals: Comply with the requirements of the technical sections

5.20.1.24. Operation and Maintenance Manuals for Electrical Works: Submit operation and maintenance manuals for electrical works that provide basic data relating to the design, operation, and maintenance of the electrical system. This shall include:

5.20.1.25. Single-line diagram of the "as-built" electrical works

5.20.1.26. Schematic diagrams of electrical control system

5.20.1.27. Manufacturers' operating and maintenance manuals on active electrical equipment, as applicable.

5.20.1.28. Operating Instructions: Submit text of proposed operating instructions for each system.

5.21. Products

5.21.1. General

5.21.1.1. All materials equipment, and workmanship shall conform to the applicable chapters of the National Electrical Code (NEC), the National Electrical Safety Code (NESC), and the terms and conditions of the Transmission Provider's and other Authorities having lawful jurisdiction pertaining to the work required.

5.21.1.2. All products shall be capable of compliance with all OSHA lockout requirements

5.21.1.3. Underground cable shall be as required by final design. Provide all rubber termination and splice materials.

5.21.1.4. Padmounted transformer(s) as described in the padmount transformer technical specification which is a part of the document.

5.21.1.5. Junction box medium voltage terminations shall utilize "T" type connectors that will allow for the easy relocation of surge arrestors.

5.21.1.6. Pedestals for padmount transformers shall be fiberglass, pre-cast, or cast-in-place concrete.

5.21.1.7. Junction boxes shall be pad mounted within the confines of the power substation.

5.21.1.8. Junction boxes, such as DC combiner boxes, located within the solar array may be pad mounted or mounted to deep foundation post(s).

5.21.2. Condition of Products

5.21.2.1. Except as otherwise indicated, provide new electrical products free of defects and harmful deterioration at the time of installation. Provide each product complete with trim, accessories, finish, guards, safety devices and similar components specified or recognized as integral parts of the product, or required by governing regulations. Unless otherwise indicated by the plans or specifications or approved in writing, the materials and equipment furnished under these specifications shall be the standard products of manufacturers regularly engaged in the production of such equipment and shall be the manufacturers' standard design.

5.21.3. Uniformity

5.21.3.1. Where multiple units of a product are required for the electrical work, provide identical products by the same manufacturer without variations.

5.22. Grid Connection

5.22.1. Factors should be considered during the project development process. The study should evaluate any unforeseen that may impact the viability of the project.

5.22.2. Proximity – The distance from the site to the grid connection point. In order to ensure the grid connection does not adversely affect project economics, it is necessary to carry out a feasibility study to assess power evacuation and transmission line routes.

5.22.3. Availability – The grid availability is the percentage of time that the network is able to accept power from the solar PV facility. The annual energy yield from a facility may be significantly reduced if the grid has significant downtime. Availability statistics should be evaluated.

5.22.4. Capacity – The capacity of the grid to accept exported power from a solar facility will depend on the existing network infrastructure and current loading of the system. The substation and export line capacity shall be sized for the capacity.

5.22.5. Utility requirements – Technical requirements for connection shall comply with Utility company codes and interconnection requirements which may include.

5.22.5.1. Limits on harmonic emission

5.22.5.2. Limits on voltage flicker

5.22.5.3. Limits on frequency variation

5.22.5.4. Fault level requirements

5.22.5.5. System protection

5.23. Execution

5.23.1. Coordination of Electrical Works

5.23.1.1. It is recognized that the electrical drawings are diagrammatic in showing certain physical relationships that must be established within the Electrical Works and in its interface with other work, including utilities and mechanical work, and that such establishment is the exclusive responsibility of the Contractor.

5.23.1.2. Arrange all electrical work in a neat, well-organized manner. Indoor conduit and similar services shall be installed running parallel with the primary lines of the building construction and with a minimum of 7 feet of overhead clearance where possible.

5.23.1.3. Arrange all electrical work with adequate access for operation and maintenance

5.23.1.4. Electrical connections shall be tightened to torque specifications stated by the equipment manufacturer.

5.23.2. Quality Control Testing

5.23.2.1. Upon completing installation of all systems and equipment, but prior to electrical substantial completion, the Contractor shall conduct an operational test of all equipment, controls, and devices installed or modified by the Contractor.

5.23.2.2. Contractor shall notify Owner in writing a minimum of three (3) days in advance of any test. This operational testing is in addition to testing required in separate sections of this specification. Where possible, combination of this testing and other testing required should be accomplished to minimize travel requirements.

5.23.3. Labeling

5.23.3.1. Install permanent labels on all electrical panels, cabinets, disconnects, motor starters, major equipment, or components. Weatherproof labels shall be either laminated black-phenolic plastic with white engraved letters, or engraved (or embossed) stainless steel nameplates. Lettering for panels and equipment shall be a minimum of 1/2 in. high. Labels shall be permanently installed by gluing or screwing to equipment covers. Labels shall show panel or load name and the circuit it is fed from.

6. Inverter Foundation (If Used)

6.1. Excavation, Backfill and Compaction

6.1.1. General

6.1.1.1. Ensure foundation site is graded in accordance with the design documents

6.1.1.2. All work shall be constructed, tested and inspected in compliance with the Project Quality Assurance Plan and as indicated in the design documents.

6.1.2. Submittals

6.1.2.1. Grain size analysis, natural moisture content and standard proctor maximum dry density test data for common fill soil materials.

6.1.2.2. Compaction test results indicating location of test, dry density and moisture content of placed fill.

6.1.2.3. Copies of all completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan, the design documents, and Testing and Inspection requirements included in this document.

6.1.3. Products

6.1.3.1. Lean Concrete: as required by the design documents.

6.1.3.2. Common Fill: Soil free of organic or deleterious material.

6.1.4. Execution

6.1.4.1. Excavate soils to the limits according to the design documents.

6.1.4.2. Prior to placing a protective lean concrete surface, a geotechnical engineer or qualified representative shall inspect and approve the subgrade conditions and record the soil type encountered, groundwater conditions, or other subsurface conditions. The observations taken should confirm the subgrade conditions are consistent with the reference geotechnical information. If the subgrade is destabilized by foot or construction traffic, the surface must be re-inspected prior lean concrete placement. Water should not be allowed to pond on the exposed subgrade.

6.1.4.3. To protect the subgrade, place a lean concrete surface, and fill to the lines and levels indicated on the drawing. It is recommended that the surface be placed as level as possible to facilitate placement of the reinforcing steel and embedment ring.

6.1.4.4. Backfill and Compaction. Place and compact common fill materials to the limits, depth and percent compaction indicated in the contract documents

6.1.4.5. Grade the site in accordance with drawings to prevent water from ponding over the foundation while maintaining the maximum depth of fill specified on the design documents.

6.1.4.6. Restore the site in accordance with the definitive project agreement.

6.1.5. Testing and Inspection

6.1.5.1. Obtain samples of common fill materials and perform the laboratory testing specified in the contract documents.

6.1.5.2. For placed and compacted fills, provide one test per lift per 2,500 square feet, indicating the reporting requirements of ASTM D6938.

6.1.5.3. All other tests and inspections described in the Project Quality Assurance Plan and as indicated in the design documents.

6.2. Cast in Place Concrete and Steel Reinforcing

6.2.1. General

6.2.1.1. Concrete work shall be in general compliance with all applicable codes and specifications including the following:

a. ACI 318 latest edition, Building Code Requirements for Structural Concrete and Commentary

b. ACI 301, Standard Specifications for Structural Concrete

c. ACI 308, Standard Specification for Curing Concrete

d. ACI 309, Consolidation of concrete guide

6.2.1.2. All work shall be constructed, tested and inspected as described in the Project Quality Assurance Plan and as indicated in the design documents.

6.2.2. Submittals

6.2.2.1. Final mix design meeting the concrete specifications. Concrete mix designs shall be certified by a professional engineer and include the backup documentation required by ACI 301.

6.2.2.2. Product data for admixtures including aggregates, cements and other additives in the concrete mix. Curing of concrete shall be according to the latest ACI standards of practice/recommendations.

6.2.2.3. Mill reports for the reinforcing steel confirming the grade and strength of the reinforcing steel used on the project is as specified in the design documents.

6.2.2.4. All completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan, the design documents and, Testing and Inspection requirements included in this document.

6.2.3. Products

6.2.3.1. As specified by design documents

6.2.4. Execution

6.2.4.1. Place reinforcement and concrete in accordance with the final design dimensional tolerances.

6.2.4.2. Reinforcement shall be clean and free of rust, mud, debris and foreign material

6.2.4.3. Provide necessary chairs and standees to support rebar and prevent movement or deflection of the mats during placement of concrete.

6.2.4.4. Prevent formwork from moving during placement of concrete.

6.2.4.5. Place concrete in accordance with ACI 301.

6.2.4.6. Place successive lifts of concrete as quickly as possible to insure proper consolidation of concrete between successive lifts.

6.2.4.7. Foundation reinforcement and concrete shall be placed over a lean concrete working surface clear of debris, ponding of water, standing mud, and organic material.

6.2.4.8. Consolidate concrete in accordance with ACI 309 preventing the formation of joints, voids or honeycombing.

6.2.4.9. Create a smooth and level surface on top of concrete footings, equipment pads, and pedestal.

6.2.4.10. Cure concrete in accordance with ACI 308Apply curing compound as soon as bleeding has stopped, and free water is no longer evident at the surface.

6.2.5. Testing and Inspection

6.2.5.1. Cast compressive strength test specimens in accordance with ACI 318.

6.2.5.2. Laboratory strength test of specimens at 7 and 28 days or as required in design documents and the minimum required by ACI 318.

6.2.5.3. Casting and testing of cylinders in excess of 7 and 28 days will be the sole cost of the contractor.

6.2.5.4. Perform a minimum of one air test per concrete truck.

6.2.5.5. Perform a minimum of one slump test per cylinder test.

6.2.5.6. Perform all other tests and inspections described in the Project Quality Assurance Plan and as indicated in the design documents.

6.2.5.7. All concrete, reinforcement, anchor bolts, embed plates, formwork, etc. shall be inspected per the current International Building Code (IBC), Chapter 17, “Special Inspections.”

6.3. Anchor Bolts and Embedment Plates

6.3.1. General

6.3.1.1. Products, execution and testing are specified to provide durable anchor bolts per most applicable codes and standards set for the solar industry.

6.3.1.2. All work shall be constructed, tested and inspected as described in the Project Quality Assurance Plan and as indicated in the design documents.

6.3.2. Submittals

6.3.2.1. Product data for anchors and hardware

6.3.2.2. Mill certificates for anchors indicating the yield strength.

6.3.2.3. Mill certificates for the embedment ring indicating the material meets the minimum strength requirements.

6.3.2.4. Tension test data for anchor bolts that are tested indicating bolt location and tension value.

6.3.2.5. Copies of all completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan, the design documents and Testing and Inspection reports.

6.3.3. Products

6.3.3.1. As required by design documents.

6.3.4. Execution

6.3.4.1. The final engineered dimensional tolerances shall be adhered to for all installations.

6.3.4.2. Use a template ring to set anchor bolt plumbness and position. Ensure the template ring is set in accordance with the specified construction tolerances.

6.3.4.3. Place and level the embedment ring in accordance with the specified tolerances.

6.3.4.4. Insure the embedment ring is properly anchored to prevent movement.

6.3.4.5. After placement of concrete and at the final elevation, seal the space between the anchor bolt and the anchor bolt sleeve to prevent water from entering the sleeve annulus prior to setting of equipment and grouting of baseplate.

6.3.4.6. After setting of the equipment and grouting the baseplate anchor bolts shall be tensioned according to the specified tensioning procedure to a force as specified in the final design. The tensioning device for the anchor bolts should be calibrated in accordance with the approved procedure described in the Project Quality Assurance Plan on a regular basis to insure required tensions are achieved.

6.3.5. Testing and Inspection

6.3.5.1. After all bolts have been tensioned or torqued; a minimum of 10% shall be tested to verify that the final design tension has been achieved by use of an approved testing procedure.

6.3.5.2. All work shall be constructed, tested and inspected as described in the Project Quality Assurance Plan and as indicated in the design documents.

6.4. Grout

6.4.1. General

6.4.1.1. The grout selected must cure to the required strength as specified in the design documents.

6.4.1.2. All work shall be constructed, tested and inspected as described in the Project Quality Assurance Plan and as indicated in the design documents.

6.4.2. Submittals

6.4.2.1. Manufacturers' product data for grout

6.4.2.2. Grout cube strength test results

6.4.2.3. All completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan, the design documents and Testing and Inspection reports.

6.4.3. Product

6.4.3.1. Non-Shrink Grout: Pre-packaged grout conforming to design documents

6.4.4. Execution

6.4.4.1. Mix, place and cure grout in accordance with manufacturer's instructions

6.4.5. Testing and Inspection

6.4.5.1. Cast grout cubes and perform laboratory strength testing at 3 and 28 days or in accordance with design documents.

6.4.5.2. All other tests and inspections described in the Project Quality Assurance Plan and as indicated in the design documents.

6.5. Miscellaneous Concrete Embeds

6.5.1. General

6.5.1.1. All work shall be constructed, tested and inspected as described in the Project Quality Assurance Plan and as indicated in the design documents.

6.5.2. Submittals

6.5.2.1. Documentation stating that electrical conduit and grounding grid have been installed in accordance with the manufacturer requirements.

6.5.2.2. All completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan and design documents.

6.5.3. Product

6.5.3.1. Electrical Conduit: In accordance with manufacturer requirements.

6.5.3.2. Grounding Grid: In accordance with manufacturer requirements.

6.5.4. Execution

6.5.4.1. Verify the location of miscellaneous concrete embedments and ensure they are properly secured to prevent movement during concrete placement.

6.6. Miscellaneous Submittal Requirements

6.6.1. Documentation from the Structural Engineer of record confirming that they have reviewed the testing and inspection records and that the work was performed in conformance and compliance with the design documents. The review does not relieve the Contractor of the work due to errors contained in those documents.

6.6.2. Submit copies of testing and inspection records

7. Infrastructure Facilities Layout

7.1. Not used

8. Solar Generator Step-up Transformer, Three-Phase Padmount Loop Feed

Note: Engineer of record shall review this specification to identify and report inconsistencies within the specification and areas where the specification may not be compatible with the overall solar facility design.

8.1. Codes and Standards

8.1.1. All transformers shall conform to the applicable standards of ANSI, ASTM, IEEE, NEC, NEMA, and NFPA ll materials and devices shall be in accordance with the applicable requirements of the Federal “Occupational Safety and Health Administration” Standards

8.1.2. In case of conflict between the requirements of the various parts of these documents, the requirements of the different parts shall govern in the following sequence: Mandatory governmental regulations, codes and standards, this Specification and the referenced industry codes and mid standards

8.2. Enclosure Construction

8.2.1. The exterior color of the transformer shall be the manufacturer’s standard color.

8.2.2. The transformer doors shall be equipped to latch in the open position.

8.2.3. Each door shall open 180°

8.2.4. Heavy 18” stainless steel door rods

8.2.5. All compartment door-latching bolts shall be self-aligning, captive, penta-head and be in accordance with Figure 1 of IEEE C57.12.28

8.2.6. The penta-head cylinder and hasp shall have ½ inch (minimum) holes for padlocking.

8.2.7. The transformer connection compartment shall be arranged so that the high-voltage section shall be separated from the low voltage section by a vertical steel barrier.

8.2.8. An automatic pressure-relief valve shall be installed in the low-voltage compartment.

8.2.9. A pressure vacuum gauge shall be located in the low voltage compartment.

8.2.10. A liquid level gauge shall be located in the low voltage compartment.

8.2.11. A dial type thermometer with maximum temperature indicator shall be installed in the low voltage compartment.

8.2.12. A drain valve and sampler shall be installed such that it is enclosed in and accessible by opening an external lock box. The lock box and hasp shall have ½-inch (minimum) holes for padlocking.

8.2.13. The transformer nameplate shall be located on the inside of the low voltage cabinet door and shall contain data listed in Table 7 of IEEE Standard C57.12.00-2010, under Nameplate. The serial number of the transformer shall also be indicated on the low voltage tank wall. The nameplate shall also include the volume of insulating fluid in gallons and the statement “INSULATING FLUID IS NON-PCB CONTAMINATED.” Taps shall be listed in actual voltage rather than percent of nominal. All protective devices, such as fuses and isolation links shall be identified on the nameplate schematic.

8.2.14. All bushings, terminals, and switches shall be identified on the tank wall in yellow stencil or decal.

8.2.15. To preclude exposing internal parts designed to be under oil, the transformer shall be capable of operation without derating when placed on a flat surface up to five degrees out of level in any direction.

8.2.16. The termination cabinets shall be a minimum of 36 inches deep.

8.2.17. A clear barrier on top and front of low voltage circuit breaker.

8.2.18. Dielectric fluid shall be PCB-free mineral oil.

8.2.19. There shall be a minimum of 2 grounding pads in the high voltage compartment and low voltage compartment. Bronze, vice type (Fargo GC-208 or approved equivalent) grounding lugs shall be installed in each ground pad and shall accommodate a 1/0 conductor.

8.2.20. The high voltage bushing pattern shall be, at a minimum, as shown in IEEE C57.12.26 figures 2 and 3.

8.2.21. The low voltage bushing pattern shall be, at a minimum, as shown in IEEE C57.12.26 figures 3 and 4a.

8.2.22. Core ground shall be accessible through a hand hole.

8.3. Service Conditions Class I power transformer

8.3.1. The padmount transformers will be used as Photovoltaic solar inverter step-up transformers in a multi inverter solar facility.

8.3.2. Multiple transformers will be connected in parallel to the same distribution voltage collector circuit and/or branch of the collector circuit.

8.3.3. Approximately 4 MW of Photovoltaic generation will be connected on one circuit.

8.3.4. Design elevation = 1,000 meters a.s.l

8.3.5. Design ambient temperature max = +40°C

8.3.6. Ambient temperature min = -40°C

8.3.7. The transformer shall be connected to the inverter, and other transformers, in such a way that the transformer(s) may be subject to abnormally high voltages associated with an inverter load rejection and other transient conditions. Therefore, the transformer shall be designed to withstand the voltage stress associated with 1.4 times the rated voltage applied to the transformer terminals for 5 seconds.

8.3.8. The transformer will be designed to withstand voltage excursions associated with substation breaker closing.

Table 8.1 Transformer Specifications

Feed configuration	Loop feed
kVA	10% at 25°C greater than the maximum generation level allowed by the inverters.
Phases	3
Frequency	60 Hz
Maximum average temperature rise above ambient	65°C at rated kVA for the combination of connections and taps that gives the highest average temperature rise
Maximum (hottest spot) temperature rise above ambient	80°C at rated kVA for the combination of connections and taps that gives the highest average temperature rise
High voltage	Per One-line or per Engineer of record
Low voltage	XXX grounded Y [Engineer of Record to specify]
High voltage taps	Two full-capacity taps above nominal-rated voltage in 2.5% steps. Two full-capacity taps below nominal-rated voltage in 2.5% steps.
High voltage BIL	xx kV (per site requirements, EOR to specify)
Low voltage BIL	xx kV (per site requirements, EOR to specify)
* Neutral BIL, grounded Y	xx kV
* Neutral BIL, impedance grounded Y	xx kV
Low voltage bushing	Per Engineer of Record
Target impedance	As specified by the Engineer of Record

Losses:	
** No load losses @ 20°C	**
** Load losses @ 85°C	**
High voltage bushings	Six XXX-amp dead break or load break bushing [Engineer of Record to specify]
Low voltage bushings	Engineer of record to specify
Low voltage bushings supports	Engineer of record to specify
	*Engineer of Record is to specify grounded Y or Impedance grounded Y neutral BIL requirements
	**

8.4. Auxiliary Equipment and Accessories

8.4.1. Internal expulsion cartridge fuse x3

8.4.2. Parallel oil-immersed partial range current limiting fuse x6

8.4.3. Hook stick operable, two position, amp rating per EOR, under oil, loop feed switches. Switch positions shall be labeled “open” and “closed.” Switch position labels shall be readable from 2 feet away. (Engineer of Record to specify amp requirements.)

8.4.4. Hook stick operable tap change switch located at an accessible location which does not require reaching behind cables. The tap change switch shall snap into each voltage setting. The switch shall be visible indicating from 2 feet. Provisions, such as a spring loading locking pin or set screw shall be made to assure that accidental operation of the tap changer will not occur.

8.4.5. Low voltage surge arrestor: Ferraz Shawmut surge arrestor or Owner approved equal. The low voltage surge arrestor shall be mounted in an easily viewable and accessible location and shall not be mounted behind cables.

8.4.6. Low voltage power breaker. ABB SACE Emax, or equivalent, as specified by the Engineer of Record.

8.5. Documentation

8.5.1. Factory recommended spare parts list

8.5.2. Shop drawings

8.5.3. Operations and maintenance manual(s)

8.5.4. Certified factory test reports

8.6. Shipment and Storage

8.6.1. Transformer shall be shipped in a manner that they are protected from damage, and with provisions for safely moving them onto and off the shipping vehicle.

9. High Voltage Interconnection (Power Substation) and Transmission

Introduction: It is the intent of this section to provide general specifications for the procurement, installation and testing of a high voltage substation with the goal of interconnecting a large-scale solar facility. The interconnection of such facility consists of building an on-site high voltage substation, typically consisting of a (1) main high voltage Breaker, (1) main GSU (Generation Station Unit) Transformer, and two or more medium voltage vacuum breakers receiving the power coming out of the solar feeders. Up to two solar feeders can be connected to a medium voltage vacuum breaker. Each solar feeder is able to carry up to 20 or 25 MW of solar power. On the high voltage side, typically an H-frame structure is erected to connect an overhead transmission line (exclusive for the solar site), to the Point of Interconnection (POI) approved and indicated by the local Utility. In case the transmission line runs underground, dead-end pole structures are erected.

9.1. General

9.1.1. Section includes general provisions for the electrical Installation.

9.1.2. Related Sections

9.1.2.1. All sections included in this project.

9.1.3. System Description

9.1.3.1. The work covered by this specification shall include furnishing all labor, material, equipment and services to construct and install the complete electrical system as shown on drawings and specifications.

9.1.4. Design Drawings

9.1.4.1. The Engineer of Record drawings shall serve as the working drawings. They indicate the general layout of the complete electrical system.

9.1.4.2. Field verification of scale dimensions on plans is directed since actual locations, distances and levels will be governed by actual field conditions.

9.1.4.3. The Contractor shall also review architectural, structural and mechanical drawings to avert possible installation conflicts. Should drastic change from original plans be necessary to resolve such conflicts, the contractor shall notify the Engineer of Record, and secure written approval and agreement on necessary adjustments before the installation is started.

9.1.4.4. Discrepancies shown on different plans, or between plans and actual field conditions, or between plans and specifications, shall promptly be brought to the attention of the Engineer of Record for a decision.

9.1.4.5. All items not specifically mentioned in the specifications or noted in the drawings, but which are obviously necessary to make a complete working installation shall be included.

9.1.5. Temporary Power

9.1.5.1. The Contractor shall furnish, install, maintain, and remove after construction is completed a temporary power and lighting system.

9.1.6. Safety Precautions

9.1.6.1. The Contractor shall furnish and place proper guards for prevention of accidents.

9.1.6.2. Contractor shall provide and maintain any other construction required to secure safety of life or property, including the maintenance of sufficient lights.

9.1.7. Submittals

9.1.7.1. The Contractor shall submit detailed dimensioned shop drawings covering all items of equipment, data for each type of product used in the project. No equipment should be ordered until these shop drawings and/or data sheets have been approved.

9.1.8. Closeout Submittals

9.1.8.1. The Contractor shall keep a complete set of drawings at the site of work for the express and only purpose of noting thereon on a continuous basis all changes in construction, layout or conduit, ducts, etc., which are affected during construction due to field conditions, change orders, etc.

9.1.8.2. This set of provisional record drawings shall be kept up to date with all changes noted thereon, and these provisional record drawings shall be submitted for the inspection and approval of the Engineer of Record at least five days prior to any partial monthly payment.

9.1.8.3. Upon termination of the work, the Owner shall furnish a complete set of copies, on which the Contractor shall, in a neat and workmanlike manner, make a complete record of all changes and revisions to the original work. These drawings shall be delivered to and be approved by the Engineer before final liquidation of the contract.

9.1.9. Manuals

9.1.9.1. The Contractor shall provide the Owner with four bound copies of Instruction Manuals on the operation and maintenance of each piece of equipment installed, including: inspection, maintenance, cleaning, grounding, precaution and operation.

9.1.9.2. At the time the manuals are given, the Contractor shall supply the Owner with four copies of the equipment manufacturer's recommended spare parts list.

9.1.9.3. The Contractor shall provide four copies of the time current curves of each protective device furnished.

9.1.10. Delivery, Receiving and Storing

9.1.10.1. All electrical materials, equipment and accessories required to complete the work shall be delivered to, received, unloaded and stored by the Contractor until they are installed.

9.1.10.2. Prior to shipment, all items shall be protected or crated to prevent damage during shipment and handling. Wooden covers shall protect equipment flange faces. Contractor shall perform all required uncrating, unpacking, cleaning and inspection prior to installation.

9.1.10.3. All items shall be inspected as soon as they are received to determine if any damage has occurred in transit. Damaged items shall be repaired or replaced immediately to prevent delay in the construction schedule.

9.1.10.4. All items shall be properly protected during all phases of the work. Materials, equipment and accessories, which are not weatherproof, shall be protected against weather damage during storage. The Contractor shall be responsible for the safekeeping of all items during receiving, storing and installation.

9.1.10.5. Defective equipment or equipment damaged in the course of relocation, installation, or test shall be replaced or repaired in a manner meeting with the approval of the Owner.

9.2. Products

9.2.1. Electrical materials shall be new and products of recognized manufacturers and as noted on the drawings and/or stated in these specifications.

9.2.2. It is the intent of these specifications to establish quality standards of materials and equipment installed. Hence, specific items are identified by manufacturer, trade name or catalog designation.

9.2.3. Substitutions

9.2.3.1. Should the Contractor propose to furnish material and equipment other than those specified as permitted by the "similar to" or "approved equal" clauses, he shall submit a written request for any or all substitutions to the Owner representative. Such a request shall be accompanied with complete description (manufacturer, brand name, catalog number, etc.) and technical data for all items.

9.2.3.2. Acceptance or rejection of the proposed substitutions shall be subject to approval of the Owner representative. If requested the Contractor shall submit samples of both the specified and the proposed items for inspection.

9.2.3.3. Contractor shall be responsible for notifying any other Contractor whose work should become affected due to the substitution of a piece of equipment other than that which is incurred by the other trades due to the substitution.

9.2.4. Labor

9.2.4.1. All workmanship shall be first class and performed by persons qualified in this trade.

9.2.4.2. Insofar as is it possible, the Contractor shall keep the same foremen and workmen throughout the project duration.

9.2.5. Supervision

9.2.5.1. During the entire progress of the job, the Contractor shall have a competent experienced engineer and all necessary assistants. This engineer shall not be changed during the progress of the job without the consent of the Owner representative.

9.2.6. Sleeves, Openings, And Inserts

9.2.6.1. The Contractor shall furnish and install all sleeves or openings through floor or walls required for passage of all conduits or ducts installed by him.

9.2.6.2. The Contractor shall furnish and install all inserts and hangers required to support bus ducts, conduits, pull boxes, luminaires, etc.

9.2.6.3. If the sleeves, hangers, inserts, etc. are improperly installed, the Contractor shall do all necessary cutting and patching at this own expense, to rectify the errors.

9.2.7. Cutting and Patching

9.2.7.1. Cutting of walls, partitions, floor and roof that may be necessary for this installation shall be done in a neat workmanlike manner. Openings shall be cut only large enough to facilitate the installation.

9.2.7.2. Cutting of structural members or cutting that in any manner weakens the structure is forbidden.

9.2.7.3. Patching shall be done with the same type of material as was removed. The completed patching work shall restore the surface to its original appearance. Rubble and excess patching material shall be promptly removed from the premises.

9.2.7.4. Patching of waterproofed surfaces shall be done in a manner, which shall render the area completely waterproof.

9.2.8. Excavation and Backfill

9.2.8.1. All excavation trenching and backfilling required for properly installing the electrical duct systems shall be provided as part of the electrical work unless otherwise stated in the specifications or on the drawings.

9.2.8.2. Trenches shall be dug to the proper alignment and required depth only so far in advance of pipe laying as required to permit orderly progress of the work. Trenches shall be only wide enough to permit satisfactory joining of piping.

9.2.8.3. All excavations shall be kept free of water by pumping or other approved means, during progress of the work and until the excavations are backfilled. Backfilling shall be done immediately after the work has been inspected and approved.

9.2.8.4. Where sub-grade soils are unstable and cannot properly support piping, trenches shall be excavated at least six inches deeper than required, backfilled with an approved fill material to the proper elevation and compacted.

9.2.8.5. Special conditions for anchors, supports, thrust blocks, etc., shall be as indicated on the drawings.

9.2.8.6. Backfilling shall not be done until testing has been satisfactorily completed and approved and all concrete appurtenances have been properly cured.

9.2.8.7. Backfill shall be select material, free from rock larger than four inches in diameter and free from deleterious material. The backfill shall be tamped in layers not exceeding six inches in depth and shall be sufficiently damp to permit thorough compaction on each side of the pipe to provide solid support and backing against the external surface, to an elevation of at least 12 inches above the top of the pipe. The balance of the fill shall contain no rock larger than eight inches in its largest dimension and free from deleterious matter. The balance shall be compacted thoroughly by puddling or flooding, or by tamping if the material does not consolidate readily by puddling.

9.2.8.8. All excess excavated material not used for backfill shall be removed from the site.

9.2.9. Field Quality Control

9.2.9.1. All material and workmanship shall be subject to inspection, examination and test by the Owner representative or QAR at any and all times during construction.

9.2.9.2. After the installation is completed, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of these specifications. The test shall be performed in the presence of the Owner representative.

9.2.9.3. The Contractor shall furnish promptly, without additional charge, all reasonable facilities, labor, materials and equipment for the safe and convenient inspection and tests that may be required by the Owner representative.

9.2.9.4. The electrical installation shall meet the approval of the local Power Utility Authority and the Contractor shall furnish a Certificate of this approval.

9.2.10. Cleaning and Painting

0.1.1.13 All equipment, luminaires, conduits, ducts and other exposed work shall be thoroughly cleaned. All plated, polished or painted work shall be bright and clean.

0.1.1.14 All equipment shall have factory standard finish unless otherwise called by technical specification for special treatment. Painting Contractor shall provide other painting.

9.2.11. Guarantee of Work

0.1.1.15 All the work herein specified shall be guaranteed free from labor and material defects for one year after the work is received. The Contractor shall deliver a document covering the terms of this guarantee to the Owner.

9.3. Outdoor Potential Transformer Procurement Specification

9.3.1. General

9.3.1.1. Outdoor inductive type potential transformer (PT), oil insulated (PCB free), of the two-bushing type (full insulation for line-to-line connection). The PT shall be built in accordance with ANSI Standard C57.13-1993 and all applicable NEMA Standards. Manufacturer shall include with proposal mounting layout. The potential transformer shall be supplied with primary terminal connectors suitable for 4/0 stranded conductor. Shall provide two secondary windings (X, Y). The insulator shall include an oil sight glass to see the oil level. The PT's nuts, bolts, and washers shall be made of stainless steel.

9.3.2. Products

Table 9.1 Electrical Characteristics

Item	Description	Requirement
1	System Voltage Line to Line	As indicated on Single Line
2	Insulation class	As indicated on Single Line
3	Basic insulation level	As indicated on Single Line

4	Creepage distance	Based on Standards.
5	Power capacity	As indicated on Single Line
6	Ratio	As indicated on Single Line
7	Accuracy	As indicated on Single Line

9.3.2.1. Construction Requirements

9.3.2.1.1. The transformer shall be constructed for the site environment to where it will be installed. The contractor shall reach out to the owner in order to obtain site environmental conditions. Supporting Pedestal, their attachments and anchorages shall be designed as to withstand wind and seismic forces calculated as per minimum design loads for buildings and other structures ASCE 7.

9.3.2.1.2. Submit all components and anchorage design and drawings for approval.

9.3.3. Execution

9.3.3.1. Routine tests

9.3.3.1.1. Each PT shall receive the following routine test:

- Applied voltage dielectric test between windings and between winding and ground
- Induced Voltage test
- Accuracy test
- Polarity test
- Ratio test
- Power Factor test

9.3.3.1.2. The supplier shall submit the Routine Test reports for each PT to the Owner representative.

9.4. Substation Class Post Insulators

9.4.1. General

9.4.1.1. Section includes outdoor station class post insulators for high voltage systems.

9.4.2. Construction

9.4.2.1. General

9.4.2.1.1. Manufacturers: Those approved by the owner.

9.4.2.1.2. Strength Station Post Insulators:

9.4.2.1.3. Single piece high strength porcelain body with externally attached hardware. Drop forged steel, malleable iron or ductile iron, hot dipped galvanized caps and bases, porcelain caps, hot dipped galvanized bases with interchangeable bolt holes and bolt circle. Provide adapter plates and spacers as required for mounting holes.

9.4.2.1.4. Maximum recommended working load shall be less than forty percent (40%) of the publishing rating under normal operating conditions.

9.4.2.1.5. Voltage rating: as indicated on single line diagrams.

9.4.2.1.6. Finish color shall be Gray 70.

9.4.2.1.7. Acceptable manufacturers: Lapp, Ohio Brass, Joslyn. Loading

- Mounting structure is specified or shown on drawings shall be designed so after the complete equipment is installed the supporting pedestal, their attachments and anchorages shall be designed as to withstand wind and seismic forces calculated as per minimum design loads for buildings and other structures ASCE 7.

9.5. GOAB Switch

9.5.1. General

9.5.1.1. This specification describes Gang Operated Air Break (GOAB) switch for Substation application. The switch shall be furnished with operating mechanism, mounting bolts, terminal lugs, channel bases, insulators, and provisions for mounting key interlocks.

9.5.1.2. The GOAB switch type shall be Single End Break unless specified differently by the owner.

9.5.2. References:

9.5.2.1. All work shall be in accordance with all applicable codes and standards to include, but not limited to, the following:

9.5.2.1.1. The GOAB shall be built following the latest applicable ANSI/IEEE NEMA requirements.

9.5.2.1.2. ASTM Standard and the herein included

9.5.2.1.3. The following standards shall form part of this specification unless otherwise stated:

- ANSI C29.9 Wet-Process Porcelain Insulators
- IEEE C37.30 IEEE Standard Requirements for High- Voltage Switches
- ANSI C37.32 Schedules of Preferred Ratings, Manufacturing Specification, and Application Guide for High Voltage Air Switches
- ANSI C37.34 Test Code for High-Voltage Air Switches
- ASTM 123 Zinc Coating (Hot Dip) on Iron and Steel Hardware
- NEMA SG6 Power Switching Equipment

9.5.3. Products

9.5.3.1. Conducting Parts Characteristics

9.5.3.1.1. Conducting Parts shall be fabricated with high conductivity copper and copper alloy (or bronze) casting parts. The GOAB shall be designed to limit the temperature rise to 30ºC over an ambient of 40ºC (as per NEMA standard). Switch ratings shall be in accordance to single line diagram.

9.5.3.1.2. All jaws contacts shall be silver to copper and designed so that wiping action is provided with a minimum of roughening or wear on the silver surfaces. Wear of contacts shall not result in diminished contact performance due to reduction of contact pressure. The number and size of contact fingers shall be sufficient to ensure adequate transfer of rated current from the blade to the jaw. All contacts shall be self-aligning and self- adjusting and designed to ensure firm positive contact.

9.5.3.1.3. Each switch blade shall conform one solid piece and shall be so assembled that no part can move relative to another. Ends of switch blades shall be completely close except for drain holes. Switch blades shall be high conductivity copper alloy and of tubular construction.

9.5.3.1.4. Terminal pads on each end of the switch shall be located at the same height above the insulator terminal pads shall have flat, machined surfaces. Terminal pads shall have NEMA Standard.

9.5.3.1.5. The contact fingers shall maintain pressure during normal and short circuit operation without back-up springs or other pressure compensating devices. The hinge contact fingers shall be in continuous contact with the switch blade thought the complete opening and closing operation.

9.5.3.1.6. To increase pressure during short circuit conditions contacts shall be high pressure, self-wiping, reverse loop female type.

9.5.3.1.7. Contact surface between jaws (fingers) and blades shall be copper to silver or silver to silver.

9.5.3.2. Switch Base

9.5.3.2.1. Bases shall be constructed with rigid galvanized steel.

9.5.3.2.2. The switch shall have provisions to adjust for installation irregularities during the field.

9.5.3.2.3. To make adjustments, the switch shall include 4 leveling bolts on the base of each insulator.

9.5.3.3. Insulators

9.5.3.3.1. Porcelain, grey, voltage and BIL as indicated on single line diagram.

9.5.3.3.2. Bearings used at the rotating insulator and operating mechanism shall be made with stainless steel balls and races and will be sealed, permanently lubricated to provide maintenance free operation.

9.5.3.4. Operating Mechanism

9.5.3.4.1. The operating mechanism shall be swing handle, worm gear. The operating mechanism shall include outboard bearings, bell cranks, horizontal and vertical operating rods, pipe guides, pipe coupling, ground strap, grounding clamp, arching horn, grounding operator platform and operating handle. Operating mechanism shall include provision for padlocking ½” Ø shackle in the Close and Open positions with Closed and Open indicators.

9.5.3.4.2. The use of worm gear operator transmission will be 4:1 ratio, sealed, maintenance free.

9.5.3.4.3. The operating mechanism shall include auxiliary switch (for remote status indication).

9.5.3.4.4. The auxiliary switch shall be mounted on the vertical operating rod.

9.5.3.4.5. Key interlock system shall be supplied with the associated main breaker.

9.5.3.4.6. Grounding operator platform shall be made of aluminum checkered plate, 36” X 24”.

9.5.3.4.7. The vertical operating rod shall be 1-1/2” Ø, rigid galvanized steel.

9.5.3.5. Connectors

9.5.3.5.1. Terminal connectors shall be furnished with each GOAB switch. The terminal connectors shall be for conductors or tubing with the diameter specified in the drawing or requisition.

9.5.3.6. Grounding Blades

9.5.3.6.1. The grounding blades shall be furnished on the line side of the GOAB switch and shall be gang operated, 3 pole and single throw.

9.5.3.6.2. The operating mechanism of the grounding blades and the associated air disconnect shall be mechanically interlocked.

9.5.3.6.3. The grounding blades shall be pivoted on the structure mounted. Shall be furnished complete with outboard bearing, bell crank, horizontal and vertical operating rods, pipe guides, grounding operator platforms, ground straps, grounding clamp and operating handle, etc. Operating mechanism shall have provisions for padlocking, ½" Ø shackle in the closed and open position. Grounding blades shall be equipped with strap and terminal lug for connecting 4/0 stranded copper grounding conductor.

9.5.3.6.4. Grounding operator platform shall be made of aluminum checkered plate, 36" X 24".

9.5.3.7. Mounting

9.5.3.7.1. The attachment components and anchors shall be stainless steel or other material approved by the Owner. Mounting structure is specified or shown on drawings and shall be designed so after the complete equipment is installed the supporting pedestal, their attachments and anchorages shall be designed as to withstand wind and seismic forces calculated as per minimum design loads for buildings and other structures ASCE 7.

9.5.3.7.2. Submit all components and anchorage design and drawings for approval.

9.5.3.8. Materials and Workmanship

9.5.3.8.1. The equipment shall be new and of standard commercial, first-grade quality as to materials, workmanship, and design, in accordance with the best engineering practice, and shall be such as has been proven to be suitable for the intended purpose. All welding shall be done by welders experienced in the process to be in a manner evidencing good workmanship.

9.5.3.9. Packing and Shipping

9.5.3.9.1. All parts and materials shall be protected with wooden crate, properly sized and fabricated to protect the unit from damage during transportation and subsequent storage. Conducting parts, insulators and base must be supplied fully assembled (per phase) inside wooden crates. Additional materials shall be packed in weatherproof boxes and identified with weatherproof labels.

9.5.3.9.2. All materials, elements, parts and hardware shall be shipped in flatbed trailers and stored in such a way so that they can be unloaded by finger lifts. Deliveries in containers or closed platforms where finger lifts cannot be used will not be accepted.

9.6. Manual Switches

9.6.1. The maximum height to the hook stick connection point shall be 12 ft.

9.7. Lightning Arresters

9.7.1. General

9.7.1.1. This specification covers the minimum requirements for the design, manufacturing and testing of metal oxide, outdoor, station class lightning arresters. The lightning arrester shall meet or exceed the requirements and comply with the test established in the latest applicable ANSI and NEMA Standards.

9.7.1.2. The equipment described in the specification requires qualification.

9.7.2. Products

9.7.2.1. Construction

9.7.2.1.1. The housing shall be constructed of polymeric material (silicon rubber) with glass reinforced epoxy collar. It shall maintain a clean and moisture free atmosphere for its internal components.

9.7.2.1.2. The Manufacturer shall stamp the arrester nameplate with the factory measure dielectric-loss (watt loss) for each unit supplied. The plate shall be made of aluminum or suitable for coastal environment.

9.7.2.1.3. The lightning arresters shall have the minimum units per stack. The manufacturer shall specify number of units per stack, mounting dimensions, size, weight and electrical characteristics.

9.7.2.1.4. Each arrester shall be provided with terminals for connecting line and ground conductors.

9.7.2.1.5. Arresters shall be designed for application of 60 Hz and average daily temperature as indicated on site environmental conditions.

9.7.3. Loading

9.7.3.1. The attachment components and anchors shall be stainless steel or other material approved by the owner. Mounting structure is specified or shown on drawings shall be designed so after the complete equipment is installed supporting pedestal, their attachments and anchorages shall be designed as to withstand wind and seismic forces calculated as per minimum design loads for buildings and other structures ASCE 7.

9.7.3.2. Submit all components and anchorage design and drawings for approval.

9.8. Liquid-Filled Power Transformers (GSU) Procurement Specification

9.8.1. General

9.8.1.1. This specification covers the main power transformers GSU. Transformers shall be designed for continuous duty over a minimum design life of 30 years at full rated load in any mode (self-cooled or under forced cooling).

9.8.2. Attached Data Sheets

9.8.2.1. The appended project specific data sheet forms an integral part of this specification.

9.8.3. Applicable Standards

9.8.3.1. Unless otherwise specified, the transformer and all associated equipment shall conform to the latest revision of all applicable standards including but not limited to the standards listed in this section.

9.8.3.2. American National Standards Institute (ANSI)

9.8.3.2.1. C57.12.10 - Safety Requirements: 230 KV and Below, 833/958 Through 8333/10,417 KVA Single-Phase, and 750/862 Through 60,000/80,000/100,000 KVA Three-Phase Without Load Tap Changing; and 3750/4687 Through 60,000/80,000/100,000 KVA with Load Tap Changing

9.8.3.2.2. C57.12.70 - Terminal Markings and Connections for Distribution and Power Transformers

9.8.3.2.3. C57.12.80 - Standard Terminology for Distribution and Power Transformers

9.8.3.2.4. C57.12.90 - Standard Test Code for Liquid-Immersed Distribution, Power, and regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers

9.8.3.2.5. C57.13 - Standard Requirements for Instrument Transformers

9.8.3.2.6. C57.19.00 - Standard General Requirements and Test Code for Outdoor Power Apparatus Bushings

9.8.3.2.7. C57.19.01 - Standard Performance Characteristics and Dimensions for Outdoor Power Apparatus Bushings

9.8.3.2.8. C57.91 - Guide for Loading Transformers

9.8.3.2.9. C57.93 - Guide for Installation of Liquid-immersed Power Transformers

9.8.3.2.10. C57.98 - Guide for Transformer Impulse Tests

9.8.3.2.11. C57.100 - Standard Test Procedure for Thermal Evaluation of Liquid- Immersed Distribution & Power Transformers

9.8.3.2.12. C57.109 - Guide for Liquid-Immersed Transformer Through-Fault Current Duration

9.8.3.2.13. C57.113 - Guide for Partial Discharge Measurement in Liquid-Filled Power Transformers and Shunt Reactors

9.8.3.2.14. C57.115 - IEEE Guide for loading Mineral-Oil Immersed Power Transformers Rated in excess of 100 MVA (650 C Winding Rise)

9.8.3.2.15. C57.120 - Loss Evaluation Guide for Power Transformers and Reactors.

9.8.3.2.16. C57.131 - Standard Requirements for Load Tap Changers

9.8.3.2.17. C62.11 - Standard for Metal-Oxide Surge Arresters for AC Power Circuits (> 1kV)

9.8.3.2.18. C62.22 - Guide for the Application of Metal-Oxide Surge Arresters for Alternating

9.8.3.2.19. Current Systems

9.8.3.2.20. Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.

9.8.3.3. American Society for Testing and Maintenance (ASTM)

9.8.3.3.1. D3487 - Standard Specification for Mineral Insulating Oil for Use in Electrical Apparatus

9.8.3.4. National Electrical Manufacturers Association (NEMA)

9.8.3.4.1. TR1 - Transformers, Regulators, and Reactors

9.8.3.4.2. ICS 1 - General Standards for Industrial Controls and Systems

9.8.3.4.3. ICS 2 - General Standards for Industrial Control Devices, Controllers, and Assemblies

9.8.3.4.4. ICS 6 - Enclosures for Industrial Controls and Systems

9.8.3.4.5. MG1 - Motors and Generators

9.8.3.5. The Bidder shall clearly identify any deviation from the specification, accompanying data sheet or an applicable ANSI/IEEE, NEMA or CSA standard in the Bid. If such a statement is not provided, it will be considered as the Bidder’s confirmation of total compliance with the specification and standards.

9.8.4. Construction

9.8.4.1. Core and Coil Design

9.8.4.1.1. The transformer core shall be of circular (non-rectangular) design. However, a wound core is not necessary. The coils shall be copper. The core and coil designs shall be standard, proven designs for the manufacturer.

9.8.4.1.2. The manufacturer shall be prepared to submit at the Owner's request, a list of at least 10 installations of similar size, voltage configuration and core and coil design that have been operating satisfactorily within the continental United States for a minimum of 5 years.

9.8.4.1.3. Core ground bushing shall be accessible without opening the tank.

9.8.4.2. Oil Preservation System

9.8.4.2.1. The transformer shall be provided with a conservator type oil preservation system. The conservator shall be provided with a membrane system to minimize potential exposure of the oil to moisture.

9.8.4.2.2. As an option, the manufacturer may provide a regulated nitrogen blanket system only if this system is provided with a Nitrogen generation system that shall operate to fully protect the oil without the changing of Nitrogen bottles as a maintenance procedure.

9.8.4.3. Impedance

9.8.4.3.1. Unless specified otherwise in the accompanying data sheets, the transformer shall be designed with standard base impedance as specified by ANSI C57.12.

9.8.4.4. Limitation of Transformer Capacity

9.8.4.4.1. Nothing in this specification shall be construed as permitting any component (main or auxiliary) of the transformer and associated equipment to limit the use and rating of the transformer to values below those permitted by ANSI/IEEE/CSA standards. For example, bushings, C.T.'s (including secondary windings, etc.), shall not limit the overloading capability of the transformer and shall permit safe overload operation of the transformer per ANSI C57.92 and IEEE C57.115.

9.8.4.5. Instrument Transformers

9.8.4.5.1. Bushing CTs shall be provided per the data sheet.

9.8.4.5.2. The CT secondary resistance shall not exceed 0.0025 Ohms per turn.

9.8.4.6. Surge Arresters

9.8.4.6.1. The transformer shall be equipped with station class surge arresters for all windings which have bushings brought out. These arresters shall be provided with brackets for mounting directly to the transformer tank.

9.8.4.6.2. The arresters shall be selected by the transformer manufacturer such that they are suitable for both the system TOV and each winding BIL (lowest BIL if the winding has graded insulation).

9.8.4.6.3. The Bidder shall furnish the maximum MCOV that can provide an 80% protective margin for the lowest BIL of each winding and shall furnish calculations establishing the adequacy of the MCOV and Discharge Voltage chosen by the Bidder.

9.8.4.6.4. Each arrester shall be supplied with a terminal cap to accommodate a standard NEMA four-hole terminal conductor.

9.8.4.7. Bushings

9.8.4.7.1. All bushings with rated voltage less than or equal to 35kV shall be ANSI 70 porcelain and shall be suitable for hot collar testing.

9.8.4.7.2. All bushings of rated voltage greater than 35kV shall be ANSI 70 porcelain, oil filled, draw lead condenser type bushings with a capacitance tap and weather tight plugs to cover the probe test connection point when not in use.

9.8.4.7.3. Bushings shall have bronze threaded studs. Stud connectors shall be furnished by Contractor.

9.8.5. Grounding

9.8.5.1. Provisions shall be made for the neutral ground lead (grounded-wye applications) and for the surge arrester ground lead consisting of brackets, welded to the transformer, at no more than 3'-0" spacing, beginning at a point 1'-0" above the transformer base and ending at a point 1'-0" below the transformer cover. Brackets shall have (1) 9/16" diameter hole for termination of grounding equipment. The holes shall be aligned vertically.

9.8.5.2. Stainless steel grounding pads shall be provided on all 4 corners of the tank.

9.8.6. Control Cabinet and Control Wiring

9.8.6.1. The transformer shall be equipped with a NEMA 4 control cabinet. All customer connections to transformer control and auxiliary power devices shall be via molded terminal blocks (GE EB-25 or equal) in the control cabinet.

9.8.6.2. All Owner connections to current transformers shall be via shorting type molded terminal blocks (GE EB-27 or equal) in the control box. The control cabinet shall be equipped with thermostatically controlled heaters to prevent condensation from accumulating inside.

9.8.6.3. Terminal blocks for control wiring, where applicable, shall be 12-point, 600-volt, 30 amperes equipped with strap screw contacts and a white marking strip. All conductors shall have a permanently affixed identification band on each end that clearly identifies the conductor with its representation on the associated schematic and wiring diagrams.

9.8.6.4. A door operated light shall be provided.

9.8.6.5. The control cabinet shall have hinged doors with three-point latching system and mechanical stops to allow doors to remain open when necessary and mounted with anti-vibration pads. All external circuits shall enter the bottom of the cabinet through conduit. The cabinet shall be provided with a gasketed removable blank bottom plate that can be drilled or punched in the field for entry of the conduits.

9.8.6.6. The Control Cabinet shall be provided ground bus and grounded via minimum 4/0 copper conductor to tank grounding pad. All hinged doors and panels shall be electrically bonded to the cabinet using flexible braided conductors.

9.8.6.7. All openings shall be equipped with fine mesh filters and stainless steel rodent/insect screens.

9.8.6.8. A storage holder for the transformer drawings shall be provided on the inside of the cabinet door.

9.8.6.9. One (1) 120V AC, 20 ampere, GFI single phase duplex receptacle shall be provided. An additional 120V AC, duplex receptacle shall also be provided.

9.8.6.10. The control circuit contacts and associated equipment that are meant/specified for use in

9.8.6.11. DC circuits shall be suitable for operation at 125 Volts DC.

9.8.6.12. Galvanized rigid metal conduit or galvanized intermediate metal conduit shall be used for all control and other low voltage wiring whenever such wiring is located outside of cabinets. Cable having all heat and light stabilized materials, moisture and heat resistant or wires installed in liquid tight conduit will be permitted between the raceway and a device. All control wiring inside the control cabinet/s shall be installed inside plastic wire way with removable cover.

9.8.6.13. All control wiring shall be minimum 12 AWG except for C.T. circuits which shall be 10 AWG Wire shall be stranded copper with synthetic insulation, rated at 600 volt and 1050 C minimum. No more than two wires shall be terminated at any one terminal point. Insulation compound shall be flame retardant, oil and moisture retardant, having physical and electric properties appropriate for the application.

9.8.6.14. Control and power wiring shall be terminated with heavy duty crimp type ring tongue terminals with an insulating sleeve.

9.8.6.15. All electrical devices, including fans, control relays, alarm/trip contacts, current transformer secondary, etc., which mount on or in the transformer shall be factory-wired complete to and within the below named devices and terminals so that the only field connections necessary for operation shall be the main auxiliary power supply conductors for the fans and auxiliary equipment and the attachment of incoming control conductors and C.T. leads to the terminals. There shall be adequate room inside the control cabinet for connection of all interconnecting wiring without crowding. The Bidder shall provide all wiring necessary for all equipment specified and wiring for future equipment where such wiring is specified.

9.8.7. Cooling System

9.8.7.1. The transformer shall be equipped with a forced air cooling system consistent with the data sheet. The system shall consist of 2 sets of fans, the first of which shall increase the transformer’s output rating to 133% of self-cooled, the second of which shall increase the transformer’s output rating to 167% of self-cooled.

9.8.7.2. The cooling groups shall be connected to operate as independent groups through a manually operated selector switch that changes the order in which the groups are energized so operating time can be equalized by periodic operation of the switch. Valves shall be provided for each cooling group’s radiators so each may be removed for maintenance without de-energizing the transformer.

9.8.7.3. Tank and radiators shall be designed for full vacuum.

9.8.7.4. Cooling fan motors shall be rated for the voltage indicated in the accompanying data sheet and shall be rated for 60 Hz and Class F insulated with Class B temperature rise.

9.8.7.5. Fan Blades shall be one piece and cast of an alloy that requires no painting. Fans shall have “OSHA fan Guards”.

9.8.8. Protection and Monitoring Devices

9.8.8.1. Sudden pressure rise device (63SPR) with seal-in relay (63SPR-X) having 2 alarm and 2 trip contacts

9.8.8.2. Winding temperature thermometer (49T) with alarm and trip contacts. Hottest spot winding temperature detector/indicator shall be furnished with separate relay/s for each stage of forced cooling. The relay/s shall control the fans. The winding temperature detection system shall consist of a low voltage current transformer, shunt, heating coil and detector bulb. Construction shall be per ANSI C57.12.10.

9.8.8.3. Oil temperature thermometer (26Q) with alarm and trip contacts

9.8.8.4. Oil level device (71Q) with alarm and trip contacts

9.8.8.5. Tank pressure relief device (63PR) with alarm contacts

9.8.8.6. Tank oil preservation system high / low pressure device (63VP) with high and low pressure alarm contacts

9.8.8.7. Fan power under voltage relays with alarm contacts

9.8.8.8. All gauges shall be visible and readable completely from the ground. All gauges with re- settable pointers shall be mounted 5'+/-6" above the transformer base to permit resetting from the ground. Level gauges shall provide a visual indication of liquid level and shall have two sets of electrical contacts, one of which shall close at high level and one shall close at low level. Construction and installation shall conform to ANSI C57.12. Pressure – vacuum gauges shall include a pressure test connection (air test valve).

9.8.8.9. Buchholz relays with alarm and trip contacts shall be provided (minimum 2 of each).

9.8.9. Welding

9.8.9.1. Welding procedures and welders shall be qualified in accordance with ASME Section IX and AWS D1.1 certification for structural (non-pressure) boundary welds. Contractor shall prepare and maintain on file at the manufactures plant the following documents for Owner review:

9.8.9.1.1. Welding and Repair Procedure

9.8.9.1.2. Cleaning and Painting Procedure

9.8.9.1.3. Shipping Preparations and Shipping Procedure

9.8.10. Accessories

9.8.10.1. Lifting lugs and jacking pads sized for the full-assembled weight of the transformer filled with oil

9.8.10.2. Detachable radiators with sealing valves on the main tank

9.8.10.3. Mounting brackets for HV and LV surge arresters

9.8.10.4. Drain / sampling valve

9.8.10.5. Stainless steel nameplates per IEEE C57.12.00

9.8.11. Color

9.8.11.1. The transformer shall be painted ANSI 61 or 70 gray.

9.8.12. Shipping

9.8.12.1. The transformer shall be shipped FOB job site.

9.8.12.2. The transformer shall be free of rust, scale, manufacturing residue and foreign material to the extent that it can be put into operation without further cleaning.

9.8.12.3. The transformer shall be shipped without oil and with radiators and bushings removed.

9.8.12.4. Openings shall be securely sealed against the entrance of moisture and foreign material. The Contractor shall furnish the oil in a tanker truck at the job site.

9.8.12.5. If the transformer is to be shipped without oil, it shall be filled with dry air. The dew point shall be measured and recorded prior to shipment.

9.8.12.6. Machine-finished or bright surfaces shall be coated with a suitable corrosion-preventative compound and suitably wrapped or otherwise protected against shipping damage.

9.8.12.7. Contractor shall pay attention to the proper packaging and bracing of the equipment to ensure its safe arrival at the job site. Precautions required for handling and storing the equipment shall be clearly indicated on the outside of the containers.

9.8.12.8. Contractor shall be responsible for equipment damage due to improper preparation for shipment and shall repair or replace such damaged equipment expeditiously at their expense.

9.8.12.9. The transformer shall be properly prepared for shipment and shall be fitted with an impact recorder capable of recording X, Y and Z axes.

9.8.13. Optional Prices

9.8.13.1. The supplier shall quote optional prices for the following:

9.8.13.2. Unload the unit onto the Owner provided pad

9.8.13.3. Assembly, oil fill, and test the unit

9.8.14. Factory Testing and Inspection

9.8.14.1. Each unit provide per this specification shall have all factory tests designated as “Routine” in Table 17 of ANSI / IEEE C57.12.00. Certified reports of these tests shall be provided to the Owner immediately upon completion of factory testing, to be no later than the shipping date of the transformer. In addition, the Contractor shall be prepared to produce upon request certified reports of any tests identified by Table 17 of ANSI / IEEE C57.12.00 as design tests or type tests.

9.8.14.2. The Owner reserves the right to inspect the unit at the factory and witness all factory testing at no additional cost other than the travel and local room / board expenses for the Owner’s designated representative(s). The Contractor must notify the Owner at least 3 weeks prior to the commencement factory testing and within 1 week, the Owner shall confirm that they will either witness the testing or waive the requirement for inspection / witness test.

9.8.14.3. The Owner reserves the right to perform tests at his own expense to prove compliance with this Specification. If, during a test performed by the Owner, the equipment fails as a result of design or fabrication error, or for any other cause which is the responsibility of the Contractor, the Contractor shall determine the cause of failure and resubmit acceptable proof of performance. The Contractor shall be charged for all subsequent modifications and tests made for acceptance of the equipment.

9.8.15. Loss Evaluation

9.8.15.1. If called for on the data sheets accompanying this specification, the supplier shall provide guaranteed loss values at no-load and load levels as defined by ANSI C57.120 with their proposal. The evaluation factors are defined on the data sheets accompanying this specification.

9.8.15.2. If a loss evaluation is called for, the evaluation shall be performed by the Owner. During factory testing, the transformer losses will be measured per ANSI / IEEE standards; if the losses exceed the guaranteed values then a loss payment shall be calculated using the evaluation factors listed on the data sheets. The loss payment shall be reduced from the amount of the payment from the Owner to the Contractor for the transformer.

9.8.16. Warranty

9.8.16.1. Transformer performance guarantees shall be provided on the following:

9.8.16.2. No Load losses (nominal tap)

9.8.16.3. Full load losses (nominal tap)

9.8.16.4. No PCB (Polychlorinated Biphenyl) content of insulating liquid (to be clearly stated on name plate).

9.8.16.5. The Contractor shall warrant the transformer specified herein to be free from defects in design, materials, and workmanship. The warranty shall cover all expenses to repair or replace all defective portions of the transformer as well as any other components of the transformer that are damaged by failures caused by defective portions of the transformer.

9.8.16.6. In the event that the transformer must be removed from the project site for repairs, then Contractor shall be responsible for all costs to remove the transformer from the site, transport it to the repair facility. After repairs, the Contractor shall, at its own expense, return the transformer to the job site, and reinstall it in its operating position. In no event shall the warranty for the transformer specified herein be for a period of less than 12 months after energization or 18 months after shipment, whichever is shorter. If the Contractor’s standard warranty is less than 5 years, the Contractor shall quote an option to extend the warranty to 5 years.

9.8.17. Drawings and Manuals

9.8.17.1. The Contractor shall supply drawings to the Owner in electronic format for approval.

9.8.17.2. Approval drawings may be provided either in AutoCAD dwg format or Adobe PDF format.

9.8.17.3. Each document shall identify, near the title block, Owner’s specification number, project name, and applicable equipment tag number.

9.8.17.4. At least 4 weeks prior to shipment of the transformer, the Contractor shall provide certified drawings to the Owner in AutoCAD dwg format. At least one complete paper copy of all certified drawings shall be shipped with each transformer.

9.8.17.5. The Contractor shall supply 6 copies of complete operating and maintenance manuals that are specific to the unit being supplied. If the Contractor must supply generic sections of the manual, irrelevant sections of the manual shall be clearly identified as such.

9.8.17.6. All drawings and Manuals shall pertain specifically to the transformer being supplied and shall be in English.

9.8.17.7. Dimensions shown on all drawings and documents shall be in Imperial Units.

9.8.17.8. Outline drawings shall indicate the center of gravity and structural loading requirements.

9.8.18. Quality Control

9.8.18.1. The Contractor shall provide project specific quality control plan to control the quality of the items and services to meet the requirements of the specification, referenced codes and standards and other contract documents. Contractor- furnished materials, parts, components, services and associated documentation are subject to review by the Owner. Contractor shall perform quality control and inspection during assembly.

10. Data Sheet

Project			**Date**	
Transformer #	T1			
Main Transformer Ratings				
Transformer Continuous MVA (ONAN/ONAF/ONAF)	XXX/XXX/XXX/		2-Winding or 3-Winding Transformer	2
Transformer Rated Rise Temp (Degrees C)	65 ℃		Nominal H-X Imdedance - % on ONAN Basis	8.5% (typical)
Windings and Bushings				
HV Winding Connection (Delta or Grounded Wye)	As per single-line diagram		HV Winding Nominal Voltage (kV)	As per single-line diagram
HV Winding BIL (kV)	As per single-line diagram		HV Bushing Type	Oil-filled w/ Capacitance
HV Bushing	Cover			
XV Continuous MVA (OA/FA/FA/)	Same as Overall Transformer Rating		XV Winding Connection (Delta or Grounded Wye)	As per single-line diagram
XV Winding Nominal Voltage (kV)	As per single-line diagram		XV Winding BIL (kV)	As per single-line diagram
XV Bushing Type	Bulk Porcelain		XV Bushing BIL (kV)	As per single-line diagram
Creepage Distance (Std or Extended)	Standard		If Extended Creepage, Specify Distance	N/A
TV Windings Required	Yes		TV Winding Function	
TV Winding Rated MVA (ONAN/ONAF/ONAF)	35% of Transformer ONAN Rating		TV Winding Nominal Voltage (kV)	13.8
TV Winding Configuration	Delta		TV Winding BIL (kV)	110
TV Winding Broken Delta with 2 – Bushings Brought Out and Link Bar to Complete Delta Across Bushings?	N/A		TV Winding Embedded?	N/A
Bushing Current Transformers				
HV Bushings CTs / Phase	As per single-line diagram		XV Bushings CTs / Phase	As per single-line diagram
HV Bushing CTs	As per single-line diagram		SV Bushing CTs – Top	As per single-line diagram
HVN Bushing CT Qty	As per single-line diagram		XVN Bushing CT Qty	As per single-line diagram
HVN Bushing CT	As per single-line diagram		XVN Bushing CT	As per single-line diagram
TV Bushings required	0		TV Bushing Type / Rating	N/A
TV Bushing CTs				
Tap Changing Equipment				
Automatic LTC Required	Y		LTC Location	Control Board
LTC Range	As per LTC manufacturer		LTC # of Steps	As per LTC manufacturer
LTC Control			LTC Remote Position Indication	Y
DETC Required	Y		DETC Location	HV
DETC Taps Above Normal	2 x 2.5% FCAN		DETC Taps Below Normal	2 x 2.5% FCBN
Surge Arresters				

HV SA Type	Gapless Station Class		HV SA MCOV Rating	As per single-line diagram
XV SA Type	Gapless Station Class		XV SA MCOV Rating	As per single-line diagram
Loss Evaluation Factors – All Loss Evaluations to be Performed per the Methodology of the Latest Version of ANSI C57.120.				
Loss Evaluation Required	Y		No-Load Loss ($ / kW)	
			Full Load-Loss ($ / kW)	
Additional Requirements				

11. High Voltage SF6-Insulated Circuit Breaker Procurement Specification

11.1. General

11.1.1. Summary

11.1.1.1. Section includes high voltage outdoor, dead tank, low pressure SF6-insulated circuit breaker and associated equipment in freestanding cubicle.

11.1.2. References

11.1.2.1. All work shall be in accordance with all applicable codes and standards to include, but not limited to, the following:

11.1.2.2. NEC – National Electrical Code

11.1.2.3. OSHA – Occupational Safety and Health Act

11.1.2.4. UL – Underwriters Laboratories

11.1.2.5. ANSI – American National Standards Institute

11.1.2.6. NEMA – National Electric Manufacturers Association

11.1.2.7. NETA – International Electrical Testing Association

11.1.2.8. IEC – International Electro technical Commission

11.1.2.9. IEEE – Institute of Electrical and Electronic Engineers

11.1.3. Submittals

11.1.3.1. Shop Drawings: Indicate outline dimensions, enclosure construction, lifting and supporting points, anchor bolt hole locations and recommended minimum bolt size, ground lug location, weight center of gravity, shipping weights, electrical rating, schematic and point to point wiring diagrams. Diagrams and breaker drawings shall be provided in AUTOCAD format in addition to the hard copies.

11.1.3.2. Project Record Documents: submit data for components and accessories.

11.1.3.3. Test Reports: Indicate procedures and results for specified factory and field testing and inspection.

11.1.3.4. Installation Instructions: Submit manufacturer's installation

11.1.4. Closeout Submittals

11.1.4.1. Project Record Documents: Include copy of manufacturer's certified drawings.

11.1.4.2. Factory Test Reports: Manufacturer shall submit certified test reports of production tests as soon as the tests are completed satisfactorily. The following factory tests shall be made on the circuit breaker:

- 11.1.4.2.1. Tests in accordance with ANSI C37.09, including a 60 Hz AC HIPOT completely assembled 3-pole breaker.
- 11.1.4.2.2. A complete wiring and control circuit tests and checks with complete verification of all circuits.

11.1.4.3. Operation and Maintenance Data: Submit operating instructions for manually and electrically opening and closing switches, and include instructions for contact replacements, switch adjustment, and lubrication.

11.1.4.4. Spare Parts: Provide spare parts list, including parts location and diagram or drawing.

11.1.5. Qualifications

11.1.5.1. Manufacturer specializing in manufacturing products specified in this section with a minimum of three years of experience.

11.1.5.2. Testing agency specializing in testing products specified in this section with a minimum of three years of experience.

11.1.6. Delivery, Storage and Handling

11.1.6.1. Manufacturer shall be solely responsible for the adequacy of the preparation for shipment of materials.

11.1.6.2. The breaker shall be shipped fully assembled except extension legs. The breaker shall have at least 5 psig SF6 gas during shipment. Owner does not have to evacuate at site during commissioning of the breaker. The Contractor shall supply SF6 gas to top it off at site.

11.1.6.3. Accept circuit breaker on site. Inspect for damage.

11.1.6.4. Lift only using lugs provided. Handle carefully to avoid damage to internal components, enclosure and finish.

11.1.6.5. Protect products from weather and moisture by covering with plastic or canvas and by maintaining heating within enclosure.

11.1.6.6. The breaker shall be delivered with the bushing terminals protected with conducting grease. Sun resistant plastic material shall be installed on factory to protect the terminals and the bushing (down to CT's) for prolonged outdoor storage.

11.1.6.7. On site Owner training shall be provided on the purchase order.

11.1.7. Maintenance Materials

11.1.7.1. Furnish a complete set of special maintenance tools, spare parts and accessories as required, including but not limited to the following:

11.1.7.1.1. SF6 Gas Bottle fully charged.

11.1.7.1.2. SF6 Gas Leakage Detector.

11.1.7.1.3. SF6 Gas Filling Device (complete with vacuum pump, if required).

11.1.7.1.4. Moisture Detector.

11.1.7.1.5. High Voltage and current Test adapter.

11.1.7.1.6. Two (2) Sets of Gaskets.

11.1.7.1.7. One (1) Spare Bushing.

11.1.7.2. The tools shall be new and engraved with the purchase order number and equipment number when unique only to one component.

11.1.8. Testing

11.1.8.1. The Contractor shall submit factory performed time travel test and graphic records for individual breakers. The manufacturer shall also provide the expected values, maximum and minimum limits, acceptable for the following tests:

11.1.8.1.1. Main contact opening time measured from test initiation.

11.1.8.1.2. Delta main contact opening time within the breaker (open- contact synchronization).

11.1.8.1.3. Open and close over-travel.

11.1.8.1.4. Open and close rebound.

11.1.8.1.5. Main contact closing time measured from test initiation (contact make).

11.1.8.1.6. Delta main contact closing time within the breaker (close-contact synchronization).

11.1.8.1.7. Contact wipe.

11.1.8.1.8. Total travel (stroke).

11.1.8.1.9. Open and close velocity.

11.1.8.1.10. Reference points for Zone 1 velocity.

11.1.8.1.11. 1 Reference points for Zone 2, if available.

11.1.8.1.12. 1 Trip free dwell time within a phase.

11.1.8.1.13. 1 Trip free dwell time within the breaker.

11.1.8.1.14. 1 Trip free main contact opening time measured from test initiation.

11.1.8.1.15. 1 Reclose dead time within a phase.

11.1.8.1.16.1 Reclose dead time within the breaker.

11.1.8.1.17.1 Main contact reclosing time measured from test initiation.

11.1.8.1.18.1 Delta main contact reclosing time within the breaker.

11.1.8.1.19.1 Open current.

11.1.8.1.20.20 Close current.

11.1.9. Warranty

11.1.9.1. Provide manufacturer’s standard warranty and indicate duration of this warranty.

11.2. Products

11.2.1. General

11.2.1.1. Product Description: Sulphur hexafluoride (SF6) gas-insulated circuit breaker and associated equipment for outdoor installation. The circuit breaker shall be completely factory assembled.

11.2.1.2. Except as otherwise stated herein, all equipment noted in this Section shall comply with the latest applicable codes and standards of the International Electrotechnical Commission (IEC) and ANSI standards as far as applicable. As a minimum the following individual Codes and Standards shall apply:

a. IEC 56-4 – High Voltage Alternating Current Circuit Breakers.

b. IEC 129 – Alternating Current Disconnectors and Earthing Switches.

11.2.1.3. Manufacturers: ABB, SIEMENS, AEG, or equivalent approved by Owner

11.2.1.4. The circuit breaker shall be constructed for the outdoor site conditions where it will be installed. Breakers supporting frames, their attachments and anchorages shall be designed as to withstand wind and seismic forces calculated as per minimum design loads for buildings and other structures.

11.2.1.5. Submit all components and anchorage design and drawings for approval.

11.2.2. Ratings

11.2.2.1. The Circuit Breaker and associated equipment shall comply with the following requirements or ratings:

11.2.2.1.1. Operating Voltage (RMS KV): as indicated on single line KV

11.2.2.1.2. Rated frequency: 60 Hz

11.2.2.1.3. Current Rating: as indicated on single line.

11.2.2.1.4. Continuous: As indicated on single line.

11.2.2.1.5. Minimum Symmetrical Interrupting Capacity: As indicated on single line.

11.2.2.1.6. Close and Latching Capability: As suggested by manufacturer.

11.2.2.1.7. Insulation Level: as indicated on single line.

11.2.2.1.8. Bushings Basic Impulse Level: as indicated on ingle line.

11.2.2.1.9. Low Frequency Withstand: as indicated on BIL tables.

11.2.2.1.10. Rated Full Wave Impulse Withstand Peak Voltage: as indicated on BIL Tables.

11.2.2.1.11. Operating Voltages: as indicated on single line.

11.2.2.1.12. Closing: 125 Vdc.

11.2.2.1.13. Tripping: 125 Vdc.

11.2.2.1.14. Auxiliary Power Voltage: 120/240 Vac, 1ø, 60 Hz.

11.2.2.1.15. Rated Voltage Range Factor (K): 1

11.2.2.1.16. Rated Permissible Tripping Delay Time (seconds): 1

11.2.2.1.17. Minimum Creepage Distance of Bushings (inches): Required as per maximum operating voltage.

11.2.2.1.18. Ambient Temperature: as indicated by the site environmental conditions.

11.2.3. Circuit Breaker Control

11.2.3.1. Trip Circuit Requirements:

11.2.3.1.1. The breaker shall be furnished with two trip coils.

11.2.3.1.2. Fused disconnect switches or molded case circuit breakers shall be provided for the trip circuits.

11.2.3.1.3. Trip circuit operating voltage shall be 125 Vdc. Trip circuits shall operate properly within a range of 70 to 140 Vdc as measured at the circuit breaker.

11.2.3.2. Closing Circuit Requirements:

11.2.3.2.1. A fused disconnect switch or molded case circuit breaker shall be provided for the closing circuit.

11.2.3.2.2. Closing circuit operating voltage shall be 125 Vdc. Closing circuit shall operate properly within a range of 90 to 140 Vdc as measured at the circuit breaker.

11.2.3.3. Breaker Wiring:

11.2.3.3.1. All control devices and alarms shall be connected to terminal blocks located in the breaker control cabinet.

11.2.3.3.2. Current transformer leads shall be connected to short circuiting type terminal blocks located in the breaker control cabinet. The short-circuiting strips of these blocks shall be grounded. All current transformer leads shall be #12 AWG.

11.2.3.3.3. All terminal blocks shall have a screw and all wiring terminations shall be made using ring tongue connectors.

11.2.3.3.4. All terminal blocks shall be adequate to receive #10 AWG wire control cable terminals.

11.2.3.3.5. All control wiring shall be #14 AWG minimum type SIS.

11.2.3.3.6. Legible sleeve type wire markers shall be provided at each end of wires over six inches in length.

11.2.3.4. Auxiliary Switches:

11.2.3.4.1. Provide multi-contact auxiliary switches.

11.2.3.4.2. Ten (10) contacts type A and ten (10) contacts type B shall be provided in addition to those normally provided for the circuit breaker operation. Type A means normally open, Type B means normally closed.

11.2.3.5. Trip and Close Devices:

11.2.3.5.1. A local trip and close station shall be provided in the breaker control cabinet. The trip button shall include provisions at a terminal block for connections to block the automatic reclosing sequence.

11.2.3.5.2. The breaker shall be equipped with a position indicator in the cabinet which is visible from the outside of the breaker. Indications of OPEN/CLOSE shall be green-open and red-closed.

11.2.3.5.3. The breaker shall have a mechanical operation counter which is visible from the outside of the cabinet.

11.2.3.5.4. A manual trip device shall be furnished, accessible from the control cabinet. Also, an auxiliary electrical contact shall be included in the close circuit to prevent closing until manually reset. The manual trip device shall not require an external power source to trip the circuit breaker. The trip device shall trip all three poles simultaneously.

11.2.3.5.5. The circuit breaker’s trip-1, trip-2 and close control schemes shall have provisions to be wired by the Owner from separate DC circuits from the Owner’s source. No fuse or MCB’s are required to protect control schemes inside control cabinet. Provisions for key interlock system shall be provided.

11.2.3.6. Control Cabinet:

11.2.3.6.1. The breaker control cabinet shall be outdoor weatherproof design, 316 stainless steel gauge 14 NEMA 4X including hinged doors for full opening with provisions for holding doors for full opening in the open position and a handle with three-point latch and padlocking provisions for holding doors in closed position.

11.2.3.6.2. All breaker controls, terminal blocks, etc. shall be consolidated in the control cabinet, including current transformer secondary.

11.2.3.6.3. The Owner shall furnish a 60 Hz, 120 Vac, single phase power supply to the breaker. The Manufacturer shall furnish appropriate terminals in the control cabinet for terminating the Owner's single-phase service and fused disconnect switches or circuit breakers for the control circuit.

11.2.3.6.4. The control cabinet shall be furnished with suitable strip heaters, with thermostat, to prevent condensation.

11.2.3.6.5. The control cabinet shall be equipped with a weather proof, separately fused, 15 A 125 V, 2 poles, 3 wires polarized, grounded, duplex GFCI outlet, connected to the 120 VAC power supply. The outlet shall be mounted on a convenient location on the control cabinet housing and shall be accessible from the outside without opening the cabinet. A lighting fixture suitable for the connection of an incandescent lamp of not less than 60 Watts, connected to the 120 VAC power supply, shall be provided inside the control cabinet.

11.2.3.6.6. The control cabinet shall be in an accessible location mounted at a convenient operating height.

11.2.3.6.7. All wiring and connections within the control cabinet shall be readily accessible for maintenance.

11.2.3.6.8. The control cabinet shall have a removable steel plate for entrance of up to eight conduits of 2" Ø, through which the power and control cables will enter by separate conduits.

11.2.3.6.9. Control cabinet shall be furnished with a keyless lock suitable for ½" Ø padlock shackle.

11.2.3.6.10. Any access inside of the control cabinet shall be by means of hinged doors.

11.2.3.6.11. Control cabinet doors shall have windows to see breaker position indication (open/close) and the SF6 gas pressure gauge.

11.2.3.6.12. A Ground Bus for the individual connection of the neutral secondary wires from the CT's shall be supplied on a convenient and accessible location at the bottom of the control cabinet with provision to be connected to the substation – ground mat.

11.2.3.7. Interrupters

11.2.3.7.1. The interrupters shall be single break and single pressure units. The interrupter contacts shall be made of a material highly resistant to burning, pitting, and blistering caused by material electric arcs. The motion and travel of these contacts shall be adjustable. The contacts shall be easily replaceable. The circuit breaker shall be able to perform at least twenty full rated fault interruptions without requiring maintenance.

11.2.4. Current Transformers

11.2.4.1. The circuit breaker shall have a quantity of twelve (12) multi- ratio, bushing type current transformers, 2 per bushing. The bushing current transformers shall conform to the following requirements:

11.2.4.1.1. Bushing current transformers shall conform to ANSI Standard C.57.13 1978 or latest revision thereof. The accuracy shall be C400. Ratio shall be as indicated on single lines.

11.2.4.1.2. Continuous Thermal Current Rating Factor (R.F.): 2.0.

11.2.4.1.3. Insulation test: At least 100 MEGA OHMS.

11.2.4.2. All of the CT taps shall be provided wired to individual shorting type terminal blocks Marathon Series 1500. These terminal blocks shall be supplied on a convenient, visible and easily accessible location inside the control cabinet. Also, the CT taps and ratios shall be clearly described on its nameplate.

11.2.4.3. In addition, three (one per load side bushing) fixed or multi ratio metering grade or C400 accuracy class CT'S shall be provided capable to handle a burden of 0.1 ohms.

11.2.5. Operating Mechanism

11.2.5.1. The circuit breaker operating mechanism shall be mechanically and electrically trip free, and shall be spring drive type. The spring drive mechanism shall be capable of storing enough energy to complete an open-close-open cycle when the AC power is lost. The mechanism shall have provisions to be manually charged with a hand crank. The mechanism shall have the necessary dry contacts for a spring charge alarm. This alarm shall have a time delay permitting the mechanism charge the spring.

11.2.5.2. The operating mechanism shall be charged by means of a universal motor, with an AC/DC nominal voltage of 120 VAC/115 VD. Also, the mechanism can be charged manually.

11.2.5.3. The operating mechanism shall provide blocking of TRIP and CLOSE operations when the SF6 gas pressure is too low to perform a proper operation. A low-pressure contact alarm shall be provided prior to this blocking function.

11.2.5.4. The operating mechanism shall have provisions for the connection of a motion transducer for timing test equipment, compatible either with DOBLE equipment.

11.2.5.5. Hydraulic shock absorbers in the mechanism shall dampen the closing and opening operations, protecting the mechanism from undue mechanical stress.

11.2.6. Bushings

11.2.6.1. Bushings shall be hollow, one-piece porcelain, BIL as indicated on single line, filled with SF6 gas common to the breaker tanks. The materials shall be homogeneous free from laminations, cavities or other flaws affecting its mechanical strength or dielectric quality.

11.2.6.2. Bushings shall be ANSI 70 Light Gray in color.

11.2.6.3. Terminals shall be 2" Ø IPS to NEMA pad flexible.

11.2.6.4. Each bushing shall be designed to withstand all the mechanical stresses resulting from the circuit breaker operation and shall be designed for easy replacement in the field.

11.2.6.5. Bushing shall be in accordance with the applicable ANSI Standards C37.010-1999.

11.2.7. Circuit Breaker Tank and Piping

11.2.7.1. Interrupter tank shall be steel construction.

11.2.7.2. All pressure switches, valves, relays, etc. shall be readily accessible and located in suitable, outdoor, weather tight enclosures.

11.2.7.3. All gas piping, fittings, gauges, and other connections shall be made leak tight. Valves used in gas systems shall have seats designed to insure a leak tight breaker with low maintenance requirements.

11.2.7.4. Breaker tanks containing SF6 gas pressure shall be designed, built, and tested to meet applicable standards.

11.2.8. Frame and Painting

11.2.8.1. The circuit breaker shall have all three poles mounted on a Hot-Dip Galvanized Steel frame with legs which bolt directly to the foundation.

11.2.8.2. Two NEMA 2-hole drilled and tapped copper or stainless-steel ground pads shall be provided, one each on opposite sides and ends of breaker.

11.2.8.3. The circuit breaker shall be painted with ANSI 70 light gray color. All exposed bolts, washers and nuts shall be stainless steel or must be steel coated.

11.2.9. SF6 Gas

11.2.9.1. The SF6 gas used in the circuit breaker shall comply with the ASTM standard

11.2.9.2. Submit the Material Safety Data Sheet of the gas.

11.2.9.3. One (1) bottle of gas per circuit breaker shall be provided to fill the unit for a proper operation.

11.2.9.4. The maximum allowable gas leakage rate shall be less than 1% per year, guaranteed for ten years.

11.2.9.5. The circuit breaker shall be equipped with pressure relays with adjustable set points to actuate alarms for SF6 gas when pressure is lower than normal, and to prevent operation when pressure reaches a value below acceptable limits. Pressure switch shall be temperature compensated.

11.2.10. Nameplate

11.2.10.1. Provide a breaker nameplate mounted inside the breaker control cabinet with the following data:

11.2.10.1.1. Manufacturer's name and address.

11.2.10.1.2. Breaker Type and model number.

11.2.10.1.3. Breaker serial number.

11.2.10.1.4. Rated nominal and maximum voltages.

11.2.10.1.5. Rated voltage factor K.

11.2.10.1.6. Rated continuous current.

11.2.10.1.7. Rated symmetrical interrupting capacity at maximum rated

11.2.10.1.8. Voltage.

11.2.10.1.9. Rated frequency.

11.2.10.1.10. Rated BI

11.2.10.1.11. Quantity of insulating medium.

11.2.10.1.12. Operating ranges of control circuit voltages.

11.2.10.1.13. Date of manufacture.

11.2.10.2. Provide a current transformer nameplate with the following data:

11.2.10.2.1. CT ratios.

11.2.10.2.2. CT connection.

11.2.10.2.3. Drawing number of saturation and phase angle, and ration correction factor curves if metering accuracy.

11.3. Protection and Control Prefabricated/Prewired Building

11.3.1. General

11.3.1.1. Summary

a. Section includes a protection and control prefabricated / prewired building for the associated high and medium voltage circuit breakers and related substation components as shown on drawings.

11.3.1.2. References

a. All work shall be in accordance with all applicable codes and standards to include, but not limited to, the following:

- NEC – National Electrical Code
- OSHA – Occupational Safety and Health Act
- UL – Underwriters Laboratories
- ANSI – American National Standards Institute
- NEMA – National Electric Manufacturers Association
- NETA – International Electrical Testing Association
- IEEE – Institute of Electrical and Electronic Engineers

11.3.1.3. Submittals

11.3.1.3.1. Shop Drawings: Indicate outline dimensions, enclosure construction, foundation bolt holes, support weight, mounting details, available conduit space, clearance for accessibility, cable terminated space, shipping splits, lifting and supporting points, electrical single and three line diagrams, AC and DC systems schematic diagrams and equipment electrical ratings.

11.3.1.3.2. Seismic Design Structural Calculations: Submit structural calculations signed and sealed by a Professional Engineer.

11.3.1.3.3. Project Record Documents: submit data for components and accessories.

11.3.1.3.4. Test Reports: Indicate procedures and results for specified factory and field testing and inspection.

11.3.1.3.5. Installation Instructions: Submit manufacturer's installation instructions covering all equipment.

11.3.1.4. Closeout Submittals

11.3.1.4.1. Project Record Documents: Include copy of manufacturer's certified drawings.

11.3.1.4.2. Operation and Maintenance Data: Submit operating instructions for the prefabricated building components as follows but not limited to:

- Protection relays and control cabinets
- Batteries and battery chargers
- Remote Terminal Unit (RTU)
- Dynamic System Monitor, if requested by owner.
- HVAC units
- Lighting fixtures
- Communication rack (Equipment to be provided by PREPA)

11.3.1.4.3. Spare Parts: Provide spare parts list, including parts location and diagram or drawing.

11.3.1.5. Qualifications

11.3.1.5.1. Manufacturer specializing in manufacturing products specified in this section with a minimum of 10 years of experience.

11.3.1.5.2. Testing Agency specializing in testing products specified in this section with a minimum of three years of experience.

11.3.1.6. Delivery, Storage and Handling

11.3.1.6.1. Deliver in the indicated maximum width, shipping splits, individually wrapped for protection and with shipping skids.

11.3.1.6.2. Accept building on site. Inspect for damage.

11.3.1.6.3. Lift only using lugs provided. Handle carefully to avoid damage to internal components, enclosure, and finish.

11.3.1.6.4. Protect products from weather and moisture by covering with plastic or canvas and by maintaining heating (when specified) within enclosure.

11.3.1.7. Field Measurements

11.3.1.7.1. Verify field measurements prior to fabrication.

11.3.1.8. Maintenance Materials

11.3.1.8.1. Furnish a complete set of special tools required for installing, operating and maintaining the equipment furnished under these specifications.

11.3.2. Products

11.3.2.1. General

11.3.2.1.1. Manufacturers: Schweitzer or other previously approved by the owner.

11.3.2.2. Building

11.3.2.2.1. Outdoor Hot-Dip Galvanized Gauge 14 Walk-in type enclosure layout as shown on drawings.

- The building shall be equipped with guarded interior lighting fixtures, duplex GFI protected receptacles. Totally prewired to the AC utilities distribution panel board. The doors shall be provided with panic latches and provisions for external padlocking. The building shall be provided with an air conditioning unit. Building ceiling and walls shall be provided with insulation to avoid water condensation.
- The building shall be constructed for the site conditions where it will be installed.
- Building Supporting Frames, their attachments and anchorages shall be designed as to withstand wind and seismic forces calculated as per minimum design loads for buildings and other structures ASCE 7.
- Submit all components and anchorage design, calculations and drawings for approval. Structural calculations and drawings shall be signed and sealed by a Professional Engineer.

11.3.2.3. Control and Protection Panel Assembly

11.3.2.3.1. General

- These specifications describe the substation protection and control system. The equipment outlined in these specifications consists of protection and control relays, Vac and Vdc distribution panels and other auxiliary equipment. The protection and control system will be sheltered in the prefabricated building.

- The design, furnish, delivery, installation, testing and commissioning of the control and protection assembly will be part of the project.
- The assembly shall conform to the latest applicable standards of ANSI, IEEE, NEMA and NEC including but not limited to:
  - ANSI C37.1 Standard Definition, Specification and Analysis of Systems Used for Specification and Analysis of Systems Used for Supervisory Control, Data Acquisition and Automatic Control
  - ANSI C37.2 Standard for Electrical Power System Device Function Numbers
  - ANSI C37.11 Standard Requirement for Electrical Control for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis or a Total Current Basis
  - ANSI C57.13 Standard Requirements for Instrument Transformers
  - ANSI C63.2 Electromagnetic Noise and Field Strength, 10 kHz to 40 GHZ
  - ANSI Y14.15 Drafting Practices for Electrical and Electronics Diagrams
  - ANSI Y32.2 Graphic Symbols for Electrical and Electronic Diagrams.
  - ANSI C37.90 Relays and Relay Systems Electric Power Apparatus Associated with:
  - ASTM D2472 Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips
  - ISA S18.1 Annunciator Sequences and Specifications
  - OSHA 29 CFR Occupational Safety and Health Standards for the Part 1926 Construction Industry

11.3.2.3.2. Relays & Control

- Protection and control equipment will be provided as shown in the enclosed Plans Drawing and One Line Diagram. The protection relays and auxiliary relays will be installed on separate cabinets in the prefabricated building. In addition, a Remote Terminal Unit (RTU) shall be supplied if specified and indicated by the owner.
- Relays shall be digital, multifunction, microprocessor-based, standard type flush or semi-flush mounted on the panels and must comply with ANSI/IEEE Standard C.37.90: Relays and Relays Systems Associated with Power Systems Apparatus. Type and settings, with test blocks and plugs, shall be as indicated:
  - Shall provide all necessary equipment for testing relays, including card extenders, software, and communications equipment. Must also provide DOBLE test plan for relay test using DOBLE relay test set and DOBLE protection software.
  - Metering shall be provided through a meter approved by the owner. Three phase metering is required. As minimum Amps, Volts, MWatts, and MVars shall be provided. These values should be shown on the relay under normal conditions.

Meters shall be placed in the front panel and at an adequate height (about 66 inches).

- A power quality meter shall also be installed. This meter shall be capable of measuring harmonics, THD, and individual harmonic contributions.
- Relays and meters shall be capable of communicating with the RTU or SCADA RTAC Relay via fiber optic local area network IEEE 802.3 with DNP 3.0 and/or through a fiber optic DNP 3.0 network. DNP 3.0 communication can be implemented via an intermediate device capable of providing this functionality, like SEL-3354 or approved equal. All DNP 3.0 IEDs shall be certified.
- All relays and or protection systems to be used shall be approved by the owner.

- The control voltage and power supply voltage of relays shall be 125 VDC.
- Protection system shall be as shown on the one line and schematic diagram.

11.3.2.3.3. Remote Terminal Unit (RTU)

- If requested by the owner, an RTU shall be supplied by the manufacturer. The prefabricated control building manufacturer shall leave enough room, next to the control panels, to be able to mount an RTU unit.

11.3.2.3.4. Cabinets (Protection)

- All cabinets shall be made with galvanized stretcher rolled steel gauge
  - All steel surfaces to be painted shall receive a phosphate or equivalent treatment prior to application of paint. External and internal surfaces shall be coated with at least one coat of corrosion-resisting paint. The preferred color for the interior finish shall be Light Gray No. 61 (Munsell Notation 8.3G6.10/0.54).

- Each cabinet shall be completely fabricated, wired and assembled by the supplier at his factory. Each cabinet furnished shall be fully equipped and completely wired to the terminal blocks specified herein for all control and monitoring required by the ultimate installation.
- All cabinet doors shall be hinged on the left or right side, equipped with a three-point latching system operated with a single handle. Door shall also be equipped with an automatic brace system to hold the door open at least 90 degrees from the closed position. Hinges for doors, and interior swinging panels, shall not permit sagging due to weight of the door or panel or any devices mounted thereon.
- An engraved nameplate shall be furnished for each device mounted on the cabinet including each relay, switch, breaker, indicating light, and control switch. Nameplate material shall be 3-ply plastic white surface and black core, Nameplates shall be 1/8-inch-thick with 5/8 height and ¼ inch letter engraved through the top lamination to the black interior.
- Each cabinet shall be dust tight and gasket construction. Each cabinet

shall be a rigid, self-supporting and self-contained welded or bolted metal enclosed steel structure.

- Each cabinet shall include heaters equipped with thermostat control and protective grills to prevent accidental contact by personnel.

11.3.2.3.5. Wiring and Control Cabinet Design

- All protection and control cabinets will be completely wired, tested, and ready for field installation. External cables for connection to breakers, transformers, etc. Control cables will enter through the top of the cabinet. The Contractor will provide the necessary cutouts and space to allow cable access, with cable glands to connect the cable shield properly.
- Wiring shall conform to NEC requirements. Current and insulation rating shall meet the requirements of the control circuits.
- Wiring shall be neatly arranged, firmly laced and secured to the panel or supported by suitable brackets as required. Splicing of wires is not acceptable.
- Internal control wiring will be installed in approved horizontal and vertical wiring channels with removable covers for each access.
- All field wiring shall terminate on terminal blocks with numbering strips to identify each terminal or fuse block. All required jumpers shall be located opposite to the field terminations on the terminal block. Each terminal screw shall carry no more than two wires.
- Terminal blocks shall be suitably mounted, not less than 12 inches above the bottom panel. The terminal strips shall be mounted vertically, unless otherwise specified or shown on the drawings. Terminal blocks shall be arranged in a series of rows. Panel wiring and field wiring shall be segregated from one another by the rows of terminal blocks. No devices, or other material, shall obstruct access to the terminal blocks for connections of terminals or for installation of control cables. Terminal blocks shall be mounted on stand-off supports to the top of the block is flush with the top of the plastic wiring ducts. All interface terminal blocks (to connect to other cabinets and equipment or to DCS, etc.) shall be numbered in sequence without interrupting sequence by terminal block name.
- Completely separated and isolated circuits must be used for control, tripping, alarms and auxiliary devices. The controls and protection for each circuit breaker shall also contain as a minimum the following equipment within the cabinet.
    - Terminal blocks and terminations for each control wire connected to the circuit breaker disconnect switches, and grounding switches. A maximum of two wires per terminal will be permitted.
    - The following separate DC circuits are required:
    - One 125 Vdc, two-pole miniature circuit breaker (MCB) for breaker control and trip circuit #1.
    - One 125 Vdc, two-pole MCB for breaker trip circuit #2.
    - One two-pole MCB for each motor.
    - Terminal blocks and termination of all wires associated with

electrical interlocking schemes.

- Terminal blocks for alarm circuits and miscellaneous remote-control functions.
- Terminal blocks for all spare contacts of circuit breaker.
- A total of 10% spare terminal blocks.
- Test switches shall be provided for any AC or DC circuit for any IED (protection meters, etc.) according to its application (voltage, current and voltage and current combination type).

- Each control circuit shall be protected by a two-pole circuit breaker (CB) with auxiliary N/C contacts. The auxiliary contacts of all CB's of the same circuit type shall be wired in series to a group alarm terminal.
- Wiring shall be terminated by insulated terminals with brazed barrels. Crimping shall be done with a ratchet-type crimping tool. Wiring shall be marked at both ends at the device and at the terminal block or other device).
- A duplex convenience outlet rated 120 V AC, 15 A, with ground fault interrupter shall be provided inside the breaker control cabinets.
- A connection point providing 120V/AC, three phases, shall be provided in one of the control cabinets for the use of maintenance and testing personnel.
- Cable schedules indicating origin and destination of all control and miscellaneous external (not prefabricated) wires shall be provided.
- Cable indexes indicating wire number, wire color, conduit number, and wire use for all control and miscellaneous external (not prefabricated) wires shall be provided.
- All wiring shall meet the following minimum requirements: 90°C, 600-volt switchboard wire, type SIS, 41 strand, tinned copper with PVC wire markers machine stamped sleeves or stamped wires on both ends. Each wire end to be stamped with wire destination. Minimum sizes for AC and DC power and control cables shall be as follows:
  - 120/240 VAC Power #12 AWG or 4mm2
  - 125 VDC Control #14 AWG or 4mm2
  - 120 VAC Potential (PT) #10 AWG or 6mm2
  - Trip and Close Control #12 AWG or 4mm2
  - Current Transformer #10 AWG or 6mm2
- Wiring of relays in the same panel shall be made by direct interconnection. Wiring between different panels shall be made via terminal blocks in each panel.
- All panel-mounted devices shall be sufficiently supported to prevent distortion and warping of the equipment bearing panel or sub-panels. All the terms of equipment called for in these specifications shall be installed in the cabinets.
- Equipment mounted within a cabinet shall be mounted on sub- panels or equipment stand-offs and be easily accessible. No bolts shall protrude through the sides of the cabinet for mounting devices inside the cabinet.

- Shielded control cables shall be grounded at one point.
  - A flat copper bar ground bus shall be installed. The bus shall be drilled for a NEMA 2-hole lug for connection of the station ground cable. All instruments and devices requiring grounding shall be connected to the ground bus by copper conductors via compression type lugs.

11.3.2.3.6. Interlocking

- Electrical and mechanical interlock sequence of operation shall be defined to prevent incorrect sequential operation and/or equipment malfunction that might result in equipment damage and personal injury. The mechanical interlock for circuit breakers and auxiliary switches shall be the type of Kirk Key or approved equal.

11.3.2.3.7. Battery Banks and Battery Chargers

The prefabricated building will include one (1) Battery Bank and one (1) Battery Charger, unless specified differently by the owner. The Charger will be supplied from a VAC load center via disconnecting switches. The battery bank shall be tied with a circuit breaker. The battery bank shall have the capacity to supply the whole substation. The system shall comply with the following:

- Equipment for the battery system must comply with the latest version of ANSI/IEEE 485 and ANSI-C2.
- The battery system shall be rated to provide backup power for the complete facility.
- Batteries shall be Lead Acid.
- The battery and battery charge shall be sized to provide backup power for eight (8) hours and six (6) open/close operations per switching device (breakers, etc.), unless specified differently by the owner.
- The station battery shall be housed in a separate room in the Prefabricated Building with a door to the outside. There shall be no direct access from the battery room to the control room.
- Forced ventilation shall be provided to limit hydrogen build up and acid fumes.
- A containment barrier shall be provided to hold acid spills inside the battery room.
- Battery chargers shall be located in the main control room, separate from the battery room.
- Battery room lighting fixtures shall be gas tight type.
- An eye shower shall be installed outside the battery room, next to the battery room door.
- The battery charger must be provided with at least the following accessories:
  - AC voltage failure alarm relay and DC low voltage alarm relay with contacts connected to a terminal block for easy connection to external circuiting.
  - Contacts for ground detector alarm wired to terminal blocks for easy connection to an external circuit.

11.3.2.3.8. Production Tests

- All products shall be tested and inspected as part of the regular manufacturing procedure and in accordance with ANSI C37.20, paragraph 5.3 for Switchgear Assemblies. Testing shall include but not be limited to the DC Transient test and the Surge Withstand Capacity test in accordance with the latest version of IEEE 472 (ANSI C37.90a).

11.3.2.3.9. Additional Testing

- The following test shall be performed to the assembled control panel:
  - Verify all wiring between cubicles and relay panels.
  - Verify relay general performance operation.
  - Injection testing of all relays and meter to verify correct operation.
  - The entire above test must be performed on the fully assembled control panel at manufacturer location. The owner reserves the right to witness tests. The Manufacturer shall notify the owner at least four (4) weeks prior to the date of test. The owner may waive the witness of test and in substitution request certified test results.

11.3.2.3.10. Accessories

- The following accessories shall be supplied, but not housed:
  - Identification nameplates for each relay in the front and rear side of the panels and each test switches and other devices in the panels.
  - Any software for relay settings, test and calibration shall be provided.

11.3.2.3.11. Information Required with Proposals

- The Manufacturer shall submit with his proposal sufficient information to show the general design of the equipment offered and to permit an engineering comparison with equipment offered by other Manufacturers. He shall furnish the following specific information:
  - Drawings showing outline dimensions and arrangements
  - Descriptive catalog information
  - List of exceptions, if any, to the specifications
  - Catalog descriptions of standard equipment the Bidder proposes to use
  - Names of manufacturers of component parts not provided by the Protection and Control Prefabricated / Prewired Building Manufacturer.
  - List of names and locations of previous projects supplied with a Remote-Control Unit using CDC and DNP communication protocols.
  - DNP 3.0 Certificate

11.3.2.3.12. Spare Parts

- The Manufacturer shall submit with his proposal an itemized list of spare parts with prices for every item.

11.4. Conductors: High Voltage Cable

11.4.1. General

11.4.1.1. Summary

11.4.1.1.1. Section includes high voltage cables to be installed in conduits and ducts; and cable splices and terminations.

11.4.1.2. References

11.4.1.2.1. All work shall be in accordance with all applicable codes, standards, and regulations to include, but not limited to, the following:

- NEC – National Electrical Code
- OSHA – Occupational Safety and Health Act
- UL – Underwriters Laboratories
- ANSI – American National Standards
- ASTM – American Society for Testing and Materials
- NEMA – National Electrical Manufacturers Association
- ICEA – Insulated Cable Engineers Association
- IEEE – Institute of Electrical and Electronic Engineers
- AEIC – Association of Edison Illuminating Companies.
- NETA – International Electrical Testing Association

11.4.1.3. System Description

11.4.1.3.1. Provide high voltage cables, splices and cable terminations as indicated on Drawings.

11.4.1.4. Submittals

11.4.1.4.1. Product Data: Submit for each conductor, splice and cable termination.

11.4.1.5. Qualifications

11.4.1.5.1. Manufacturer specializing in manufacturing products specified in this section with a minimum of three years' experience.

11.4.1.6. Delivery, Storage, And Handling

11.4.1.6.1. All materials furnished under this section shall be new and unused.

11.4.1.6.2. Cables shall be delivered to the job in standard reels with approved tags noting length, cable size, insulation type and manufacturer's name. Cable ends shall be sealed prior to shipment.

11.4.1.6.3. All materials shall be protected from weather and damage during storage and handling at the job.

11.4.1.6.4. If factory seals are cut off, new tape seals must be applied to prevent moisture entry into cable.

11.4.1.6.5. Whenever possible, the factory applied lagging (protective cover) should be left in place until removal is necessary. Additional covering may be used, if cable is to be stored for long periods outdoors or in excessively dirty dusty areas.

11.4.1.6.6. Store reels of cable on a firm surface, paved if possible, or on planking to prevent settling into soft ground. The storage area should have good drainage.

11.4.1.6.7. Use fencing or other barriers to protect cables and reels against damage by vehicles or other equipment moving about in the storage areas.

11.4.1.6.8. Reels of cable must not be dropped from any height, particularly from trucks of other transporting equipment.

11.4.1.6.9. Lift reels using following methods: Crane or boom type equipment: insert shaft (heavy rod or pipe) through reel hubs and lift with slings on shaft, preferably utilizing spreader or yoke to reduce or avoid sling pressure against reel head. Forklift type of equipment may be used to move smaller, narrower width reels. Fork tines should be placed so that lift pressure is on reel heads, not on cable, and must reach all the way across reels so lift is against both reel heads.

11.4.1.6.10. Reels may be moved short distances by rolling. Reels should be rolled in the direction indicated by arrows painted on reel head. Surfaces over which the reels are to be rolled should be firm, clear of debris, and clear of protruding stones, humps, etc. which might damage the cable if the reel straddled them.

11.4.2. Products

11.4.2.1. General

11.4.2.1.1. For entire high voltage cable installation, some of the following types, as noted on Drawings, shall be used:

- Single Conductor, shielded, TR-XLP Extra Clean insulation
- Single Conductor, shielded, EPR insulation.

11.4.2.1.2. The cable shall be designed with an insulation that can stand the continued stress of an additional 10% of the cables nominal kV rating phase to phase.

11.4.2.1.3. The cable shall meet the applicable requirements of the Insulated Cable Engineering Association (ICEA) Standard No. S-66-524 for tree retardant cross-linked polyethylene or S-68-516 for Ethylene Propylene Rubber supplemented by the specifications of the Association of Edison Illuminating Companies (AEIC) Bulletin No. CS87-87 and CS6-87 respectively.

11.4.2.1.4. Cable shall have permanent identification of manufacturer and classification visible on the outer jacket.

11.4.2.2. Conductor

11.4.2.2.1. The conductor shall be compressed; watertight type, concentric laid, stranded, Class B, and shall be made of annealed uncoated copper wires. The interstices between wires shall be filled with a watertight compound. The filling compound shall be a high viscosity polymeric based thermoplastic compound, which adheres to metals and polymeric materials, and compatible with semiconducting, and insulation materials.

11.4.2.2.2. Size of conductor should be based on load flow calculations considering permissible voltage drops.

11.4.2.3. Insulation

11.4.2.3.1. The insulation shall be extra clean, tree retardant XLP or EPR

11.4.2.4. Shielding

11.4.2.4.1. Conductor shall be covered with a layer of extruded semiconducting material.

11.4.2.4.2. Insulation shielding shall be extruded and shall consist of black, semiconducting thermoset material applied directly over the insulation.

11.4.2.5. Extrusion and Curing

11.4.2.5.1. The conductor shielding, insulation, and insulation shielding shall be extruded utilizing a simultaneous triple extrusion process in clean room environment.

11.4.2.5.2. Dry curing method is mandatory.

11.4.2.5.3. A polyvinyl chloride (PVC) jacket shall be applied over the copper shielding tapes.

11.4.2.6. Factory Tests

11.4.2.6.1. All tests shall be made on the cable in accordance with the requirement call for in the Standards on Article 2.1 C of these specifications.

11.4.2.6.2. The supplier or manufacturer shall provide the qualification test results described in Section L of AEIC CS7-87 or CS6-87 as applicable. The cable shall not be considered or evaluated without these qualification test results.

11.4.2.6.3. The manufacturer shall state clearly that it has manufactured and tested the cable in accordance with these specifications and shall inform the Owner or any deviation from them.

11.4.2.7. Terminations

11.4.2.7.1. Cable terminations shall be factory-manufactured kits to suit the specific type and size of the cable.

11.4.2.7.2. The local Power Utility Authority shall approve Cable terminations.

11.4.2.8. Lubrication for Cable Installation

11.4.2.8.1. Cable pulling lubricants used to reduce the coefficient of friction between the cable and the containing conduit or duct shall be compatible with the materials of construction of the cable.

11.4.3. Execution

11.4.3.1. Examination

11.4.3.1.1. Verify conduit, duct, pull boxes and manholes are ready to receive cable.

11.4.3.1.2. Verify routing and termination locations of cable prior to rough in.

11.4.3.2. Installation

11.4.3.2.1. Thoroughly swab all conduits by rodding and brushing before pulling in cables.

11.4.3.2.2. Thoroughly mandrel and swab all conduits before pulling in cables. Use rod equipped with brass knuckle- joint fittings, so the rod can be joined and disjoined. Push rod into duct and couple other rods. Repeat coupling rods until rods extend from manhole to manhole. Repeat rodding of duct until duct is clear of obstruction. If obstructions are encountered, use proper cleaning tool to eliminate obstructions.

11.4.3.2.3. Pull cables into raceway at same time.

11.4.3.2.4. Cable shall be installed in accordance with manufacturer's recommendation. At no time during or after installation shall the cable be bent to a radius smaller than manufacturer's recommendation.

11.4.3.2.5. Use suitable manufacturer approved lubricants. Cable pulling compound shall be applied at the beginning of the cable entry into the conduit and at each manhole along the conduit run.

11.4.3.2.6. Use suitable manufacturer approved pulling equipment. Sustain cable-pulling tensions below manufacturers recommended limits. A tension-monitoring device must be used during the pulling system to ensure that the cable maximum pulling tension is not exceeded. This must be a continuous monitoring device so that cable pulling is not interrupted.

11.4.3.2.7. Attachment to the cable can be accomplished with any of the commercially available devices (Kellemps grips, Greenlee wire grip, etc.) or by factory-made pulling eyes. If the pull is through wet or damp locations, the cable ends must be positively sealed to prevent moisture entry and resealed after pulling.

11.4.3.2.8. Factory applied seals on cable ends may be disrupted during the pulling operation and, therefore, should be checked and replaced, if the cables are not going to be spliced or terminated right after pull-in. This is especially important for underground runs where cable ends may be left in manholes, which are subject to flooding.

11.4.3.2.9. Contractor shall pump dry all manholes prior to cable installation. Install cables in manholes or pull boxes along wall providing longest route.

11.4.3.2.10. Roller tracks and/or cable guides shall be placed in each manhole to ensure that the manufacturer's minimum bending radius is not exceeded and to protect the cables during the transition from top to bottom or bottom to top conduit positions within a given manhole.

11.4.3.2.11. Arrange cables in manholes or pull boxes to avoid interference with conduit or duct entrances.

11.4.3.2.12. Install, terminate, and splice cables in accordance with cable manufacturer's recommendations. Splices shall be permitted only when necessary. All splicing shall be approved by the local Power Utility. Cable splices shall be made by certified cable splicers with a minimum of 10 years' experience in splicing cables of this type.

11.4.3.2.13. Support cables to galvanized steel channels and porcelain insulators.

11.4.3.2.14. Cable shields on all splices and terminations and grounding conductor at all manholes shall be properly connected to the ground rods.

11.4.3.2.15. Fireproof cables in manholes using fireproofing tape in half-lapped wrapping. Extend fireproofing 1 inch into duct.

11.4.3.3. Field Quality Control

11.4.3.3.1. Inspect exposed cable sections for physical damage.

11.4.3.3.2. Inspect cable for proper connections.

11.4.3.3.3. Inspect shield grounding, cable supports, and terminations for proper installation.

11.4.3.3.4. Perform inspections and test listed in NETA, Section 7.3.3 (Cables: Medium Voltage), Section 7.13 (Grounding System)

11.4.3.3.5. All testing shall be performed according to the manufacturer's instructions and test value limitations indicated by testing equipment company or cable manufacturer.

11.4.3.3.6. The reference Standards are available as follows:

11.4.3.3.7. International Electrical Testing Association (NETA)

11.4.3.3.8. PO Box 687, Morrison, CO 80465

11.4.3.3.9. Tel: (303) 697-8441; Fax: (303) 697-8431

11.4.3.3.10. E-mail: neta@netaworld.org – Web site: www.netaworl.org

11.4.3.3.11.

11.4.3.3.12. If any cable fails or tests, in the opinion of the testing agency, show unacceptable cable defects, all cables in that conduit between the nearest pulling points on each side of the failure shall be withdrawn. If, in the opinion of the testing agency, other cables that have been installed in the same duct are not damaged, they may be reinstalled, but the failed cable shall be replaced with new cable without additional charge.

11.4.3.3.13. After replacement of the faulty cable and any other damaged cables, all cables or the circuit in that conduit shall be retested. If a cable fails again or if tests, in the opinion of the testing agency, show unacceptable cable defects, all cables shall be replaced without charge and this procedure shall be repeated until tests proved satisfactory.

11.4.3.4. Protection of Installed Construction

11.4.3.4.1. Protect installed cables from entrance of moisture.

11.4.3.5. Cleaning

11.4.3.5.1. Clean interior of manholes and pull boxes to remove dust, debris and other material.

11.5. Grounding Systems for Substations

11.5.1. General

11.5.1.1. Summary

11.5.1.1.1. Section includes all necessary conductors, rod electrodes, exothermic connections, mechanical connections and additional accessories to construct a ground grid that provides a grounding system for a Substation.

11.5.1.2. References

11.5.1.2.1. All work shall be in accordance with all applicable codes and standards to include, but not limited to, the following:

- NEC – National Electrical Code
- OSHA – Occupational Safety & Health Act

- UL – Underwriters Laboratories
- ANSI – American National Standards
- NEMA – National Electric Manufacturers Association
- NETA – International Electrical Testing Association
- IEEE – Institute of Electrical and Electronics Engineers
- LOCAL POWER UTILITY

11.5.1.3. System Description

11.5.1.3.1. Provide materials and labor to ground electrical systems as shown on Drawings to include but not limited to, the following:

- Substation Structure
- Transformers, Switchgears, Air Interrupter Switches, Circuit Breakers, and additional equipment included in the Substation.
- Substation Fence and access doors.
- Raceway system
- Center point of delta-wye Transformers.

11.5.1.3.2. Provide a complete ground-grid enclosing the substation and including the fence within the ground-grid are Except as otherwise indicated on Drawings:

- The perimeter conductor of the grid will be parallel to the fence line at not less than three (3) feet outside the fence.
- Cross conductors shall be provided interconnecting the perimeter conductor in both directions. Exothermic connections shall be used in the points of crossing of all conductors.
- The ground-grid shall be installed at least 18 inches below the ground level. The depth of the crushed-stone (minimum resistivity of 3000 ohms-meter) layer that will cover the ground-grid area is not included in this minimum buried dimension.
- Provide ground electrodes, connected to the ground-grid, in the points of connection of the down conductor from the surge arresters, the transformer neutral and the plate where the air interrupter switch will be operated. Provide additional ground electrodes as indicated on Drawings.

11.5.1.3.3. The system shall be in accordance with ANSI/IEEE Std. 80 – Guide for Safety in ac Substation Grounding.

11.5.1.4. Performance Requirements

11.5.1.4.1. Grounding System Resistance: 5 ohms maximum except as otherwise indicated on Drawings.

11.5.1.5. Submittals

11.5.1.5.1. Product Data: Submit data for each type of product used.

11.5.1.5.2. Test Reports: Indicate overall resistance to ground, resistance of the individual ground rods. Report values greater than 5 ohms for remedial action.

11.5.1.6. Closeout Submittals

11.5.1.6.1. Project Record Documents: Record actual locations of components and grounding electrodes.

11.5.1.7. Delivery, Storage, And Handling

11.5.1.7.1. All material shall be new, unused and delivered in original manufacturer’s packaging.

11.5.1.7.2. Protect from weather and construction traffic, dirt, water, chemical and mechanical damage, by storing in original packaging.

11.5.2. Products

11.5.2.1. General

11.5.2.1.1. Except as otherwise indicated, provide electrical grounding and bonding systems indicated on Drawings; with assembly of materials, including, but not limited to: cables, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, and additional accessories needed for a complete installation.

11.5.2.1.2. All materials shall be listed and approved for the intended application.

11.5.2.2. Manufacturers

11.5.2.2.1. Subject to compliance with requirements, provide grounding and bonding products of one of the following manufacturers (for each type of product):

- Blackburn (T&B)
- Burndy Corporation.
- Cadweld Div; Erico Products Inc.
- Copperweld.
- East Jordan Iron Works (ground test boxes).
- Josam Manufacturing Company (ground test boxes).
- OZ Gedney Div; General Signal Corp.
- Penn-Union.
- Thomas and Betts Corp.
- Stewart R. Browne (clamps).
- 1 Sherman (lugs and connectors).
- 1 Kearney (lugs and connectors).

11.5.2.3. Cable

11.5.2.3.1. Soft drawn, copper, bare or insulated (as indicated), stranded with 95% conductivity.

11.5.2.3.2. Ground Cable to be sized in accordance with NEC Tables.

11.5.2.4. Bonding Jumper Braid

11.5.2.4.1. Stainless Steel braided tape constructed of 30-gauge bare stainless steel wires and properly sized for indicated applications.

11.5.2.5. Ground Electrodes

11.5.2.5.1. Ground Rods: shall be ¾ inch by 10-foot copper clad steel unless otherwise specified on Drawings.

11.5.2.5.2. Ground Test Boxes: shall be 8-inch diameter by 24 inch long concrete pipe with belled end, and a cast iron cover with legend "ground" embossed on top.

11.5.2.6. Connections

11.5.2.6.1. Exothermic connections (cadweld or approved equal) shall be the standard method of splicing ground wire underground.

11.5.2.6.2. Provide ground clamp connectors for joining ground cable to pipe or plate. Clamps shall be fabricated of high-strength metals to provide corrosion-resistant permanently tight connection.

11.5.3. Execution

11.5.3.1. Examination

11.5.3.1.1. Verify existing conditions under which electrical grounding and bonding connections are to be made. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer.

11.5.3.1.2. Verify that final backfill and compaction has been completed before driving rod electrodes.

11.5.3.2. Installation

11.5.3.2.1. Install ground-grid as indicated on Drawings.

11.5.3.2.2. Exothermic welds shall be made strictly in accordance with the weld manufacturer’s written recommendations. Welds which are “puffed up” or which show convex surfaces indicating improper cleaning are not acceptable.

11.5.3.2.3. Install rod electrodes at locations indicated on drawings. The rod electrode shall be driven full length into the earth. The maximum resistance of a driven ground shall not exceed 5 ohms. If this resistance cannot be obtained with a single rod, a sufficient number of additional rods shall be installed not closer than 6 feet in center so that the resultant resistance will be within that limit.

11.5.3.2.4. Install ground test boxes for grounding electrodes with detachable cable connections at locations indicated on the drawings. Install well box top flush with the finished grade.

11.5.3.2.5. Ground the substation fence at each gate post and corner post and at intervals not exceeding 10 feet. Bond each gate section to the fence post through a 1/8-inch by one- inch flexible braided copper strap and clamps.

11.5.3.2.6. Connect surge arrester down conductor, substation structure, air interrupter switch operator, transformer tank, metal-clad switchgear and enclosures of additional equipment to the ground- grid.

11.5.3.2.7. The ground connection of the electric system neutral shall be made in each substation as shown on the drawings. An insulated neutral conductor must be carried from the switchgear neutral bus back to the transformer neutral. The insulated neutral wire must not be grounded on the downstream side of the switchgear in the feeders.

11.5.3.3. Field Quality Control

11.5.3.3.1. Inspect and test in accordance with NETA.

11.5.3.3.2. Grounding and Bonding: Perform inspections and tests listed in NETA section 7.13

11.5.3.3.3. Perform ground resistance testing in accordance with IEEE 14

11.5.3.3.4. Perform leakage current tests in accordance with NFPA 9

11.5.3.3.5. Perform continuity testing in accordance with IEEE 142

11.5.3.3.6. Perform ground resistance measurement for each piece of equipment.

- An independent testing contractor engaged in the business of electrical acceptance testing similar to the inspections and tests specified shall perform the testing. Contractor shall have at least five years of experience
- The testing contractor shall submit proof of qualifications to the Owner. Proof shall include but not be limited to:
- Name of the required registered electrical engineer.
- Certified International Electrical Testing Association (NETA) test

technician.

- Experience as a testing laboratory for a minimum of five years.
- Equipment available for use in this project.

11.5.3.3.7. Test in cooperation with other affected contractors. The Owner shall approve the schedule of tests. Three-day notice shall be given prior to testing, unless otherwise necessary or specified.

11.5.3.3.8. All testing shall be performed according to the manufacturer's instructions and test value limitations indicated by testing equipment company or equipment manufacturer.

11.5.3.3.9. The reference Standards are available as follows:

- NETA Grounding System Tests

  International Electrical Testing Association (NETA)
  PO Box 687, Morrison, CO 80465
  Tel: (303) 697-8441; Fax: (303) 697-8431
  E-mail: net@netaworld.org – Web site: www.netaworld.org

- IEEE Std. 142, IEEE Std 81, and IEEE Std. 80

  Institute of Electrical and Electronic Engineers (IEEE)
  IEEE Customer Service Center
  445 Hoes Lane
  P.O. Box 1331
  Piscataway, NJ 08855-1331
  Tel: (732) 981-0060; E-mail: ieee.org/shop

- NFPA 99

  National Fire Protection Association
  1 Battery March Park, Quincy MA 02269-9101
  Tel: (800) 344-3555

11.6. Acceptance Testing

11.6.1. General

11.6.1.1. Summary

11.6.1.1.1. Section includes Acceptance Testing for the electrical equipment in a substation.

11.6.1.2. Applicable References

11.6.1.2.1. All inspections and field tests shall be in accordance with the latest edition of the following codes, standards, and specifications except as provide otherwise herein.

- ASTM – American Society for Testing and Materials
- ANSI – American National Standards Institute
- IEEE – Institute of Electrical and Electronic Engineers
- ICEA – Insulated Cable Engineers Association
- NETA – International Electrical Testing Association
- NEMA – National Electrical Manufacturer's Association
- NEC – National Electrical Code
- NFPA – National Fire Protection Association

- OSHA – Occupational Safety and Health Administration
- 10.UL – Underwriters Laboratories, Inc.

11.6.1.3. Equipment and Systems to Be Tested

11.6.1.3.1. Transformers
11.6.1.3.2. Cables and Wires
11.6.1.3.3. Metal-Enclosed Busways
11.6.1.3.4. Outdoor Bus Structures
11.6.1.3.5. Switches
11.6.1.3.6. Circuit Breakers
11.6.1.3.7. Switchgear and Switchboard Assemblies
11.6.1.3.8. Instrument Transformers
11.6.1.3.9. Metering
11.6.1.3.10. Protective Relays
11.6.1.3.11. Ground-Fault Protection System
11.6.1.3.12. Surge Arrestors
11.6.1.3.13. AC Motors
11.6.1.3.14. AC Generators
11.6.1.3.15. Motor Control
11.6.1.3.16. Adjustable Speed Drive Systems
11.6.1.3.17. Emergency Systems
11.6.1.3.18. Uninterruptible Power Systems
11.6.1.3.19. Capacitors
11.6.1.3.20. Direct-Current Systems
11.6.1.3.21. Grounding Systems.

11.6.1.4. System Description

11.6.1.4.1. The work covered by this specification shall include furnishing all labor, material, equipment and services to perform de acceptance tests for the complete electrical system.

11.6.1.4.2. Preliminary acceptance tests are defined as those tests and inspections required to determine that the equipment involved may be energized for final operations tests.

11.6.1.4.3. Final acceptance will depend upon equipment performance, characteristics, ant their compliance with the intended design as determined by system operational tests defined in this and other sections of these specifications.

11.6.1.4.4. Use the standards of the industry such as IEEE, NEMA, ANSI, IPCEA, NETA and guides in testing the equipment.

11.6.1.5. Qualifications

11.6.1.5.1. The testing shall be performed by an independent testing contractor engaged in the business of electrical acceptance testing similar to the inspections and tests specified. Testing laboratory shall have a minimum of five years of experience.

11.6.1.5.2. The testing contractor shall submit proof of qualifications to the Owner. Proof shall include but not be limited to:

- Name of the required registered professional engineer.
- Qualifications of test personnel: Minimum of two years supervised field experience, or certified National Electrical Testing Association (NETA) test technician.

- Experience as a testing laboratory for a minimum of five years.
- Equipment available for use on this project.

11.6.1.5.3. Membership in the NETA may be submitted in addition to the above list to substantiate qualifications.

11.6.1.6. Test Procedure

11.6.1.6.1. The Owner will provide a set of project electrical documents to assist in ascertaining the extent of the project testing.

11.6.1.6.2. The testing laboratory shall be responsible for tests and test record for each item to be tested.

11.6.1.6.3. Test in the presence of the Owner's representative at the option of the Owner.

11.6.1.6.4. Report immediately to the Owner any system, material, or workmanship which is defective, in compliance with the specifications.

11.6.1.6.5. Provide necessary test equipment and be responsible for setting- up test equipment, wire checks of factory wiring, and any other preliminary work in preparation for the electrical acceptance tests.

11.6.1.6.6. Having a calibration program which maintains applicable test instrumentation within rated accuracy. Accuracy shall be traceable to the National Bureau of Standards. Calibration frequency shall be in accordance with the following schedule:

11.6.1.6.7. Field instruments: six months maximum

11.6.1.6.8. Laboratory instruments: 12 months maximum.

11.6.1.6.9. Dated calibration shall be visible on equipment.

11.6.1.6.10. Test in cooperation with other affected subcontractors. The schedule of tests shall be approved by the Owner's representative. Three-day notice shall be given prior to testing, unless otherwise necessary or specified.

11.6.1.6.11. Advice the manufacturer's representative of tests performed on their equipment. Give a minimum of ten-calendar-day notice to permit him to witness the equipment under test, should be desire.

11.6.1.6.12. Certain pieces of equipment have the services of a manufacturer's service engineer who will assist in performing the tests on the equipment. When this service is provided, he will verify and sign each report form.

11.6.1.6.13. Tests shall be non-destructive and shall not exceed the manufacturer's recommended limit for the equipment being tested.

11.6.1.6.14. Where required for the validity of tests of safety of equipment and personnel, isolate equipment to be tested from the system.

11.6.1.6.15. All testing shall be performed according to the manufacturer instructions and test value limitation indicated by testing equipment company or equipment manufacturer.

11.6.1.7. Test Report

11.6.1.7.1. Incorporate a record of inspections and tests into the test report.

11.6.1.7.2. The test report shall be bond and certified by the testing laboratory.

11.6.1.7.3. The Owner will specify the number of test report copies needed and these shall be received no later than 30 days after completion of project. At the discretion of the Owner's representative, due to the installation scheduling of specific items of equipment or for other reasons, testing may be subdivided into several smaller packages. In that case, one copy of a test report shall be submitted no later than 30 days after completion of each test package, and an inclusive test report containing the package reports shall be submitted in the quantity and the time specified above for the complete project.

11.6.1.7.4. Include the following in the test report:

- Summary of the project.
- Description of the equipment tested.
- Description of test performed.
- List of test equipment used and calibration dates.
- Test results.
- Conclusions and recommendation, if any.

11.6.1.7.5. Where adjustment, modifications, or repairs are made to equipment in order to meet the equipment and/or system specifications, the test results and reports shall indicate the “as left” condition.

11.6.1.7.6. The test forms shall include but not be limited to the following:

- Name plate catalog number, serial number, and rating.
- Desired performance or performance range.
- Measure performances.
- Test equipment used.
- Test personnel and date.
- Any discrepancies or repairs made.

11.6.1.7.7. Test forms that are different than NETA copyrighted test report forms shall be approved by the Owner’s representative.

11.6.1.8. Visual Inspection

11.6.1.8.1. Prior to testing, equipment shall be visually inspected to determine that there is no physical damage, loose bolts or missing parts, and the equipment is supplied in agreement with the contract documents, and properly installed and connected.

11.6.1.9. Environmental Conditions

11.6.1.9.1. Temperature

- Test results shall be corrected to 20°C both actual ambient temperature test reading and calculated, corrected to temperature, test values shall be reported.
- Test shall not be made on any equipment when the insulation temperature is below 0°C.

11.6.1.9.2. Humidity

- Test shall not be made on any equipment where the relative humidity is above 70 percent. Deviations of this requirement will only be made by the Owner’s representative, if it can be demonstrated that the higher humidity will not affect the test or that the higher humidity can be accounted for adequately in interpreting the test results.

11.6.2. Execution

11.6.2.1. Transformers

11.6.2.1.1. Dry Type Air-Cooled, 600 volt and below – Small (167 kVA Single-Phase, 500 kVA Three-Phase, and Smaller).

- Perform inspection and tests listed in NETA, Section 7.2.1.1

11.6.2.1.2. Dry-Type Air-Cooled, All above 600 Volt and 600 Volt and Below-Large (Greater than 167 kVA Single-Phase and 500 kVA Three-Phase)

- Perform inspection and tests listed in NETA, Section 7.2.1.2
- Perform any additional test required by local power Utility.

11.6.2.1.3. Liquid-Filled

- Perform inspection and test listed in NETA, Section 7.2.2
- Perform any additional test required by local power Utility.

11.6.2.2. Cables

11.6.2.2.1. Low-Voltage, 600 Volt Maximum

- Perform inspection and test listed in NETA, Section 7.3.2

11.6.2.2.2. Medium-Voltage, 69 kV Maximum

- Perform inspection and test listed in NETA, Section 7.3.3
- Perform any additional test require by the local power Utility.

11.6.2.2.3. High-Voltage

- Perform inspection and test listed in NETA, Section 7.3.4
- Perform any additional test required by local power Utility.

11.6.2.3. Metal-Enclosed Busways

11.6.2.3.1. Perform inspection and test listed in NETA, Section 7.4.

11.6.2.4. Outdoor Bus Structures

11.6.2.4.1. Perform inspection and test listed in NETA, Section 7.21

11.6.2.4.2. Perform any additional test required by the local power Utility.

11.6.2.5. Switches

11.6.2.5.1. Low-Voltage

- Perform inspection and test listed in NETA, Section 7.5.1.1

11.6.2.5.2. Medium-Voltage, Metal-Enclosed

- Perform inspection and test listed in NETA, Section 7.5.1.2
- Perform any additional test required by local power Utility.

11.6.2.5.3. High and Medium Voltage, Open

- Perform inspection and test listed in NETA, Section 7.5.1.3
- 2 Perform any additional test required by local power Utility.

11.6.2.5.4. Oil Switches: Medium-Voltage

- Perform inspection and test listed in NETA, Section 7.5.2
- Perform any additional test required by local power Utility.

11.6.2.5.5. Vacuum Switches: Medium Voltage

- Perform inspection and test listed in NETA, Section 7.5.3
- Perform any additional test required by local power Utility.

11.6.2.5.6. SF6 Switches: Medium Voltage

- Visual and Mechanical Inspection
    1. Inspect for physical damage and compare nameplate data with plans and specifications
    2. Inspect anchorage, alignment and grounding.
    3. Perform all mechanical operation and contact blade alignment tests on both the circuit switcher and its operating mechanism in accordance with manufacturer’s instruction.
    4. Check tightness of bolted bus joints by calibrated torque wrench method. Refer to manufacturer’s instruction for proper foot pound level.
- Electrical Tests

1. Measure contact resistance
2. Perform switcher travel time test if unit is properly equipped for this test.
3. Circuit switcher shall be tripped by operation of each protective device.
4. Perform insulation resistance test on each pole to ground.
5. Perform AC or DC over potential test on each pole to ground and pole to pole.
6. Perform insulation resistance test on all control wiring at 1000 volts DC (Do not perform this test on wiring connected to solid state relays).
7. All tests indicated in this section shall be verified with equipment manual and manufacturer instructions and recommendations.

11.6.2.6. Circuit Breakers

11.6.2.6.1. Low-Voltage: Insulated/Molded Case
- Perform inspection and test listed in NETA, Section 7.6.1.1

11.6.2.6.2. Low-Voltage: Power
- Perform inspection and test listed in NETA, Section 7.6.1.2

11.6.2.6.3. Medium-Voltage: Air
- Perform any additional test required by local power Utility.

11.6.2.6.4. Medium-Voltage: Oil
- Perform inspection and test listed in NETA, Section 7.6.2.2
- Perform any additional test required by local power Utility.

11.6.2.6.5. Medium-Voltage: Vacuum
- Perform inspection and test listed in NETA, Section 7.6.2.3
- Perform any additional test required by local power Utility.

11.6.2.6.6. Medium-Voltage: SF6
- Perform inspection and test listed in NETA, Section 7.6.2.4
- Perform any additional test required by local power Utility.

11.6.2.6.7. High-Voltage: Oil
- Perform inspection and test listed in NETA, Section 7.6.3.1
- Perform any additional test required by local power Utility.

11.6.2.6.8. High-Voltage: SF6
- Perform inspection and test listed in NETA, Section 7.6.3.2
- Perform any additional test required by local power Utility.

11.6.2.7. Switchgear and Switchboard Assemblies

11.6.2.7.1. Perform inspection and test listed in NETA, Section 7.1

11.6.2.8. Instrument Transformers

11.6.2.8.1. Perform inspection and tests listed in NETA, Section 7.10

11.6.2.9. Metering

11.6.2.9.1. Perform inspection and tests listed in NETA, Section 7.**11**

11.6.2.10. Protective Relays

11.6.2.10.1. Perform inspection and tests listed in NETA, Section 7.9

11.6.2.10.2. Perform any additional test required by latest PREPA regulations.

11.6.2.11. Ground-Fault Protection System

11.6.2.11.1. Perform inspection and tests listed in NETA, Section 7.14

11.6.2.12. Surge Arrestors

11.6.2.12.1. Low-Voltage Surge Protection Devices

- Perform inspections and tests listed in NETA, Section 7.19.1

11.6.2.12.2. Medium and High-Voltage Surge Protection Devices

- Perform inspections and tests listed in NETA, Section 7.19.2

11.6.2.13. AC Motors

11.6.2.13.1. Perform inspection and test listed in NETA, Section 7.15.1.1

11.6.2.14. AC Generators

11.6.2.14.1. Perform inspection and test listed in NETA, Section 7.15.2.1

11.6.2.15. Motor Control

11.6.2.15.1. Motor Starters: Low Voltage

11.6.2.15.2. Motor Starters: Medium Voltage

- Perform inspection and test listed in NETA, Section 7.16.1.2

11.6.2.15.3. Motor Control Centers: Low and Medium Voltage

- Perform inspection and tests listed in NETA, Section 7.16.2.1

11.6.2.16. Adjustable Speed Drive Systems

11.6.2.16.1. Perform inspection and test listed in NETA, Section 7.17

11.6.2.17. Emergency Systems

11.6.2.17.1. Engine Generator

- Perform inspection and test listed in NETA, Section 7.22.1

11.6.2.17.2. Automatic Transfer Switches

- Perform inspection and test listed in NETA, Section 7.22.3

11.6.2.18. Uninterruptible Power Systems

11.6.2.18.1. Perform inspection and test listed in NETA, Section 7.22.2

11.6.2.19. Capacitors

11.6.2.19.1. Perform inspection and test listed in NETA, Section 7.20.1

11.6.2.20. Direct-Current Systems

11.6.2.20.1. Batteries

- Perform inspection and test listed in NETA, Section 7.18.1

11.6.2.20.2. Battery Chargers

- Perform inspection and test listed in NETA, Section 7.18.2

11.6.2.21. Grounding Systems

11.6.2.21.1. Perform inspection and test listed in NETA, Section 7.13

11.6.2.22. References

11.6.2.22.1. The reference Standards are available as follows:

- International Electrical Testing Association (NETA)
  P.O. Box 687, Morrison, CO 80465
  Tel: (303)697-8441; Fax (303)697-8431
  E-mail: neta@netaworld.org – Web site: www.netaworld.org

12. Attachment 1: Deliverables (Documentation after Award)

12.1. Drawings and Specifications

Table 12.1 Owner Drawing List

Sheet	Title	Equip. Spec Review	30% Design Review	Equipment Drawing Review	60% Design Review	90% Design review	As-Builts
-	Coversheet		Yes			Yes	
S100	Structural General Notes		No		Yes		Yes
S101	Racking details		Yes			Yes	
S102	Racking assembly details		Yes			Yes	
S103	Racking configuration		Yes			Yes	Yes
S300	Existing site topos		Yes				Yes
S301	Final site grades		No		Yes		Yes
S302	Fence plan		No		Yes		Yes
S3202	Fencing details		No		Yes		
E100	Legend & specifications		Yes			Yes	Yes
E101	Site Plan - Electrical	Yes	Yes			Yes	Yes
E102	Partial Site Plan - Electrical		Yes			Yes	
E103	Partial Site Plan - Electrical		Yes			Yes	
E104	Substation Detail Drawings		Yes			Yes	Yes
E105	Transmission Line Drawings		Yes			Yes	Yes
E106	Transformer Detail Drawings		Yes			Yes	Yes
E300	One Line Diagram	Yes	Yes			Yes	Yes
E301	Array Circuit Schematic		Yes			Yes	Yes
E302	Cable schedule		No		Yes	Yes	Yes
E303	Communication wiring		No		Yes	Yes	Yes
E400	Interconnect Detail		Yes			Yes	Yes
E401	Trench detail		Yes			Yes	
E402	Grounding plan		Yes			Yes	Yes
E403	Grounding details		Yes			Yes	
O1	Engineer studies and calculations		Yes			Yes	
O2	Startup & commissioning plan				Yes		Yes
O3	Performance test procedure					Yes	Yes
O4	QA/QC plan		Yes			Yes	
O5	Inspection test plan		Yes			Yes	
O6	O&M Manual					Yes	Yes

O7	Construction schedule		Yes		Yes	Yes	
O8	Engineered Equipment Specs	Yes					
O9	Manufacturer's Drawing			Yes		Yes	Yes

12.1.1. Drawings Furnished by Contractor to Owner: Contractor shall prepare and furnish necessary fabrication and erection drawings for installation by others. The Contractor shall submit digital media containing digital copies of all data and drawings compatible with AutoCAD Plant Design Suite or Bentley Open Plant required to perform the work. All drawings shall be transmitted electronically to the Owner. The drawings required and their descriptions are as follows: All physical outlines as required showing the overall size and space requirements (including that required for dismantling and maintenance) and the inter-relationship of the various components. All angles shall be indicated. Cross sections and details as required satisfying the Owner that all components conform to these requirements including design and physical arrangement. All information required by the Owner for the design and location of all connecting Owner furnished structural, mechanical, or electrical items, such as steel supports, anchor bolts, piping, etc. Weight of the equipment and distribution of the static, live, wind, and other loads. Equipment assembly drawings. Erection drawings of Contractor's furnished equipment. Details of special features. The project location and Owner's purchase order number shall be shown on all drawings, including sub-supplier drawings. When of necessity, non-reproducible material is furnished; three (3) copies shall be transmitted to the Owner. Drawings will be examined promptly for general arrangement, general dimensions and suitability and returned with or without comments or suggestions. The Owner has the right to make minor changes and changes required for compliance with these specifications at no change in the Purchase Order price. SUCH REVIEW SHAL NOT RELIEVE THE CONTRACTOR OF RESPONSIBILITY FOR THE ACCURACY OR CORRECTNESS OF ITS WORK OR FOR THE PROPER CONSTRUCTION AND SUCCESSFUL PERFORMANCE OF THE EQUIPMENT IN ACCORDANCE WITH THE CONDITIONS SPECIFIED IN THE CONTRACT. After the first drawing submittal, all drawing changes shall be clearly marked or circled by the Contractor and identified with a complete description in the revision block of the drawing. "General Revision, Per Owner's Marked Print" is not a complete description and is not acceptable. If the Owner's comments or suggested changes are all incorporated into the drawings, then the Contractor may release the drawings for construction. Fabrication or construction shall not be performed until the Owner has returned all drawings related to that work with approval. If the Owner's comments or suggested changes are all incorporated into the drawings, then the Contractor may release the drawings for construction. Fabrication or construction shall not be performed until the Owner has returned all drawings related to that work with approval.

12.2. Operation and Maintenance Manuals

12.2.1. The Contractor shall furnish one (1) hard copy and one electronic set of Owner approved installation, operation, and maintenance instructions and final design approval. The manuals shall include but are not limited to the following:

12.2.1.1. A description of the equipment or engineered system, including major components.

12.2.1.2. Operating theory and enough information to assist the operators and maintenance personnel to properly care for the equipment.

12.2.1.3. Operating instructions, which includes, but is not limited to, proper start-up and shutdown instructions, upset and emergency instructions, operating adjustments, general operating and maintenance procedures, trouble-shooting guides and personnel safety instructions, including warnings for maintenance.

12.2.1.4. Recommended spare parts list.

12.3. Xcel Energy Drawing Standards

The Contractor shall comply with the following drawing standards in the Appendix.

12.3.1. EEC 7.970 W01 Rev. 1.6 Drawing Deliverable Standards

12.3.2. EEC 7.970W01 Rev. 1.6 NSP Title Block

13. Attachment 2: Performance Guarantees

13.1. Functional Tests

13.1.1. The equipment shall be tested for performance prior to commercial operation. This process shall verify the installed system is performing per the design based on the current weather variables.

13.1.2. Prior to the performance test, the Contractor shall perform functional tests. As part of the commissioning process of the newly constructed solar array, the Contractor shall perform a functional test on each of the circuits to verify that they are all operating as expected and designed.

13.1.3. The Contractor shall start up and commission each of the inverters and ensure they are running under their MPPT (Maximum Power Point Tracking) range for optimal performance. The Contractor shall perform an infrared scan to confirm site DC system health prior to conducting the performance tests. The Contractor shall perform repairs or replacements for each string that is not performing as designed.

13.2. Availability Test

13.2.1. This portion of the performance test shall be conducted after the Contractor completes the functional tests and is required for commercial operation. The Availability Test shall be conducted in accordance with the standard outlined in Attachment 16 Availability Test.

13.3. Capacity Test

13.3.1. The Capacity Test shall be conducted prior to commercial operation per the detailed test procedures in Attachment 17 - Capacity Test. The basis for the Capacity Test procedures is ASTM E2848 – Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance

13.3.2. The performance test boundary for the solar array shall be Contractor supplied weather station and the production power meter or other meter shown on the one-line in interconnection agreement in Attachment 8: Interconnection Agreement with One-line Diagram.

13.3.3. The weather data and MWh (megawatt hour) output data shall be recorded during the test with the Owner approved DAS software. The measured total MWh output during the test shall be the actual output of the solar array. The measured total MWh output shall include the accuracy of the production power meter, line loss between inverters and meter and temperature coefficient correction factor (defined by panel manufacturer).

13.3.4. The weather data recorded during the test shall be entered in the PVsyst or equal model included in the As-Built design. The PVsyst model or another numerical model shall be used to calculate the expected MWh output over the duration of the test. The solar irradiance input in the PVsyst model shall be corrected for the accuracy of the weather station pyranometers.

13.3.5. This portion of the performance guarantee shall be met if the actual measured MWh output is greater than or equal to the expected MWh output calculated by PVsyst or another numerical model. If the actual measured MWh out is less than the expected MWh output, the Contractor shall repair or replace components as required and retest the solar facility to meet this portion of the performance guarantee.

13.3.6. This portion of the performance test may be suspended and restarted due to transient weather conditions as mutually agreed to by the Owner and Contractor. The data collected during the test suspension shall be excluded from the performance calculations. The test suspension period shall not extend the overall test period.

13.4. Production Test

13.4.1. The Contractor shall complete a PVsyst model or Owner approved model based upon the final design of the system and 30-year historical weather data for the area that shall provide an expected monthly production estimate for each of the 12 months of the year. The Contractor shall track the monthly production and compare it to the predicted values and the actual observed weather data to ensure the system is preforming as expected from month to month for the two-year warranty period.

13.4.2. The Contractor shall also perform the Performance Ratio Test in *Attachment 12: Production Test - Facility Performance Ratio Test Specification* to fulfill the performance guarantee requirements.

13.4.3. The purpose of a Performance Ratio Test is to compare the Measured Performance Ratio of the facility to its Expected Performance Ratio at the Test on Completion (upon taking over of the facility) and during two years of the warranty period.

14. Attachment 3: Site and Ambient Conditions and Reference Materials

14.1. Summary

14.1.1. Attachment 3 outlines the site conditions used as the basis for performance guarantees, performance tests, and equipment design for the facility site.

14.2. Location

14.2.1. Contactor to specify solar project location.

14.3. Ambient Design Criteria (Contractor to provide per site location.)

14.3.1. Meteorology

14.3.1.1. Local Instrumentation data is used for design wet-bulb temperature, dry-bulb temperature, wind, and other design criteria.

14.3.1.1.1. Temperature and Humidity:

14.3.1.1.2. Maximum Summer Extreme Temperature: degrees F

14.3.1.1.3. Minimum Winter Extreme Temperature: degrees F

14.3.1.1.4. Summer Design Dry Bulb Temperature up to: degrees F

14.3.1.1.5. Summer Design Wet Bulb Temperature: degrees F

14.3.1.1.6. Winter Design Dry Bulb Temperature Down to: degrees F

14.3.1.1.7. Indoor Temperatures

14.3.1.1.8. Summer Design Temperature (Ventilated Areas)

14.3.1.1.9. Winter Design Temperature (Heated Areas)

14.3.1.1.10. Winter Design Temperature (Freeze Protection)

14.3.1.1.11. Precipitation and Snow:

14.3.1.1.12. Annual precipitation in the site vicinity is expected to average xx inches. Annual snowfall in the vicinity averages xx inches.

14.3.1.1.13. Rain Fall Depths (in)

	100 – Year	25 – Year	10 – Year
1 hour			
6 hour			
24 hour			

14.3.1.2. Elevation/Barometric Pressure: The standard barometric pressure adjusted to the facility elevation of xx feet is xx psia**.**

14.3.1.3. Wind Speed

- Structures shall be designed for wind loads in accordance with the currently adopted local building codes, IBC, and ASCE 7.
- The minimum exposure classification shall be “C”.
- Pressure coefficients shall be determined in accordance with ASCE 7
- Wind tunnel design Procedures shall be completed according to ASCE 7, Chapter 31.

14.3.2. Seismic Design

14.3.2.1. Seismic design shall be in accordance with the current local building codes and the IBC. The soil shall be classified as Site Class “D”, unless indicated otherwise in the project geotechnical investigation report.

15. Attachment 4: QAQC (Including Inspection Test Plans)

Table of Contents

Appendix B- QAQC Checklists

Introduction

The purpose of this Quality Management Plan (QMP) is to provide minimum performance standards for Quality Assurance/Quality Control (QA/QC) during the construction of the Project. Procedures and processes will be adjusted to account for the various types of equipment installed and topography of the site. Minimum guidelines will be outlined and will serve as a baseline for the EPC Contractors, prime contractors and/or Subcontractors assigned to the project. Specific requirements shall be put forth in the agreement between the relevant contractors but shall be no less stringent than the minimum requirements set forth in this document.

Specifications and quality standards defined by OEM provider and material suppliers shall supplement the requirements set forth in this document and where conflicts between this document and OEM suppliers exist the installer shall default to the more stringent requirements.

All standards are to be defined and agreed prior to construction start and if necessary shall be modified exclusively through written change order to the scope of work.

Noncompliance to any of the requirements set forth in this document or the design, specifications shall be documented and adjudicated using the Noncompliance Report process. RFIs shall not be used to document and adjudicate deviations to the quality requirements.

General Requirements

All requirements shall follow the standard order of precedence for construction projects. Where there is disagreement between requirements, the more stringent of standards shall apply. These requirements shall not supersede any requirements dictated by applicable codes or standards of the applicable Authority Having Jurisdiction (AHJ) for the project.

Project Quality Policy

It is the responsibility of the installation contractor to provide and maintain an effective PQP, in compliance with the contract documents, applicable codes and standards, while providing a safe work environment for employees and subcontractors. The contractor shall ensure the performance of pre-planning, inspection and, when required, testing of all work included in this project. Tests and inspections will be performed to validate the quality of materials, workmanship, and functional requirements mandated by the O&M provider and contract documents. Results of tests and inspections will be documented on the appropriate forms. Contractor shall insist subcontractors and suppliers shall have a written quality program of their own that equals or exceeds the contractor's own quality program. Subcontractor/supplier may adopt Contractor’s quality program; which subcontractor or supplier will adapt to their work.

Team

1. **Quality Management Team**
   a. The quality management team will include a designated representative from each stakeholder in the project including the Owner, consultant, third-party inspectors, Contractor and Subcontractors.
   b. These team members will be identified early in the project and remain in their respective roles throughout the project.
   c. Although it is not necessary to have meetings involving the entire team at one time, members will attend meetings and inspections related to their area of expertise and will verify the quality of the work under their scope on the project.
2. **Personnel**
   Each project will assign quality management duties to suit the size and complexity of the project and assigned staff. This QA/QC plan will identify staff responsibilities. Dual roles may be assigned for small projects. The following is a suggested general assignment of quality management responsibilities for a typical project:

   a. **Project Manager (PM)**
   The PM is charged with the overall responsibility for the successful completion of the project. The PM's responsibilities include, but are not limited to:
      i. Preparing the QMP with assistance of the other members of the project management team.
      ii. Initiating pre-installation meetings with Subcontractors.
      iii. Monitoring and reporting project progress.
      iv. Interfacing with Owner and resolving disputes and complaints.
      v. Initiating actions to mitigate quality concerns.
      vi. Directing third-party consultants.
      vii. Establishing internal review processes for all QMP documents being sent externally.
      viii. Establishing documentation procedures.

   b. **Project Superintendent (PS)**
   The PS coordinates Contractor and Subcontractor activities on the site. The PS's responsibilities include, but are not limited to:
      i. Overall responsibility for the site and the site personnel.
      ii. Participating in the development of the QMP.
      iii. Participating in pre-installation meetings with Subcontractors.
      iv. Supervising field personnel for compliance with contract scope and quality requirements.
      v. Enforcing implementation of QMP and quality control measures.
      vi. Coordinating day-to-day site inspection activities.
      vii. Coordinating Contractor's and the Owner's third-party consultants

   c. **Project Engineer (PE)**
   The PE is responsible for documentation and information flow. The PE's responsibilities include, but are not limited to:
      i. Participating in the development of the QMP.

ii. Maintaining and distributing the most current contract documents and approved modifications.
iii. Managing QMP related documents such as inspection reports, photographs, deficiency notices, etc.
iv. Documenting quality-related activities such as pre-installation meetings, first work quality control inspections, deficiency log management, etc.
v. Monitoring subcontractor verification that materials delivered to the site are in accordance with the contract documents and approved submittals.

d. Site Quality Manager (SQM)

The SQM's responsibilities include, but are not limited to:

i. Assisting the project management team with the development and execution of the QMP.
ii. Establishing and documenting quality control procedures.
iii. Initiating the pre-installation meetings with Subcontractors and Project team members.
iv. Coordinating Subcontractor communication.
v. Performing and documenting inspections of the Project.
vi. Monitoring Subcontractor compliance with the QMP.

e. Subcontractor (SUB)

i. Subcontractor will provide a quality manager for their scope of work.
ii. Subcontractor will resolve deficiencies within 5 business days.
iii. Subcontractor will verify that all materials delivered to the site are approved and correct.
iv. Subcontractor will attend all pre-installation and first work inspections.
v. Subcontractor will provide mockups as required by their contract.

Quality Control and Assurance

Pre-Installation Meetings

a. Schedule meetings as tasks in the construction schedule and add to submittal schedule.
b. Develop site specific checklists to confirm that the quality requirements for the installation / construction of the project.
c. Use the site-specific checklists for first work inspections and during regularly scheduled site walks.

First Work Inspections

d. Schedule inspections as tasks in the construction schedule and add to submittal schedule.
e. Use checklists and pre-installation meeting minutes to confirm that the work being reviewed meets project requirements.
f. Site Observations / Issues / Resolution
    i. Assigned staff (PS, SQM, SUB) will walk the project regularly and record and transmit deficiencies.
    ii. All non-compliant work will be resolved in 10 working days.
g. Testing and Inspection program
    i. Review the testing standards specified for equipment installed. Confirm that OEM recommendations are appropriate for the specific project.
    ii. Review inspection requirements and develop a protocol for notification and resolution of inspection deficiencies.
    iii. Verify all tools used for testing and inspection is has been calibrated within 12-months.
    iv. See Appendix B for IMTE Calibration List.
h. Digital Photographic record
    i. Maintain a digital photographic record of installation to begin on day one of construction.
    ii. Sub-contractors will also maintain a photographic record of all work and existing conditions.
i. Sub-Contractor requirements and responsibilities
    i. Digital photo record of their work.
    ii. Provide a Quality Management Plan for their work.
    iii. Provide QA/QC inspections daily/weekly as determined by site specific needs.
    iv. Install all equipment according to OEM and/or project specifications.
    v. Maintain up-to-date punch list and status of punch-list work on-going.
    vi. Completion of punch-list items.
    vii. QA/QC punch-list items.

Acceptance (Punch List and Closeout)

j. Completion lists and Punch List
k. As-Built documents
l. Warranties
m. Commissioning
n. Turnover

Electrical Distribution & Communication Components

Vaults & Junction boxes

All electrical and communication above and below ground utility service vaults and junction boxes will be identified. Vaults and junction boxes shall be installed plumb and level, and have proper drainage. Manufacturer instructions and recommendations will be followed for proper installation.

Sitework - Roads

Roads shall be constructed per the project design. Roads shall be compacted to the requirements based on the soils report, and the Engineer of Record. Testing shall be performed at the recommend intervals by the third-party testing company.

Sitework - Trenches

General

Trenches shall be constructed in conformity with Applicable Law. Trenches shall be constructed with applicable stepping/benching or feature adequate shoring to ensure a safe working environment.

All cable trenches must follow straight lines between staked points to the greatest extent possible.

Secondary and service trenches must extend in a straight line from takeoff points wherever possible. The trenches must be dug so that the bottom has a smooth grade. Large rocks, stones and gravel more than ¾ of an inch must be removed from the bottom of the trench.

Compaction reports shall be provided to the EOR and available for Owner's review.

AC / DC PV trenches

DC PV cable trenches shall be free of rocks, gravel, building rubble, metal, chemically active materials and organic debris prior to installation of cables. Trenches shall feature bedding no less than 3" when bedding is required and compacted to a percentage as determined by the Engineer of Record. Bedding should consist of native materials and if necessary, filtered to achieve the particle size distribution per the Plans and Specifications.

Trench backfill and compaction

General

The trenches then shall be backfilled with material excavated from the trench or other suitable materials as required. All backfill materials shall be reasonably free of organic materials and rocks ¾ of an inch diameter or larger so as not to cause subsidence or prevent excavation with hand shovels.

Non-Trafficable Areas

For trenches in non-trafficable areas the backfill shall be placed in recommended lifts from the geotechnical report or by the third-party inspector. Trenches shall be compacted to the minimum specifications called out by the EOR or the geotechnical report. Backfill shall be compacted to and tested at intervals not less than 1000'.

Trafficable Areas

For trenches under roads or other locations where vehicles will cross the trench backfill shall be placed in recommend lifts from the geotechnical report or from the third-party inspector. Backfill shall be compacted to minimum requirements stated by the EOR at intervals not less than 1000'.

Foundations

Racking Foundations (rotation)

Square or rectangular racking foundation piles or tubes shall be installed with a rotation of no greater than that allowed by the racking manufacturer.

Racking Foundations (plumb)

Racking foundations shall be installed at a variance of no greater than the degrees from plumb in either the North- South and/or East-West directions as allowed by the racking manufacturer.

Racking Foundations (embedment)

The embedment of racking foundations shall be determined and defined in the design documentation. Racking foundations shall not be installed where the top of the foundation interferes with PV modules or restricts vertical adjustment of the racking table/sub-array.

Racking Foundations (row-row spacing)

Row-Row spacing shall be determined and defined in the design documentation.

Inverter SS Foundation

Inverter SS foundations shall be installed in accordance with the design documentation. Pile foundations shall be installed to design height as specified by the EOR, rotation from true North shall be no greater than that allowed by the EOR.

Inverter SS foundations shall be galvanized or otherwise protected from corrosion.

Racking

General

Racking shall conform to the manufacturer's recommendations or the design documents. The installation of the racking system will follow the guidelines specified in the manufacturer's installation manual.

Racking Fastener Requirements

All racking fasteners shall comply with the racking manufacturer's recommendations and requirements. If such requirements are not specified, torque values shall not exceed ASME requirements for the fastener type, size and materials.

Cabling

General

All cable shall be visually inspected upon arrival at the site to ensure cable has not suffered physical damage during shipment. Testing of suspect cable can be undertaken to confirm if observed physical damage has resulted in permanent conductor damage. Visual inspection shall also confirm delivered cable conforms to the purchase specifications.

All cable shall be tested per applicable testing standards defined by the Institute of Electrical and Electronics Engineers (IEEE), Insulated Cable Engineers Association (ICEA) and International Electrotechnical Commission (IEC).

AC & DC Cable installation (visual & mechanical inspection)

All cable shall be visually inspected for damage upon delivery acceptance, during storage, before installation and prior to backfill of underground cable. Under no circumstances shall damage cable insulation be acceptable for any installation.

Cable reels shall be inspected prior to cable installation to ensure objects will not damage cable insulation during installation processes. The inside surface of wooden reel flanges shall be inspected and free of objects such as nails, screws, staples, wood burrs and chips.

All torque values for electro-mechanical connections will be verified with a 10% random check by Contractor.

Underground Electrical Collection System

1. Medium voltage cable must be inspected during installation. If a trenching installation method is used, the cables, fiber, ground wire and warning tape shall be inspected during and after they have been installed in the trench and prior to backfill. Inspection should cover cable and reel information, damage to cable, spacing, depth, bedding requirements, etc. Verification that cable meets approved submittal documents (cable manufacturer, size, etc.) must occur at each inspection.

2. Red-line drawings must be updated and reviewed by the subcontractor on a regular basis. Red-line drawings must be submitted to the Engineer of Record who will create the final as built drawings per contract requirements.

3. AC and DC Low Voltage cable must be tested after installation for phase or polarity markings and confirmed by continuity tests.

4. MV terminations and cable splices, shall be installed by qualified persons using approved methods and materials by the Engineer of Record and termination/splice manufacturer and located per project specifications. The termination/splice shall be inspected during cable preparation, before heat shrink is installed and after the heat shrink is installed. The company performing the terminations/splices shall protect the area of work from blowing dirt and dust to reduce the chances of contamination.
5. Insulation-resistance tests ("Megger") will be completed on all low and medium voltage AC and DC power cables, unless otherwise specified. Megger testing procedures must meet NETA and IEEE requirements and shall be reviewed by the Engineer of Record, and Owner's Project Engineer.

6. Very Low Frequency (VLF) testing will be performed on branch circuit feeder cable runs and

performed in accordance with NETA and IEEE requirements.

7. Inspect bolted electrical connections for high resistance using one or more of the following methods:
    1. Low-resistance ohmmeter
    2. Verify tightness using a calibrated torque wrench
    3. Perform a thermographic survey

8. Inspect shield grounding, cable supports and terminations.

9. Verify cable bends meet or exceed ICEA and manufacturer's minimum bending radius.

Cable Terminations

All compression type cable terminations will be made in accordance with manufacturer recommended processes, terminals, mechanical crimp equipment and compression dies. Terminations will be made in accordance with all applicable electrical codes and standards. Terminations will be inspected prior to circuit energization.

Cable Conduit

All conduits shall feature bell-end fittings or smooth transitions.

All conduits shall use sweeps that maintain the minimum bending radius of the cable whenever the conduit changes direction.

Disconnect DC cables

All wires must have an identification label applied. The label must be legibly printed and of such material as to remain in place for a minimum of 10 years.

Any un-terminated and unused cable must be identified and labeled accordingly. Unused cable must be secured and electrically isolated in such a way as to not be hazardous to qualified service personnel working on or inside the enclosure.

The quality of DC cable installation and termination will be inspected inside each disconnect box. Items, such as, wire bend radius, wire lay or routing, labeling, wire strip length, and pull tension will be observed. Loose wire strands from PV source circuits or DC feeder cables will not be tolerated and will be promptly corrected. All screw type wire terminals, including ground terminals, will be torque checked and marked accordingly.

Anti-oxidizing compounds will be applied to appropriate aluminum/aluminum and aluminum/copper/tinned copper lug type terminations. Each will require a specific type of compound. Ground terminations provided above ground are not required to have anti-oxidizing compound applied.

Fiber Optic Cable Installation

<u>Labeling</u>

Each cable is to be permanently labeled at each end with a unique cable number. In addition, labels shall be affixed to the cable/inner duct at every transition of a vault, hand hole, riser closet, or major pull box.

Fiber Termination Standards

The terminal ends of all fibers cable strands shall be field connectorized. The connectors shall be mounted on bulkheads and installed in enclosures called Fiber Integration Centers (FIC). The choice of termination method must be in accordance with the Engineer of Record.

Fiber Cable Testing

Installation and termination:

All single mode and multi-mode fiber strands shall be tested end-to-end for bi-directional attenuation, 850 nm/1300 nm for multimode and 1310 nm/1550 nm for single-mode fibers. Tests should be conducted in compliance with EIA/TIA-526-14 or OFSTP 14, Method B, according to the manufacturer's instructions for the test set being utilized.

Tests must ensure that the measured link loss for each strand does not exceed the "worst case" allowable loss defined as the sum of the connector loss (based on the number of mated connector pairs at the EIA/TIA-568 B maximum allowable loss of 0.75 dB per mated pair) and the optical loss (based on the performance standard above, Section 2.1.1 and Section 2.2.1).

After termination, each fiber shall be tested with an OLTS / OTDR for length, transmission anomalies, and end-to- end attenuation. Results are to be recorded and supplied to the Engineer of Record and the Owner's project engineer. Test results will be supplied in the form of hard-copy printouts or photographs of screen traces.

After termination and bulkhead mounting, each terminated fiber is to be tested for end-to-end loss with a power meter/light source. Results are to be recorded and supplied to the Engineer of Record and the project engineer. Test results will be supplied in the form of hard-copy printouts or photographs of screen traces.

The maximum allowable attenuation for any splice or termination is 0.3 dB. (Or OEM spec).

The contractor or sub-contractor shall review all end faces of field terminated connectors with a fiber inspection scope following the final polish. Connector end faces with hackles, scratches, cracks, chips and or surface pitting, shall be rejected and re-polished. Terminated connectors will be replaced if re-polishing will not remove the end face surface defects. The recommended minimum viewing magnifications for connector ends are 100X for multi- mode fiber and 200X for single-mode fiber.

Electrical

General

1. The purpose of this section is to establish the quality assurance methods and procedures for installation, examination, testing and acceptance of electrical equipment and material during construction, installation, and pre-commissioning.

2. Prior to execution of work, a planning meeting shall be held.

3. All equipment, materials, products, design and construction shall be incompliance with contract documents, design drawings and specifications and the requirements of this section.

4. Contractor shall comply with manufacturers' installation instructions. If manufacturers' instructions conflict with the Agreement, the Project Manager shall request clarification through the RFI process

before proceeding. Store and protect material and equipment prior to installation per manufacturer's instructions. Submit manufacturer's operation and maintenance manuals and information to Owner and provide instruction to Owner per contract documents.

5. All testing and installation shall comply with applicable and/or specified standards, tolerances, codes, or requirements. It is the responsibility of contractor to ensure equipment is properly tagged and marked as required by applicable codes and specifications.

6. Pre-commission energization of electrical equipment will be conducted only when specified and only with permission from contractor and owner. All lockout and tagout procedures shall be followed. All parties shall be informed of energization before it takes place. Contractor shall have and maintain zip-tie type LOTO; gang clasps and locks will be used for special conditions on site for LOTO purposes.

7. Factory acceptance test reports shall be provided and submitted to Contractor and the Engineer of Record for review and approval. These tests include but are not limited to medium voltage cable, transformers, and fiber optical cable.

8. Perform system functional testing after component acceptance testing is complete to verify that all equipment and systems will operate properly. Notify owner/customer in advance to allow them to witness.

9. Functional test reports will be submitted to Contractor within the time specified, not to exceed ten (10) calendar days of completion, indicating observations, results of tests and compliance with the Agreement. Reports indicating non-compliance with the Agreement shall be submitted to Contractor within ten (10) calendar days of completion.

10. If necessary to comply with manufacturers' warranty terms or if specified in contract documents, arrange for material or equipment suppliers or manufacturers to provide qualified staff personnel (field representative) to perform certain work scopes such as inverter commissioning.

11. Contractor must comply with NEC, NESC, NETA, and applicable ASTM/ANSI requirements unless more stringent testing protocol(s) are required or established by the contract documents. Comply with local utility company requirements or owner's/customer's standards as applicable. Provide and document independent electrical inspection from local authority having jurisdiction for NEC compliance.

12. Subcontractors shall provide installation procedures, specific to the activity, when the work being installed crosses over or under any live overhead lines, transmission lines, substations, fiber optic lines, gas lines, utility lines, canals, aqueducts, water mains, public roads or rail roads.

Receiving, Storage, Testing and Inspection

The purpose of this section is to ensure that receiving, inspection and testing requirements as required by applicable codes, standards or regulatory bodies, and project contract documents, are fulfilled by the contractor. All work including direct and indirect purchased material and equipment within the scope of work described by the project contract, is covered by this procedure.

All incoming material and equipment shall be subject to a receiving observation upon arrival. The receiving observation shall be performed to assess the condition of the item(s) being received including verification of quantities, model numbers, and serial numbers, and mark numbers, compliance with the contract or other documents. Visual observation or non-destructive testing for damage or deterioration, and compliance with applicable design tolerances will also be completed.

A photographic record shall be made of all incoming materials and equipment which are damaged, deteriorated or suspected of damage or deterioration. Small damages (paint scuffs, discoloration, small dings, rough surfaces, etc.) shall be noted and evaluated on an individual basis.

All deliveries shall be logged into documentation management programs or a suitable delivery log on regular intervals.

All testing, including welding, shall be performed in accordance with applicable codes, standards or regulatory bodies. Test reports shall be generated by the party performing the test and provided to contractor within ten (10) calendar days of completion. Copies of all tests results and reports are to be provided to Owner's project engineer within 30 days of receipt.

During the term of storage, material / equipment shall be maintained as required by the contract documents. If special storage requirements are necessary, the supplier or owner, if applicable, will provide information for proper storage.

Site Fencing

Verify all posts are installed plumb and true. End, corner and pull posts are firmly anchored and supported. Fabric and tension wires shall be tight and secure. Fabric to be continuous between stretch bars. Wire ties / hog rings shall be the same material as fencing fabric.

Gates shall be installed plumb, level and secure. Gates shall swing and move freely without binding. Verify gate stops are installed, plumb and secure.

Appendix A – IMTE Calibration List

Trade/User	Tool	Measurement Type	Tool Tolerance
Pile Driving	Digital Level	Degrees	±1.5°
Racking	Torque Wrench	Ft-lbs or nm	4:1 or Greater
String Testing	Voc / Isc	V & mA	±1V , ±10mA
Megger	Insulation tester	Ohms	25ohm, 4:1 or Greater

Appendix B – QAQC Checklists

Panel Delivery
Receipt of panels
Inspection of panels upon receipt
Tracking of received panels
Acceptance of received panels

AC & Fiber Trenching QAQC
Verify Trenching Width and Depth (30"x Max. 54"
Deep) Verify Trench Bedding (3" Min.)
Verify Bedding is Free of Rock/ Debris Prior to Placement of
Cable Verify AC Conductor Size and Quantity
Verify Horizontal Spacing of Conductors (2" Min.)
Verify Horizontal Spacing Between Different Circuits in the Same Trench (4”
min) Confirm All Conductors are not Visually Damaged
Verify Vertical Spacing of Conductors (6" Min.)
Verify Warning Tape is Properly Placed (12" Below
Grade) Verify Compaction is Per the Plans and
Specifications Verify Fiber Cable Conductor Size and
Quantity
Verify Fiber Cable Conductor Spacing from AC Conductor
(6") Verify Correct Size Ground Wire

QAQC DC WIRE TRENCHING CHECKLIST
Verify Trenching Width and Depth (Min. 30"x Max. 42")
Verify Bedding is Free of Rocks/Debris Prior to Placement of
Wire Verify DC Conductor Size and Quantity
Verify Horizontal Spacing of Conductors (Min. 2")
Confirm Conductors are Not Visually Damaged
Verify Vertical Spacing of Conductors (Min. 4")
Verify Warning Tape is Properly Placed (12" Below
Grade) Verify Compaction Per the Plans and
Specifications

QAQC IES TRENCHING CHECKLIST
Verify Trenching Depth matches of the depth of the conductors coming into the IES Pad
Verify Conduit Layout Spacing is Correct
Verify the Number of Conduits is Correct
Verify the Size and Type of Conduit is Correct
Verify the Conduit Stub Ups have an End Bell on the Ends to Protect the Cable
Verify the Conduit is Plumb and Level
Verify the Height of the conduit so it makes it into the Cabinet in the Transformer or Skid
Verify the Conduit is not damaged before backfilling
Verify Bedding is Free of Rock/Debris Prior to Placement of
Wire Verify Warning Tape is Properly Placed (12" Below F.G.)
Verify Proper Compaction Per the Plans and Specifications

QAQC IES GROUNDING CHECKLIST
Verify IES Grounding Layout per Blymyer Drawings
Verify Depth of Ground Ring (30" min.)
Verify Ground Ring Connection
Verify Depth of Ground Rod (9'-6" min.)

QAQC INVERTER SKID PILES/ WELDING CHECKLIST
Verify Pile Embedment (3'-2" Max. Projection Above F.G.)
Verify Pile Size (W6x7)
Verify Pile Spacing and Orientation Per Blymyer
Drawings Verify Plate Size (8"x8"x.5")
Verify Weld Plates are Installed and Level
Verify Plates Have 3-(3/16") Field Fillet Welds
Verify Skid is Set with The Transformer and Inverters Orientated Per Plan
Specifications Verify If A Shim Has Been Inserted Between Inverter and Plate

QAQC PILE INSTALLATION CHECKLIST
Verify Corner Piles Are in Proper Location
Verify Correct Row Spacing: 23'-0" (GCR 28.6%)
Verify Correct Pile Spacing Per Blymyer Drawings
Verify Correct Array Pile Size, Projection, and Embedment
Verify Correct Motor Pile Size, Projection, and Embedment
Verify Pile Sizes Are in Correct Location
Verify Motor Row Alignment
Check Top for Damage/ Paint

QAQC RACKING INSTALLATION CHECKLIST
Verify Torque Tube Size, Gauge, Elevation and Alignment
Verify Bearing Housing Assemblyis Visually Leveled and Aligned with the Torque Tube and Piles per the Racking Install Manual
Verify BHA Rail is seated and flush with torque tube
Verify No Gaps between (BHA) Bearing Housing Assembly, BHA Mounting Bracket and the Pile
Verify the Right Size Bobtail Pins and Collars are Installed in the Right Locations
Verify Motor is Orientated on East Side of Slew Gear
Confirm All Bolts on Slew Gear Assembly are Torqued Per Nextracker Manual and have Torque
Marks Verify Installed BOMs have been galvanized
Verify SPC Box Aligned, Secured, and Orientated on South Side of Slew Gear
Verify the Interior Rows have an Interior Slew Gear and the Exterior Rows have an Exterior Slew
Gear Verify Antenna is Connected to SPC Box
Verify Damper Location, Mounting Spacing, and Orientation
Verify All Bolted Connections are Torqued to Right Value and Marked per the Racking Install
Manual Verify End Caps are Installed

QAQC MODULE INSTALLATION CHECKLIST
Verify Module Is Centered Over Torque Tube
Verify Module Spacing from Middle of Slew Gear
Verify the Right Module Wattage is in Right Location
Verify the Right Type of Rail is Installed in Right
Location
Verify All Rails are Leveled Within 0 Degrees Relative to the BHA Module Rails Before Fastening

Verify Holes in Module Frames Align with the Holes on the Rail
Verify Module is Aligned on Both Sides and Fasten with the Right Size Bobtail Pin and Collar
Verify Torque Marks on All Module Rail Straps
Verify Modules are Not Visually Damaged

QAQC STRING WIRE CHECKLIST

Verify all wires are fully plugged in and clicked
closed Verify No Wires are Hanging
Verify Zip Ties are Properly Installed with a Minimum of ¼” of
tail Verify Wire is Not Sagging
Verify No Sharp Edges Near Wire

QAQC DISCONNECT SWITCH CHECKLIST

Verify DS Piles Are in The Correct Location and
Elevation Verify Disconnect Switch Location
Verify Stub Up Location
Verify Switch Height (Min 1'-6") above ground
Verify Disconnect Switch String Count
Verify Disconnect Switch Has a Name Plate and Free of
Damage Vertical Stub Up Conduit is Not Damaged and Plumb
Verify Outside of Switch Is Not Damaged
Verify Correct Disconnect Switch Pile Size and
Embedment Verify Switch is Plumb

14.1.1.

15.1.1. Civil

15.1.1.1. The testing requirements identified in this section apply to all civil work for the Project including access roads, foundations, collection, transmission, substation, electrical equipment enclosure, O&M building, etc.

15.1.1.2. Earthwork

15.1.1.2.1. All common, select, or granular fill material shall be qualified by testing to assure minimum gradation requirements. Material selected for use as fill, shall be sampled and a gradation test performed in accordance with ASTM C136. A gradation test shall be performed at a frequency of one for each source or each 10,000 cu. yds. of fill placed. On-site excavated material or imported material from other sources must be tested.

15.1.1.2.2. Soils used for Fill Material shall be tested for Grain Size Analysis (AASHTO T27), Atterberg Limits (AASHTO T89 and T90), Moisture Content (AASHTO T265), Proctor Tests (AASHTO T99), and LA Abrasion Tests (AASHTO T96). Tests shall be performed at a frequency of one for each source or 10,000 cubic yards of filled placed.

15.1.1.2.3. For placed and compacted fills for wind turbine foundations, provide one relative moisture and compaction test per lift indicating test location, dry density, moisture content and % proctor maximum dry density.

15.1.1.2.4. For placed and compacted fills for other locations, provide the greater of 3 relative moisture and compaction tests per lift or 1,000 cubic yards placed, indicating test locations, dry density, moisture content and % Proctor maximum dry density.

15.1.1.2.5. Compaction tests shall be taken as required by the Design Documents. In the event of failed tests, Contractor shall not place additional fill until acceptable test results are obtained.

15.1.1.3. Crane Pads

15.1.1.3.1. Provide adequate testing, as specified by Engineer of Record, to ensure field subgrade bearing capacities meet or exceed main erection crane bearing pad and critical lift requirements.

15.1.1.4. Access Roads

15.1.1.4.1. Compacted Subgrade

a. Access roads shall be proof-rolled the full length in the presence of a geotechnical engineer or qualified and approved representative with a loaded tandem axle dump truck having a minimum gross weight of 25 tons. Subgrade shall be corrected if rutting greater than 1.5 inches and/or “pumping” of the subgrade occurs.

b. The method to scarify, dry and recompact subgrade shall not be allowed unless the material is proven not to contain organic material and/or material unable to remain compacted during or after a rain event.

c. **The requirements set forth in Section 15.1.1.5 shall be met if access road subgrade is cement stabilized.**

15.1.1.4.2. If applicable Nuclear Density Tests (AASHTO T310) shall be taken every 500 linear feet of road or a minimum of 3 tests per access road.

15.1.1.4.3. Aggregate Base and Top Course

a. Entire road length shall be proof-rolled. Where geogrid membrane is used, a Dynamic Cone Penetrometer (DCP) test (ASTM D6951) shall be taken at a frequency of 1 for every 500 lineal feet of road. A DCP test shall also be taken at a frequency of 1 for every 500 lineal feet of road in areas where an initial proof-roll test has failed. A sieve analysis shall be taken for placed base material and cap material at a frequency of 1 for every 2500 cu yd. A minimum of 2 standard Proctors should be performed on the road base and top course aggregate materials.

15.1.1.5. Cement Stabilization

15.1.1.5.1. Density tests shall be taken at the rate of one test every 1,000 square yards (i.e., approximately seven tests per eight ft. pass per mile).

15.1.1.5.2. Subgrade strength testing by DCP shall be done randomly for every 300 LF in each pass of the reclaimer. After at least two days of production, or when the engineer of record deems the procedure satisfactory, the testing may be increased to every 500 LF. Subgrade strength testing shall be done at 24 hours (plus or minus 4 hours) from the time of final compaction of the stabilized material. A minimum of 15 CBR is required prior to proof rolling by Contractor.

15.1.1.5.3. Additional subgrade strength testing by DCP shall be done at two to seven days from the time of final compaction on a 500 LF spacing. The test must confirm a CBR of 20 is achieved. If a CBR of 20 is not achieved, additional gravel surfacing will be required and the cement content for future stabilization will be adjusted.

15.1.1.5.4. Prior to placement of gravel surface, the subgrade shall be proof-rolled.

15.1.1.6. Concrete Works

15.1.1.6.1. All concrete, reinforcement, anchor bolts, embed plates, formwork, etc. shall be inspected per the current International Building Code (IBC), Chapter 17, "Special Inspections."

15.1.1.6.2. General Concrete Tests

a. Tests shall be conducted by an independent third-party in accordance with ASTM standards. The location, date, mix, temperature, slump and percent air shall be recorded. Concrete deliveries that do not meet the design specifications shall be rejected.

b. Cast cylinders at least once per day, between batches of differing concrete mix designs, or for every 150 cubic yards of concrete placed. Perform laboratory strength testing per ASTM C39 at 7, 14, and 28 days.

c. Perform a minimum of one air test in accordance with ASTM C231 per set of strength test cylinders cast.

d. Perform a minimum of one slump test in accordance with ASTM C143 per set of strength test cylinders cast.

e. Cast a minimum of nine grout cubes for each foundation and perform laboratory strength testing in accordance with ASTM C109 at 3 and 28 days.

f. Each test cylinder shall be identified by number and record each concrete truck number, date and time batched, number of yards, additives in the mix, the time the concrete was placed, and the structure number of the foundation poured. These records shall be reviewed by the Engineer of Record and submitted to Owner. Test reports shall be labeled in a manner that will allow each test cylinder to be identified with a particular day, time, concrete truck, and structure number.

g. A report of each test cylinder break shall be e-mailed to the Engineer of Record, Owner, and concrete supplier within 2-business days from date of test.

h. Concrete that appears to be of low strength, as evaluated by ACI 214R - Guide to Evaluation of Strength Test Results of Concrete, shall be replaced at no additional cost to Owner.

15.1.2. Electrical

15.1.2.1. Collection

15.1.2.1.1. Upon completing installation of all systems and equipment, but prior to electrical substantial completion, Contractor shall conduct an operational test of all equipment, controls, and devices installed or modified by Contractor.

15.1.2.1.2. Contractor shall notify Owner in writing a minimum of three (3) Business Days in advance of any test. This operational testing is in addition to testing required in separate sections of this specification. Where possible, combination of this testing and other testing required should be accomplished to minimize travel requirements.

15.1.2.1.3. Power Cable Acceptance Testing

Installations of power cable including terminations are to be acceptance tested using D-C or low frequency AC high potential (Hipot) testing, and at a minimum to include the following tests. After completion of a test and before handling the cable, the conductor shall be grounded to permit any charge to drain to earth.

a. Continuity -After installation of the cable and prior to the high potential test specified below, a simple continuity test shall be conducted on the system. This can be accomplished by grounding the conductor at the source and checking for continuity from the end of each tap with an ohmmeter.

b. Cable Jacket Integrity Test -Cable Jacket integrity testing shall be performed on all collection cables. Defects or damage to cable jackets shall be repaired using a cable OEM approved method, or the damaged cable section shall be replaced.

c. High Potential - After successful continuity tests of the 34.5 KV collection system, high potential tests on each length of cable, with terminations in place but disconnected from the system. The installation shall withstand a minimum of fifteen (15) minutes D-C test potential or as recommended by the cable and connector manufacturers. The voltage may either be increased continuously or in steps to the maximum test value.

d. If increased continuously, the rate of increase of test voltage should be approximately uniform and increasing to maximum voltage in not less than ten (10) seconds or more than sixty (60) seconds.

   If applied in steps, the rate of test voltage increases from one step to the next should be approximately uniform. The duration at each step shall be long enough for the absorption current to attain reasonable stabilization (one minute minimum). Current and voltage readings should be taken at the end of each step duration. The number of steps should be from five to eight.

   Once VLF testing has been completed a test voltage shall be applied to the collection feeder riser conductors. Every switchgear in that feeder should then be checked with a multimeter to verify collection phasing. This test can only be conducted once all collection cable has been terminated and landed for each feeder.

e. If more than three failures of any particular component occur within six months of commercial operation, then partial discharge testing shall be performed on all similar components.

f. Other Test and Inspections: All other tests and inspections described in the Project Quality Assurance Plan.

15.1.2.1.4. Padmount Transformer Testing

a. The following transformer checks and tests shall be completed on all units:

b. Inspection of satisfactory mechanical installation including proper torque on bolts, labeling and grounding.

c. Insulation resistance test for winding to winding and each winding to ground. Calculate Polarization Index.

d. Field test of transformer turns ratio test on all taps.

e. Routine and Design tests specified for Class I power transformers identified in IEEEC57.12.00 2010 table 18

f. Oil analysis for visual inspection, gas, liquid screen, and Karl Fischer moisture at minimum.

g. All other test and inspections described in the Project Quality Assurance Plan.

15.1.2.1.5. Quality Control Testing

Upon completing installation of all systems and equipment, but prior to electrical substantial completion, Contractor shall conduct an operational test of all equipment, controls, and devices installed or modified by Contractor.

Contractor shall notify Owner in writing a minimum of three (3) Business Days in advance of any test. This operational testing is in addition to testing required in separate sections of this specification. Where possible, combination of this testing and other testing required should be accomplished to minimize travel requirements.

15.1.2.2. Transmission Line

15.1.2.2.1. A visual inspection of phasing and overall construction shall be conducted by all interested parties prior to energization.

15.1.2.2.2. Ground resistance testing.

15.1.2.2.3. OPGW

a. Pre-installation Acceptance Testing

Contractor will require the cable manufacturer to ship the cables such that both cable ends are exposed allowing for testing in both directions

After the fiber optic cables are received, but prior to Contractor installing the cables, Contractor shall make sure there has been a bidirectional OTDR test of the cables on the reels. All fibers shall be tested.

All testing shall be done at both optical wavelengths 1300 and 1550 nanometers and results recorded and copies of the testing supplied to Owner. These tests shall be compared with the reel tests performed by the manufacturer. Contractor shall immediately report any discrepancies, defects or anomalies to the supplier and is responsible for any replacement costs incurred.

b. Installed Testing

After installing the fiber optic cables and after all required splicing and termination work, Contractor shall perform a final bidirectional OTDR test on each cable segment. All terminated fibers shall be tested from termination to termination.

Testing shall be performed for each fiber at two wavelengths (1300 and 1550 nanometers). The OTDR shall have a hardcopy feature and digital storage media compatible with standard software such as Excel or Word.

Each OTDR trance shall be identified by fiber ID (tube/color or number), end points (by site name), and launch point. Contractor shall completely investigate any discrepancies, defects or anomalies, as indicated by Owner immediately. Any damage to the fiber optic cables detected during final testing shall be repaired by Contractor at Contractor's sole expense.

In addition to OTDR testing, an optical attenuation test shall be performed on selected fiber circuits. This test shall be performed at 1300 and 1550 nanometers, using a calibrated light source and optical power meter.

Any cable that is tested with negative performance characteristics will be replaced or adjusted as necessary.

Copies of the test results shall be submitted to Owner and Engineer of Record for review and approval prior to final acceptance.

15.1.3. Substation

15.1.3.1. Tests

15.1.3.1.1. Upon completing installation of all systems and equipment, but prior to electrical substantial completion, Contractor shall conduct an operational test of all equipment, controls, and devices installed or modified by Contractor.

15.1.3.1.2. Contractor shall notify Owner in writing a minimum of three (3) Business Days in advance of any test. This operational testing is in addition to testing required in separate sections of this specification. Where possible, combination of this testing and other testing required should be accomplished to minimize travel requirements.

15.1.3.1.3. For the following sections, the term “function” or “function testing” means applying the appropriate inputs (voltage, current, pressure, temperature, etc.) to a device, and verifying all required responses or outputs. Testing shall be completed on the specified equipment after it is fully assembled and installed at its permanent location. The types of tests covered by this criteria document include, but are not be limited to the following:

15.1.3.1.4. In general, all equipment will require the following:

a. Inspection - Visual and mechanical inspections shall be performed.

b. Verify the nameplate data against the design criteria and the "Bill of Materials".

c. Check that there are no broken or cracked parts or other physical damage. Check that screws are tight. This includes relays, synchronizers, cases, and covers.

d. Check devices for moisture or damage from moisture and foreign materials that could inhibit the proper operation and functioning of the devices.

e. Check for proper contact alignment and travel, disc rotation for freedom of movement, target operation, etc. Adjust mechanical alignments per the manufacturer's specification.

15.1.3.2. Grade Tolerances

15.1.3.2.1. Grade for “rough grade” elevations shall be established to a tolerance of ± 5/8”. Horizontal plan dimensions shall be maintained within 0.05 feet of plan location. Road elevations and line shall be located within the same tolerance limits.

15.1.3.3. Structural Steel Erection

15.1.3.3.1. Contractor shall accommodate all inspection and testing activities of high-strength bolted connections and field-welded connections by Owner. Contractor shall perform tests and prepare test reports as required to ensure the complete and finished erection of steel structures.

15.1.3.3.2. Contractor shall document all non-conformances, deficiencies, or deviations identified during the inspection and test process in detail through their non-conformance reporting process and submit to the Company for review and approval of the resolution. Deficiencies revealed through inspections and laboratory tests which are determined to be in non-compliance with this Specification shall be corrected at Contractor's expense. Additional tests shall be performed at Contractor's expense, as necessary, to remove a non-compliance of the original steel erection.

15.1.3.3.3. Bolted Connections

- Field bolted connections shall be inspected in accordance with AISC specifications using the turn of the nut method.

15.1.3.3.4. Field Welded Connections

a. Contractor shall perform inspection and testing of field welded connections during the erection of the structural steel. The following activities shall be performed:

b. Visual inspection of all welds for weld profile and surface defects.

c. Instrument inspection of selected welds to check for defects and discontinuities which are not visible on the surface involving one or more of the following methods:

  - Ultrasonic Inspection: ASTM E 164.
  - Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not acceptable.
  - Radiographic Inspection: ASTM E 94 and ASTM E 142; minimum quality level "2-2T."
  - Contractor shall record the types and locations of any defects found in field welds and will outline work to be performed by Contractor to correct all deficiencies in field welded connections.

15.1.3.4. Individual Equipment Testing

15.1.3.4.1. Power Transformers

a. Main Power Transformers shall be tested from the field device to the EEE.

b. See for more information.

15.1.3.4.2. Circuit Breakers

a. Physical Testing
- Fill with gas (SF-6 breakers only) and have SF-6 tested as required.
- Connect operating Linkage (for independent pole breakers)
- Perform Hi-Pot vacuum bottles and check measurements (vacuum breakers only)
- Perform visual and operational check of mechanism
- Perform timing and velocity tests
- Perform power factor test on individual bushings and overall power factor
- Sniff/soap for leaks on gas breakers
- Measure contact resistance

b. Control Testing
- Perform current transformer (CT) Tests
- Local checks at the breaker:
- Check function of heater circuit.
- Check function of controls (trip, close, block trip/close, dual trip coil, anti-pump, etc.)
- Check alarms to terminal blocks
- Check labeling of fuses, switches and relays
- Check calibration of relays at breaker
- Wire check AC circuit
- Calibrate relaying
- All associated breaker failure relays
- All associated sync-check and voltage monitoring relays
- All associated reclosing relays
- Any synchronous pole operation controls
- All associated PLC/DCS alarm and control schemes

15.1.3.4.3. Circuit Switchers and Motor Operated Disconnect Switches

a. Physical Testing
- Verify pole synchronism. Switches should be adjusted to manufacturer tolerances.
- For Circuit Switcher and interrupter type devices, perform insulation resistance tests on each pole in accordance with the manufacturer's recommendations.
- Measure the contact resistance across each closed switchblade.
- High-Pot vacuum bottles
- Power factor test on individual bushings and overall power factor
- Check and align switch/fuse combinations
- Verify that expulsion limiting devices are present on all holders having expulsion type elements.

- All problems shall be resolved and all adjustments completed prior to driving the piercing bolts.
- For Circuit Switchers, interrupters, and similar devices, check the timing of the shunt trips and the mechanical trips on the attachments.

b. Control Testing (MOD's and Circuit Switchers Only)

- Check function of heater circuit.
- Check local function of limit switches.
- Verify proper cam positioning.
- Check local function of interlocks.
- Check function of controls from control house.
- Test and document EMS control and status

15.1.3.4.4. Capacitor Banks

a. Physical Testing

- Measure and record capacitance of strings/series groups with capacitance meter.
- Verify equipment is properly grounded

b. Control Testing

- Perform Current Transformer (CT) Tests
- Perform VT testing
- Perform capacitance value check - by voltage method (fuseless only) verify equal voltage distribution across each can
- Perform wire check of AC circuits
- Calibrate relaying
- Verify metering calibration
- Verify function of control circuits
- Test alarms to annunciator and to RTU/PLC (remote terminal unit) inputs
- Test and document EMS analog, control, alarms and status

15.1.3.4.5. Transmission Line Relaying

a. Control Testing

- Wire check AC circuits
- Check Line VTs
- Perform manufacturer's acceptance tests for all line relays
- Calibrate relaying, and verify settings for all line relays
- Set up pilot relaying and transfer trip equipment common to all piloted systems
- Apply settings
- Perform "back to back" local function tests
- Perform "end to end" piloted relaying and transfer trip tests
- Record installed signal receive levels
- Check alarms to annunciator and EMS

- Tone equipment
- Carrier equipment
- Verify metering calibration
- Function relaying control circuits
- Perform tuning of carrier equipment on ungrounded line
- Test and document EMS analog, control, alarms and status
- Download as-left relay setting files and turn as-left setting files over to Owner.

15.1.3.4.6. SCADA Systems and Annunciators

a. SCADA Tests
   - Set-up Remote Terminal Unit (RTU) equipment
   - Function test all control, indication, alarm, and analog points in the RTU, to and from the EMS. Verify SCADA descriptions match inputs.
   - Test for connection and functionality to the Turbine Supplier's SCADA system.

b. Traditional Annunciator Tests
   - Check all points including spares along to verify operation of lights, bells, cutoffs, and resets.
   - Verify labeling matches print and is to standard

c. Programmable display panel tests
   - Load configuration software
   - Verify labels are correct in both the schematic and settings spreadsheet.
   - Save final configuration to disk to leave on site.
   - Supply final configuration files to Owner.

15.1.3.4.7. Substation Batteries & Chargers

a. Physical Testing
   - Clean, lubricate and install inter-cell connectors.
   - Torque inter-cell connectors to manufacturer's specifications
   - Measure and record resistance of inter-cell connectors
   - Test DC voltage (float & equalize)
   - Measure temperature and specific gravity of each cell.
   - Perform a battery discharge test per IEEE 450 (if required)

b. Control Testing
   - Check loss of AC alarm
   - Calibrate battery monitoring relay
   - Test alarms to annunciator and to RTU/PLC inputs
   - Test and document EMS alarms
   - Verify DC lighting system (if required)
   - Verify correct coordination of charger with vent fan operation (if required)

15.1.3.4.8. Station Aux./ Transfer Switches/Load Centers

a. Check all circuit connections immediately prior to energization
b. Energize equipment one stage, section, circuit, or piece at a time to minimize the damage in the event of an equipment failure and to aid in locating trouble areas.
c. Put settings on transfer switch, verify proper voltage magnitudes, current magnitudes, phasing, and correct operation during energizing
d. Check all interlocks and verify the correct operation of keyed interlocks (Kirk® key). (If required)
e. Equipment ground verification.
f. All measurements and tests shall be recorded.
g. Load centers
   - Verify correct labeling and fusing of load center circuits
   - Check or verify that construction has functionally checked the labeling of the load center loads

15.1.3.4.9. Miscellaneous equipment

a. Control & instrument switches
b. Verify operation and design function of and proper operation sequence of all devices.
c. Check control house temp alarm (check to annunciator and EMS)
d. Check control heater and vent fan controls and proper labeling
e. Verify time stamp and time reference systems.
f. Doble® surge arresters, bus work, free standing CT's, coupling capacitors (CCs), VTs, CVTs, and CCVTs, and air core reactors.
g. Verify functionality of HVAC systems.
h. Verify functionality of security intrusion alarm systems.
i. Verify functionality of fire alarm systems.
j. Verify functionality of substation lighting control system.

15.1.3.4.10. Motors

a. Verify that the correct voltage taps are in use.
b. Verify that the proper direction of rotation is present on the three-phase motors.
c. Verify that the motor is properly lubricated.

15.1.3.4.11. Phasing and Synchronizing

a. Maintain the correct phasing on all circuits and buses. The substation buses and connections shall have the phasing as shown in the Design Documents. All bus work shall be physically checked for phasing and verified to be correct and as shown on the station general arrangement drawings, the bus plans, the three line drawings, and the relaying schematics.
b. Perform phasing tests on all circuits that can be energized from two or more sources. All voltage and current phase angles shall be referenced to the same reference quantity for all readings on a specific scheme. The

phasing shall be checked with phasing voltage probes where practical.

15.1.3.4.12. Corona Testing

a. For substations operating at or above 230 kV and for any substation that is operating with reduced phase-to-ground or reduced phase-to-phase clearances, that substation shall be tested for corona by use of "night vision" equipment.

b. Other means such as ultra-sonic equipment and time exposure photography shall also be used as needed to locate the sources of excess corona. The tester shall inspect all high voltage equipment, buses, leads, etc. for corona.

15.1.3.4.13. Substation Bus Protection

a. Perform current transformer (CT) Tests
b. Wire check AC circuit
c. Check bus VT's
d. Perform relay setting/calibrate relaying
e. Verify metering calibration
f. Check digital meter with analog mA output
g. Multifunction digital transducer/meter with MODBUS® plus output
h. Test function of control circuits
i. Perform bus differential upset test (if required)
j. Test alarms to annunciator and to RTU/PLC inputs
k. Test and document EMS analog, control, alarms and status

15.1.3.4.14. Current Transformers

a. Control Tests
b. Check that high voltage connections of transformers and breakers match the scheme
c. Verify high voltage phasing is correct
d. Verify phasing is correct
e. Verify that all documentation including, CT nameplates, M&R, relay test sheets, and schematics match (polarity marks and ratios).
f. All CT's used for revenue metering or interchange metering must have ratio correction test curves and phase angle correction test curves. All CT's in this service, which do not have these test curves available from the manufacturer or CT supplier, shall be tested and curves produced as outlined in the EEI "Handbook for Electricity Metering". Normally the ratio correction and phase angle correction curves are specified as part of the purchase specification and will be provided from the supplier.
g. Make sure CT connections are proper to give the desired protection.
h. Verify that actual tap connected will give the ratio on the scheme
i. Verify ratios and connections are correct for transformer differential relaying systems.
j. Fill out CT documentation
    - Polarity check – relative to polarity marks (physical), the bridging

direction (electrical) and the drawings
- Ratio/Taps check – all taps
- Secondary injection (excitation)
- Test and record CT voltage saturation

k. Wire checking – See Wire Checking below

l. Perform Meg Ohm test (500V scale) to ground

m. Make sure bushings are labeled with phase and bushing number

15.1.3.4.15. Voltage Transformers & Coupling Capacitor Voltage Transformers

a. VT and CCVT Physical Testing

b. Perform power factor tests

c. VT and CCVT Control Testing

d. Verify that actual tap connected will give the ratio on the scheme

e. Make sure VT nameplate, relay test sheets, and schematics match (polarity and ratios).

f. Perform wiring checks on CCVT

g. Perform ratio and polarity checks on wound VTs and distribution transformers used for metering or relaying

h. Wire checking – See Wire Checking below

15.1.3.4.16. Wire Checking

a. (CT and VT circuits only)
- Perform continuity check of all current shorting switches
- Perform continuity check of all CT wiring
- Inject currents at the source of each current transformer string and check the string at each device with a clamp-on ammeter or current probe to verify that all current transformer strings are connected in accordance with schematics
- Simulate the actual load current and fault current operation of the substation electrical systems by injecting appropriate currents into the CT strings to check the protective relay operation, the CT circuits, the meters, and the instruments.
- Perform continuity check of all VT wiring (if required):
- Pull the fuses from CVT. CCVT, PD, or VT junction boxes and apply the proper phase- to-phase and phase-to-ground voltages to the load side of the fuse blocks. Check for the proper voltages at all relays, instruments, switches, etc. to verify that the voltage circuit is connected in accordance with the schematics.
- Verify tagging/labeling to standards
- Verify proper fuse sizing of voltage circuits
- Visually and mechanically (pull on wire) inspect terminations
- Verify that all VT and CT circuits have one and only one ground (exception is for power/metering VT which are grounded at both transformer and at the first panel).

15.1.3.4.17. AC Circuits

a. Verify proper voltage rating of equipment before fusing up
b. Verify correct labeling and breaker size
c. Verify correct circuit feeds the equipment and that the scheme circuit number is correct
d. Verify that "wild leg" is not used on 120 V circuits.

15.1.3.4.18. DC Circuits

a. Verify proper voltage rating of equipment before fusing up
b. Verify correct labeling and fuse sizes as per the Design Documents
c. Verify that the scheme reflects the correct circuit number
d. Check for proper polarity at device
e. If possible, remove or turn off equipment power supplies before initial Energization then check polarity before turning on
f. Test for shorts, grounds and back-fed DC (cross-coupled voltage test) before initially installing DC fuses for the first time.
g. After each new circuit is fused up, check the battery for grounds
h. Make sure all unused fuse blocks have wooden dowels inserted

15.1.3.4.19. Metering

a. Check calibration of all metering including analog transducers, analog meters, and digital meters.
b. Apply standard configuration to programmable meters
c. Using a calibration standard, check the accuracy of the watt-hour meters and the pulse initiators (KYZ) according to ANSI C12 and as directed by the manufacturer.
d. Check and record the output at 0 percent and one non-zero point.

15.1.3.4.20. Relay Setting/Testing

a. Verify proper labeling of relay to match Design Documents. (Do not place labels on the removable covers of relays but rather on the panel or the relay itself)
b. Make sure that removable relays are tagged as well as the panel.
c. Relay testing
   - Perform acceptance tests in accordance with the manufacturer's instruction books.
   - Verify operation of all light emitting diode indicators on relays containing such features.
   - Set the contrast for liquid crystal display read-outs.
   - Check the electrical and mechanical continuity of all taps, jumpers, etc.
   - Verify that the electro-mechanical relay devices function at all tap settings (i.e., operable, not calibrated). Verify that the electro-mechanical relay devices are calibrated within the manufacturer's tolerance specifications at the relay settings provided by the Engineer.

- Install settings on relays
- Test all relays to the values provided.
- Electro-mechanical relays shall be tested in a case. Cases shall not be pulled from the relay switchboards or unwired for this purpose. Relays can be tested in the case while mounted on the relay panel or in spare cases used for bench testing.
- Solid state types of relays that are in a draw-out style case shall be tested as outlined above.
- Microprocessor and solid-state types of relays that cannot be removed from a case shall be tested, prior to being mounted or wired on the switchboard, by the use of test stabs or plugs into their access points.
- If testing is required after the relay is wired, the relay may be unwired and tested using the relay's access termination points. However, if a relay is unwired, all circuits disrupted shall be retested to verify correct termination and operation.
- All protective relay operating tolerances shall be set, at a maximum, to manufacturer's specification or +/- 5%, whichever is less.
- Verify all of the inputs and outputs of the relay device for the correct internal functioning. Verify that the correct targets drop/show for each output.
- Relays with no field settings, such as lockout and auxiliary tripping relays, shall be randomly tested for pickup and dropout voltages and times. Measure the coil impedance if required. Document and sign working copy of relay test sheets after calibration and logic testing are complete.

d. Label instruction book with date installed and equipment covered and write “substation copy” on the instruction book

e. Put label on back of relay with installed date and list communication parameters (cable, special interface software, passwords, etc.) if required

f. Provide as-left setting files for all devices including Relays, Meters, RTU’s, etc.

15.1.3.4.21. Demonstration Testing

a. Simulate real world tests with relaying systems by using AC quantities to operate the protective relays and then using the trip output to turn off the test set.

b. Trip and verify reclosing of breakers

c. Check MOD sectionalizing.

d. Trip lockouts from relays

e. Place all equipment in the condition it was found in at the beginning of the outage and place new equipment in service

15.1.3.4.22. Post-Energization Testing and Review

a. Review Design Documents to make sure all testing is documented or punch listed and that loose ends have been addressed.

b. Check all relaying is on and in service.

c. Make sure all equipment and control switches are in the position that they were switched out as.

d. Close all blocking bar switches/lockout switches if required

e. Check all panel grounds are landed.

f. Verify all unused CT's are shorted and grounded.

g. Verify all alarms and EMS points are in service.

h. Check for battery grounds.

i. Verify that switching request allows for parallel sources during load check of differential relaying before feeding radially.

j. Load check & in-service checks.

  - Load check all new/modified CT circuits
  - Differential Relays: Compare restraint to operating quantities to ensure correct configuration. It is especially important on differential relays to verify correct operation under load when all inputs are energized.
  - Distance Relays: Measure the line power flow as seen by the relay inputs and compare to line metered values to verify proper polarity and tap settings.
  - Overcurrent Relays: Compare input currents with other metered values and verify polarity where applicable.
  - Phase check new/modified voltage circuits, verify all fuses are good.
  - Verify metering locally and at EMS.
  - Check rotation of transformer pumps and fans.
  - Check load on transformer pumps/fans with clamp on meter.
  - Check for proper operation of transformer/regulator LTC and paralleling operation.
  - Check for proper operation of transformer differential relaying.
  - Verify all relays have the proper voltages and current quantities present.

15.1.3.4.23. Cable Raceway Systems

a. Contractor shall accommodate inspection and testing activities by Owner. Before backfilling Contractor and Owner shall jointly inspect all trenches, conduit, cable placement, risers, and other construction not accessible after backfilling. If corrections are required, subsequent inspections will be made until all corrections are made and accepted by Owner.

b. The excavated trenches shall be maintained to be free of accumulated water and be maintained to the depths specified. Construction shall be arranged and marked so that trenches will be left open for the shortest practical time to trench collapse due to other construction activity, rain, or accumulation of water in the trench. Safety and traffic barriers shall be installed in accordance with local, State and Federal requirements.

c. All changes in routing of underground raceway systems shall be located exactly in the Design Documents.

15.1.3.4.24. Surface Coating Repair

a. Contractor shall accommodate inspection and testing activities by Owner. Contractor shall perform all surface coating repairs as required by this Section and as requested by Owner. All surface coating repairs to damaged equipment or structures occurring while in the possession of Contractor shall be made to the satisfaction of Owner and all costs to repair such surface coatings shall be borne by Contractor.

16. Attachment 5: Startup, Testing & Commissioning

16.1. The Contractor shall be responsible for startup, testing, and commissioning of the solar facility.

16.2. The electrical equipment and its installation shall be tested according to the current International Electrical Testing Association (NETA) Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

16.3. Contractor shall submit a startup, testing, and commissioning plan for review and approval by Owner. Documentation of testing performed shall be submitted for review and approval by Owner.

16.4. The output of the solar field shall be corrected to the base conditions listed in the performance guarantees.

17. Attachment 6: Packing, Shipping & Storage

17.1. The following are the minimum requirements for post-fabrication packaging, shipping and storage at the site prior to installation.

17.1.1. Shipments shall be by truck, FOB jobsite. The Contractor shall be responsible for receiving and unloading material.

17.1.2. Storage shall be outdoors. The Contractor shall provide weather resistant covers and adequate blocking for equipment and materials per the manufacturer's requirements.

18. Attachment 7: Site Plan

[Contractor shall provide site plan for specific site chosen for the project.]

19. Attachment 8: Interconnection Agreement with One-line Diagram

[Contractor shall provide interconnection agreements and one-line diagram for the specific site chosen for the project.]

20. Attachment 9: PV Solar Equipment Suppliers

20.1. Modules- Crystalline
- 20.1.1. JA Solar
- 20.1.2. Canadian Solar
- 20.1.3. Hanwha / Q-cell
- 20.1.4. Trina

– Risen Energy

- 20.1.5. LONGi Solar
- 20.1.6.
- 20.1.7.

20.2. Modules- Thin Film
- 20.2.1. First Solar

20.3. PV Racking - Single Axis Tracker Mounting System
- 20.3.1. GameChange Solar
- 20.3.2. NEXTracker
- 20.3.3. Array Technologies, Inc. (ATI)
- 20.3.4.
- 20.3.5. Soltec
- 20.3.6. PV Hardware
- 20.3.7.
- 20.3.8.

20.4. DC Combiner Boxes
- 20.4.1. Sunlink
- 20.4.2. SolarBOS
- 20.4.3. Shoals
- 20.4.4. Amphenol
- 20.4.5. Bentek Solar

20.5. Recombiner Boxes **(If Required)**
- 20.5.1. Sunlink
- 20.5.2. SolarBOS
- 20.5.3. Shoals
- 20.5.4. Amphenol
- 20.5.5. Bentek Solar

20.6. Central Inverters

20.6.1. SMA

20.6.2. TMEIC

20.6.3. Sungrow

20.6.4. Power Electronics

20.6.5.

21. Attachment 10: Project Milestone Schedule

[Contractor shall provide a project specific schedule.]

22. Attachment 11: Geotechnical Investigation Report

[Contractor shall provide a Geotech report for the specific site chosen]

23. Attachment 12: Production Test - Facility Performance Ratio Test Specification

23.1. Purpose

23.1.1. The Performance Ratio of a solar photovoltaic (PV) power generating facility (The Facility) is defined as its energy production [kWh] divided by the product of its DC capacity [$\boldsymbol{MWp}$] and the normalized irradiance and a temperature correction factor over the Test Period.

23.1.2. The Performance Ratio Test in this specification is an application of the methodology[1] recommended by the US National Renewable Energy Laboratory (NREL) and UL 617240-3.

23.2. Requirements before the Test:

23.2.1. Before the test can commence, the following need to be completed:

23.2.1.1. The PV facility is electrically and mechanically completed, except for minor items approved by all parties that do not affect facility safety, operability or reliability.

23.2.1.2. The PV facility is connected and synchronized to the grid.

23.2.1.3. All inverters are operating in accordance with the manufacturer specifications and are calibrated and communicating properly with the PV facility monitoring system.

23.2.1.4. All commissioning tests are successfully achieved in accordance with the EPC contract.

23.2.1.5. The control and monitoring system are completed, and the facility can be monitored from the main control room.

23.2.1.6. All mandatory measurement instruments (energy meters and meteorological sensors) are installed, calibrated, operating properly. These signals shall be synchronized to the control and monitoring system.

23.2.1.7. All pyranometers have been cleaned in accordance with manufacturer's specifications.

23.2.1.8. Inverters will operate at unit Power Factor [$\boldsymbol{PF = 1}$] if they must operate at other power factors due to Utility requirements, the Guaranteed Performance Ratio shall be adjusted to this new power factor.

23.3. Measurement Requirements

23.3.1. Measurement Instrumentation Requirements

[1] Kurtz, S. et al, "Weather-Corrected Performance Ratio", NREL/TP-5200-57991, April 2013

23.3.1.1. The Plane of Array Solar Irradiance $[\frac{W}{m^2}]$ measurement instrumentation shall be used during the Test Period:

23.3.1.1.1. The Plane of Array (POA) shall mean the plane defined by the (array of) PV modules

23.3.1.1.2. POA irradiance shall be measured using ISO 9060 secondary standard rated pyranometers installed so that they are co-planar with the POA of the PV modules

23.3.1.1.3. A minimum of two of secondary standard grade pyranometers shall be installed for this facility capacity

23.3.1.1.4. Each pair (or more) of pyranometers shall be installed proximate to the PV array that they are monitoring

23.3.1.2. PV Module Backsheet Temperature [°C]

23.3.1.2.1. PV module backsheet temperature shall be measured using platinum resistance temperature detectors (RTDs) that are adhered to the back of operational PV modules using a thermally conductive compound consistent with the PV module manufacturer's recommendations

23.3.1.2.2. The tolerance of the RTDs shall meet or exceed IEC 751-95 Class A

23.3.1.2.3. A minimum of three RTDs shall be installed for this facility capacity

23.3.1.2.4. The RTDs shall be attached to PV modules that are located near the center of the PV array (up to 25 MW) that they are monitoring

23.3.1.3. Inverter Output Power [Wac]

23.3.1.3.1. Each inverter under test shall report its output power

23.3.1.4. AC Energy Production [kWh]

23.3.1.4.1. The energy production of the facility shall be measured at the Point of Metering in accordance with the EPC contract using an AC watthour meter that meets or exceeds the accuracy standards set forth in ANSI C12.1.

23.3.1.5. Copies of current calibration certificates for all required instruments shall be submitted to Owner for review and acceptance

23.3.1.6. All required instruments shall be installed and maintained in accordance with their respective manufacturer's specifications and recommendations

23.3.1.7. All pyranometers shall be cleaned monthly in accordance with the manufacturer's recommendations

23.3.1.8. All required instruments shall be synchronized and connected to a Data Acquisition System (DAS) that supports the requirements of this Specification, in accordance with the manufacturer's specifications, and that complies with the instrumentation manufacturers' specifications and recommendations

23.3.2. Measurement Data Record Requirements

23.3.2.1. All required measurement data shall be synchronized, collected and recorded at one-minute intervals and averaged into 15-minute intervals for the Test on Completion and averaged into 1-hour data during the Warranty Period.

23.3.2.2. Each measurement data record shall include the date and time, with one-minute resolution, when it was recorded

23.3.2.3. Required Measurement Data Fields

23.3.2.3.1. Each data record shall include the following data fields:

a. Date-Time Stamp: Date (Month, Day, Year) and Time (Hour, Minute)

b. Each required pyranometer

c. Each required RTD

d. The output power of each inverter

e. The watthour meter

23.3.2.4. Required Channel-Averaged Measured Data Fields

23.3.2.5. Each measurement data record shall include the following channel-averaged measured data fields:

23.3.2.5.1. The channel-averaged measured POA irradiance, shall be calculated as the average over all of the individual POA irradiance readings

23.3.2.5.2. The channel-averaged measured RTD temperature, shall be calculated as the average over all of the individual RTD temperature readings

23.4. Test Period

23.4.1. The test period is the period of time during which the required data for the Performance Ratio Test is collected for the purposes of analysis. The duration of the test period shall be sufficient to include a minimum number of Eligible Measurement Averaging Intervals (EMAIs).

23.4.2. The test period at the Test on Completion shall be seven (7) days, subject to EMAIs.

23.4.2.1. The test period during the Warranty Period shall be 2 years. The collected data for a complete year shall be used for Performance Ratio calculation.

23.4.3. Minimum Number of Eligible Measurement Averaging Intervals

23.4.3.1. The minimum number of EMAIs for the Performance Ratio Test at the Test on Completion shall be 150.

23.4.4. Eligible Measurement Averaging Intervals

23.4.4.1. An Eligible Measurement Averaging Interval (EMAI) shall:

23.4.4.1.1. Be a contiguous five-minute interval

23.4.4.1.2. Not overlap any other EMAI

23.4.4.1.3. Meet or exceed the Minimum Irradiance Requirement (Test on Completion only)

23.4.4.1.4. Only include measurements when the PV arrays do not experience any significant Shading Loss

23.4.4.1.5. Only include measurements when the output of each inverter is below its Clipping Limit

23.4.4.1.6. Exclude times when snow, ice or any other obstructions cover a portion of the array

23.4.4.1.7. Exclude time periods when force majeure events beyond the control of the Contractor impact the energy production of the facility

23.4.4.1.8. Exclude time periods during the grid unavailability when the facility is available to generate the output.

23.4.4.1.9. Not have any missing or flawed required measurement data

23.4.4.1.10. System downtime for reasons beyond Contractor control such as grid instability, scheduled preventive maintenance shall be excluded from Performance Ratio calculations

23.4.4.2. Minimum Irradiance Requirement

23.4.4.3. The Minimum Irradiance Requirement for an EMAI is an average POA irradiance of 500 $\boldsymbol{W/m^2}$ in the Plane of Array over the interval

23.4.4.4. Shading Loss: Shading Loss is significant if it is greater than one percent

23.4.4.5. Inverter Clipping Limit: The clipping limit of an inverter is defined as 98 percent of its nameplate output rating

23.4.5. Interval-Averaged Measured Data

23.4.5.1. The following measured one-minute data entries within each EMAI shall be averaged over the interval to produce an EMAI data record of interval-averaged value for that EMAI

23.4.5.1.1. Channel-averaged measured POA irradiance

23.4.5.1.2. Channel-averaged measured RTD temperature

23.4.5.1.3. The watthour meter

23.4.5.2. Date-Time Stamps for EMAI Data Records

23.4.5.2.1. Each EMAI data record shall be stamped with the date and time to at least one- minute resolution of the earliest-occurring data record included in that EMAI

23.5. Calculation of Expected Performance Ratio

23.5.1. The Performance Ratio Test compares the Measured Performance Ratio, $\boldsymbol{PR_m}$ of a solar PV facility to its Expected Performance Ratio, $\boldsymbol{PR_e}$.

23.5.2. Performance Model, Expected Solar Resource and Energy Production Estimate

23.5.2.1. Calculation of the Expected Performance Ratio, $\mathbf{PR_e}$ utilizes the following items, which shall have been mutually agreed to by The Parties prior to the commencement of the Performance Ratio Test:

23.5.2.1.1. A representative Performance Model for the facility

23.5.2.1.2. A complete Typical Year of hourly-resolution (8,760 hours/year) solar resource and weather dataset for the facility location

23.5.2.1.3. A complete-year of hourly-resolution (8,760 hours/year) Expected Energy Production Estimate using the above

23.5.2.2. Furthermore, the Performance Model for the facility must also report for each hour of the Typical Year (8,760 hours/year):

23.5.2.2.1. Expected POA irradiance

23.5.2.2.2. Expected PV module backsheet temperature

23.5.2.2.3. Note: The Pvsyst variable T_{array} (Average Module Temperature during running) is actual T_{cell}. To translate this value to Expected PV module temperature, $T_{(e,j)}$ [℃], use the following equation:

$$T_{(e,j)} = T_{array} + (3*G_{(e,j)}/1000)$$

(Ref: D.L. King, W.E. Boyson, J.A. Kratochvill, " Photovoltaic Array Performance Model", SANDIA REPORT, SAND2004-3535, Printed December 2004)

23.5.2.3. Losses Excluded from the Energy Production Estimate (EPE)

23.5.2.3.1. The following losses shall be excluded from the EPE used in the Performance Ratio Test at the test on completion when the facility is in new and clean condition:

a. Long-term degradation in PV module performance

b. Long-term soiling loss

c. System availability loss (Availability shall be 100%)

23.5.2.3.2. For the guaranteed PR of each year during the Warranty Period, soiling, long-term module degradation, and system availability loss shall be included in the guaranteed PR values.

23.5.2.4. Use of the Results from the Energy Production Estimate

23.5.2.4.1. The Expected Average Irradiance-weighted PV Module Temperature, $\overline{\boldsymbol{T_{e,k}}}$ and the Expected Performance Ratio, $\boldsymbol{PR_{e,k}}$ for each month, $\boldsymbol{k}$ are calculated using the hourly results, $\boldsymbol{j}$ from the PE, specifically:

23.5.2.4.2. Expected POA irradiance, $\mathbf{G_{e,j}}\left[\frac{\mathbf{W}}{\mathbf{m^2}}\right]$

23.5.2.4.3. Expected PV module temperature, $\boldsymbol{T_{e,j}}$[°C]

23.5.2.4.4. Energy production at the point of metering, $\boldsymbol{E_{e,j}}[\boldsymbol{kWh}]$

23.5.2.4.5. Hours in the EPE where one or more inverters operating at or above their Clipping Limit shall be excluded

23.5.2.4.6. The remaining hourly results in the EPE shall be grouped by month, $\boldsymbol{k}$

23.5.3. Monthly Expected PV Module Temperatures and Performance Ratios

23.5.3.1. Expected irradiance-weighted average PV module backsheet temperature for the $\boldsymbol{k^{th}}$ month, $\overline{\boldsymbol{T_{e,k}}}$ shall be calculated as:

$$\overline{T_{e,k}} = \frac{\sum_{i=1}^{M_k} T_{e,i} \cdot G_{e,i}}{\sum_{j=1}^{M} G_{e,j}}$$

23.5.3.2. The Expected Performance Ratio for the $\mathbf{K^{th}}$ month, $\mathbf{PR_{e,k}}$ shall be calculated as:

$$PR_{e,k} = \frac{\sum \frac{M_k}{j=1} E_{e,j}}{\frac{[P_0 \cdot Llr_e}{G_0} \cdot \sum_{j=1}^{M_k} G_{e,j}}$$

Where any hours excluded, $E_{e,j}$ and $G_{e,j}$ are set equal to zero:

$$E_{e,j} = G_{e,j} = 0$$

For any excluded hours and where:

Variable	**Units**	**Description**
$\overline{T_{e,k}}$	[°C]	Expected irradiance-weighted average PV module backsheet temperature for the k^{th} month (see **Table 23.1**)
$T_{e,j}$	[°C]	Expected PV module backsheet temperature for the j^{th} hour in a given month
$PR_{e,k}$	[%]	Expected Performance Ratio for the k^{th} month (Furthermore, the Performance Model for the facility must also report for each hour of the Typical Year (8,760 hours/year):)
$E_{e,j}$	[kWh]	Expected Energy Production in the j^{th} hour of the PE
P_0	[kWp]	Contracted DC Capacity of the Facility at STC[A]
$\Delta r_e = 1.0$	[hours]	Hourly time step in the PE
G_0	$\left[\frac{W}{m^2}\right]$	Irradiance at STC[A]

$G_{e,j}$	$\left[\frac{W}{m^2}\right]$	Expected POA irradiance in the j^{th} hour of the PE
k		Index running over all months, $k = \{1 \dots 12\}$
M_k		Total number of hours in the k^{th} month
j		Index running over all hours within a given month, $j = \{1 \dots M_k\}$

[A] Standard Test Conditions (STC): $1000 \left[\frac{W}{m^2}\right]$ POA irradiance, 25 [℃] cell temperature

23.5.3.3. Table of Expected Monthly and Yearly Values

23.5.3.3.1. Table 23.1 Monthly Expected Performance Ratios & Expected Average Irradiance-Weighted PV Module Temperatures provides places for the monthly Expected Performance Ratios, $PR_{e,k}$ and monthly Expected Average Irradiance-weighted PV Module Temperatures, $\overline{T_{e,k}}$ for each month, k to be entered.

23.5.3.3.2. The values shall be entered in prior to the start of the Test Period in accordance with this specification, as part of the terms of agreement between the Owner of the facility and the party that is responsible for its performance

Table 23.1 Monthly Expected Performance Ratios & Expected Average Irradiance-Weighted PV Module Temperatures

k	Month	$PR_{e,k}$[%]	$T_{e,k}$[℃]
1	January	XX.X%	X.XX
2	February	XX.X%	X.XX
3	March	XX.X%	X.XX
4	April	XX.X%	X.XX
5	May	XX.X%	X.XX
6	June	XX.X%	X.XX
7	July	XX.X%	X.XX
8	August	XX.X%	X.XX
9	September	XX.X%	X.XX
10	October	XX.X%	X.XX
11	November	XX.X%	X.XX
12	December	XX.X%	X.XX

Expected Average Irradiance-weighted PV Module Temperatures for a complete year is xx℃.

23.5.4. Expected Values for the Performance Ratio Test

23.5.4.1. If the test occurs partially in two months, a weighted average shall be used to calculate the $\boldsymbol{PR_e}$. If $\boldsymbol{n}$ EMAIs occur in month $\boldsymbol{k}$, and $\boldsymbol{m}$ EMAIs occur in month $(\boldsymbol{k}+\boldsymbol{1})$, where $\boldsymbol{N} = (\boldsymbol{n}+\boldsymbol{m})$ then $\boldsymbol{PR_e}$ and $\boldsymbol{T_{\bar{e}}}$ shall be calculated from Table 23.1 Monthly Expected Performance Ratios & Expected Average Irradiance-Weighted PV Module Temperatures as:

$$T_{\bar{e}} = \frac{1}{N}\left[n \cdot T_{e,k} + m \cdot T_{e,k+1}\right]$$

$$PR_e = \frac{1}{N}\left[n \cdot PR_{e,k} + m \cdot PR_{e,k+1}\right]$$

23.6. Calculation of Measured Performance Ratio

23.6.1. The Measured Performance Ratio, $\boldsymbol{PR_m}$ shall be calculated as:

$$PR_m = \frac{\sum_{i=1}^{N} E_{m,i}}{\frac{P_0 \cdot Llr_m}{G_0} \cdot \sum_{i=1}^{N} G_{m,i} \cdot a_{T,m,i}}$$

$$a_{T,m,i} = \frac{\left|1 +, B_T \cdot \left[T_{m,i} - 25\right]\right|}{\left[1 +, B_T \cdot (T_{\bar{e}} - 25)\right]}$$

Where:

Variable	Units	Description
PR_m	$[\%]$	Measured Performance Ratio
$E_{m,i}$	$[kWh]$	Measured Energy Production over the j^{th} EMAI
P_0	$[kWp]$	Contracted DC Capacity of the Facility at STC[A]
Δr_m	$[hours]$	Time duration of the EMAIs (held constant over the Test Period)
G_0	$\left[\frac{W}{m^2}\right]$	Irradiance at STC[A]
$G_{m,i}$	$\left[\frac{W}{m^2}\right]$	Measured POA irradiance over the j^{th} EMAI
$a_{T,m,i}$		PV Module temperature correction factor for the j^{th} EMAI
$, B_T$	$\left[\frac{\%}{°\mathrm{C}}\right]$	Temperature coefficient of Power (negative) for the PV modules
$T_{m,i}$	$[°\mathrm{C}]$	Measured PV module backsheet temperature over the j^{th} EMAI
$T_{\bar{e}}$	$[°\mathrm{C}]$	Expected irradiance-weighted average PV module backsheet temperature for the Test Period (see
N		Total number of EMAIs Index running over all EMAIs, $= \{1 \dots N\}$

[A] Standard Test Conditions (STC): $1000 \left[\frac{W}{m^2}\right]$ POA irradiance, 25 $[°\mathrm{C}]$ cell temperature

23.7. Performance Ratio Test

23.7.1. The Performance Ratio Test compares the Measured Performance Ratio, $\boldsymbol{PR_m}$ of the facility to its Expected Performance Ratio, $\boldsymbol{PR_e}$ reduced by the Measurement Uncertainty Allowance (MUA).

23.7.2. Measurement Uncertainty Allowance

23.7.2.1. The Measurement Uncertainty Allowance (MUA) allows for the inherent uncertainty in the measurement equipment.

23.7.2.2. The MUA shall be three percent (3%)

23.7.3. Acceptance Threshold of the Performance Ratio Test

23.7.3.1. The result from a Performance Ratio Test is acceptable if:

$$PR_m \geq PR_e \cdot (1 - MUA)$$

23.8. Reporting Requirements

23.8.1. The following data and calculations shall be provided to Owner in the Performance Ratio Test Report and associated documents.

23.8.2. General Requirements

23.8.2.1. The Performance Ratio Test Report shall include:

23.8.2.1.1. Dates of the Test Period, test conditions and Contractor's personnel responsible for The Performance Ratio Test

23.8.2.1.2. A statement of whether the Performance Ratio Test either passed or failed

23.8.2.1.3. If the Performance Ratio Test failed, a detailed explanation shall be submitted to Owner for review

23.8.2.1.4. A signed statement from Contractor that the project complies with all of the requirements set forth in this Specification

23.8.3. Requirements for Reporting Measured Data

23.8.3.1. A copy of all required measurement data collected throughout the entire Test Period shall be submitted to Owner for review and acceptance

23.8.4. Requirements for Reporting Test Results

23.8.4.1. The result from the calculation shall be submitted to Owner for review and acceptance

24. Attachment 13: Substation Scope of Work

24.1. Project Description

This scope of work is for engineering, procurement, and construction (EPC) for a high voltage substation and gen-tie (transmission line) for a Utility scale solar facility.

24.1.1. High Voltage-kV/Medium Voltage-kV, XXX-MWAC Collector Substation

24.1.2. High Voltage-kV overhead Gen-Tie (transmission line) to the local power Utility POI. The scope of this work includes the design, procurement, and installation of the proposed XXX-kV gen-tie of the solar facility Substation to the local power Utility POI.

24.1.3. The work shall be by Contractor and its suppliers, subcontractors, and subsidiaries for the Owner. The work shall comply with, and be performed in accordance with, the following:

24.1.4. Current one-line diagrams, substation plan view, and substation details, (as applicable).

24.1.5. Codes, including national, regional, and local (as applicable)

24.1.6. Industry standards (as applicable)

24.1.7. The detailed scope for each of the three portions is outlined below. Unless otherwise noted, the work outlined for each item includes all engineering design and detailing, procurement and supply, and construction including installation, testing and commissioning.

24.2. High-Voltage-kV/Medium-Voltage--kV Collector Substation

24.3. Complete substation engineering design documents including:

24.3.1. Complete construction drawings, including civil, physical and electrical engineering design.

24.3.2. System analytical studies including protection and coordination studies as follows:

24.3.2.1. Grounding Study with the objective of:

24.3.2.2. To meet touch and step voltage tolerable limits and conductor ampacity limits in accordance with IEEE during worst case fault conditions. Touch and Step voltage limits are to be met both inside the substation and around its periphery. A valid and previously approved soil testing procedure (e.g. Wenner 4-pin method) shall be used to measure soil resistivity values. A full report indicating final grounding design based on the grounding study results shall be presented.

24.3.2.3. Short Circuit and protection coordination Study:

24.3.2.4. Contractor is responsible to obtain fault contribution information at the POI (Point of Interconnection) from the Utility.

24.3.2.5. Owner will provide all PV Field related information as for medium voltage (e.g. 34.5kV), cable feeders looping all inverter stations, ISUs Transformer Electrical Parameters, Solar Inverter Electrical Parameters including their P-Q curve for reactive power capability.

24.3.2.6. Harmonic and Resonance Study with the following objectives:

24.3.2.7. To calculate the resonant/natural frequencies of the system

24.3.2.8. To evaluate harmonic levels in order to compare with the IEEE 519 standards for THD and IHD for both current and voltage.

24.3.2.9. Load Flow Analysis including:

24.3.2.10. Reactive capability for the generating facility.

24.3.2.11. Power Factor Assessment.

24.3.2.12. Capacitor bank sizing.

24.3.2.13. Transient and switching studies

24.3.2.14. Ferroresonance Study with the objective:

a. To check for ferroresonance situations likely to occur within the solar collector and HV substation system and to model these situations in an EMTP software to verify their impact on the system.

24.3.2.15. Lightning Protection Analysis

24.3.2.16. Arc Flash assessment and generation of arc flash labels for substation equipment.

24.3.3. Three weeks field measurements during energization in order to monitor harmonic, resonance and transient data up to the maximum MW exported from the PV facility. These measurements shall use THREE (3) Dranetz equipment meters or equivalent to ensure the capturing of high-speed switching events. One of the Dranetz meters shall be installed at one of the inverters AC output, the second Dranetz at the medium voltage busbar, and the third meter at the high voltage side of the GSU.

24.3.4. Engineering calculations. Including but not limited to:

a. Station Service AC loads.

b. Battery sizing for all DC loads such as Protection Relays, SCADA Relays, TELECOM Equipment, and other Emergency loads.

c. Overhead Bus bars.

d. Concrete Foundation calculations.

24.3.5. Equipment specifications and Data sheets for purchasing major equipment.

24.3.6. Design submittals made to Owner will include preliminary design documents for Owner review and final design documents intended to be issued for construction (“IFC”).

24.3.7. Site grading for the fenced substation area and the area immediately outside of the fence (within approximately 7 feet). This includes final crushed stone surface.

24.3.8. Foundations for all substation equipment and structures. Depending on individual structure loads, equipment types, and geotechnical considerations, foundations will be slab-on-grade, spread footing, or drilled piers. This includes all excavation and back fills.

24.3.9. Secondary oil containment system for main transformer. This will consist of concrete foundation and concrete containment with oil flow to a low spot with a padlockable valve used to drain water that has accumulated in the containment area.

24.3.10. Conduits, cable trenches, and terminations.

24.3.11. Substation grounding grid system

24.3.12. Fencing around the perimeter of the substation.

24.3.13. Main power transformer (GSU) with the following characteristics: XXX/XXX/XXX MVA, high- voltage-kV/medium-voltage-kV, Vector Group according to Utility requirements, including a tertiary Wye grounded winding for purposes of mitigating harmonics. Standard Impedance Z or as suggested by engineering studies, 3 phase, 60 Hz, oil filled transformer with De-Energized Tap Changer (DETC) on HV side with a regulation of +/- 5% in 2.5% steps. “No load” losses will not exceed 600 kW and load losses will not exceed 2500 kW at MVA base. Number of CTs as indicated on single line diagram. If requested by the owner, the main power transformer shall include an OLTC. Specifications for this device will be provided on later stage.

24.3.14. Steel support structures for equipment.

24.3.15. High voltage equipment including:

24.3.15.1. High Voltage Circuit breaker(s) XXX- kV, XXXX-A with current transformers ratio, accuracy, and class, as indicated on single line diagram for protective and metering purposes.

24.3.15.2. Motor operated disconnect switch(es) XXX-kV, XXXX-A, XXXX-kV BIL, XX-kAIC with ground connection.

24.3.15.3. CPT units for protective relaying purposes, ratio, accuracy, class, power rating and BIL, as indicated on single line diagrams.

24.3.15.4. High Voltage Surge Arresters, MCOV and BIL as shown in single line diagram

24.3.16. Medium Voltage equipment including:

24.3.16.1. Medium Voltage Vacuum Circuit Breakers and their respective CTs as indicated on single line diagram.

24.3.16.2. Hookstick operated switches, two sets per medium voltage vacuum circuit breakers, one set at the primary side and one set on the secondary side.

24.3.16.3. If required by Owner, a Snubber cabinet per medium voltage vacuum circuit breaker having the following configuration:

24.3.16.4. Fuse/switch disconnector – Resistor – Capacitor.

24.3.16.5. Capacitor sized as indicated on single line diagrams.

24.3.16.6. Resistor sized as indicated on single diagrams.

24.3.16.7. Capacitor and Resistor values shall be confirmed during switching/transient studies.

24.3.16.8. 1-φ Voltage Transformer for protective relaying. See quantity, voltages, and VA rating in single line diagram.

24.3.16.9. Station service transformer(s). See quantity, capacity rating and voltages in single line diagram.

24.3.16.10.MCOV surge arresters for MV feeders. See quantities, MCOV rating, and BIL class in single line diagram.

24.3.17. High voltage bus work including insulators, fittings, and conductors.

24.3.18. Backup propane generator with Automatic Transfer Switch. For generator's KW rating, transfer switch ampacity rating and voltage refer to single line diagram.

24.3.19. Equipment enclosure (i.e., "control building") consisting of a prefabricated enclosure, up to 16' x 32', for all protection and control equipment including AC and DC station service system. Space must be provided in the equipment enclosure for an RTU panel. The control building shall include at least one (1) DC and one (1) AC supply panelboards, connections between the relay panels and the Substation SCADA panel, connections between the RTU panel and fiber patch panel shall also be provided. The patch panel will serve as demarcation with others for PV facility communications.

24.3.20. Control cables

24.3.21. Supply of serial and/or Ethernet communication from all substation relays via the Substation Data Concentrator

24.3.22. Connection of all high voltage leads and wiring once commissioning is complete.

24.3.23. Relay settings for equipment in relay panels.

24.3.24. Testing and final connections of the main power transformer.

24.3.25. Active management of all engineering, procurement and construction activities to ensure a smooth and efficient workflow from timely material delivery to final commissioning.

24.3.26. Review of shop drawings, wiring diagrams, construction drawings, spare parts lists, Contractor submittals, instruction manuals, production schedules and related items for compliance with each material supply contract for our scope of the project.

24.3.27. Attendance at planning and design coordination meetings with local Utility for

Contractor's scope of the project

24.3.28. Local engineering and construction support during construction for Contractor's scope of the project.

24.3.29. Record drawings based on construction redlines for Contractor's scope of the project work in CAD format.

24.3.30. Complete assembly of manufacturer supplied equipment manuals.

24.4. Project Execution Plan

24.4.1. Project Management

24.4.1.1. Contractor will work with Owner to develop a critical path project schedule that has major project milestones and defined tasks with predecessors and successors. The project schedule will have a separate line item for each main section of work, showing the start dates and finish, days of float and duration. After agreement on the schedule for delivery of major equipment, Contractor will baseline the schedule and provides formal updates on a regular basis. Contractor will assign a Project Manager that will have the overall project responsibility and will be the single point of contact to provide regular updates to Owner and address ongoing questions and discussions during the project. The lead project engineer will be responsible for providing and tracking the appropriate document revisions. All necessary documents will be uploaded to a shared site for access by the Owner and other applicable parties (e.g., major equipment suppliers and subcontractors).

24.4.2. Project Review Meetings

24.4.2.1. Weekly project meetings will commence after receipt of contract at a time mutually agreed to by Contractor and Owner. Project deliverables, schedule and review of pending action items will be reviewed and updated. As needed, additional impromptu meetings will be scheduled with relevant parties for technical or other non-typical discussions. With less frequency, more detailed face to face meetings will be scheduled with a focus on project design reviews. Typical milestones for design review meetings are 30%, 60%, 90% and Issued for Construction, but will be customized to the project requirements.

24.5. Allowances / Alternates:

24.5.1. Var Compensation (Cap banks) and including breaker on the medium voltage bus.

24.5.1.1. If power factor study already included on base price determines the need for cap banks.

24.5.1.2. If cap banks are required, a transient switching study for cap bank switching shall be included as part of this allowance.

24.5.2. Communication Infrastructure:

24.5.2.1. Allowance for Communication infrastructure on site.

24.5.3. Adding an On-Load Tap Changer (OLTC) to the Main Power Transformer and its respective programming/configuration in case load flow/reactive power flow study (already included on the base price) determines the need for an OLTC.

25. Attachment 14 - Substation Specifications

25.1. Design

All work and materials shall be in accordance with the Project Schedule, Design Documents, all the Transmission Owner requirements and all the Transmission Provider requirements. The Collector Substation shall include, but not be limited to: foundations, breakers, protective relays, RTU, ground grid, surge protectors, Electrical Equipment Enclosure (EEE), buss bar and communications circuits to meet all host utility requirements, including any requirements imposed by the Transmission Owner, Transmission Provider and applicable NERC and FERC standards.

25.1.1. Civil/Structural Design

25.1.1.1. The substation civil/structural design shall be in accordance with **XEL-STD-CRITERIA FOR ENG & DESIGN OF CIVIL & STRUCTURAL PERFORMANCE**.

25.1.1.2. Drilled pier foundations shall include details to resist frost heave such as installing sonotube around the pier perimeter throughout the frost zone depth.

25.1.1.3. Any engineer wishing to deviate from this standard must submit exception to Owner for approval.

25.1.2. Step-Up Transformer

25.1.2.1. Refer to SOLAR FACILITY ONE LINE METERING AND RELAYING for design requirements.

25.1.2.2. Shall have an in-tank, on-load tap changer.

25.1.3. Site Layout Criteria

25.1.3.1. All substations designs shall be in accordance with this specification and accepted industry standards and practices. The National Electric Safety Code (ANSI C2) shall be followed in all cases. The National Electric Code (NFPA 70) shall be followed to the extent that is possible and practical. In certain jurisdictions, the National Electric Code is part of the law and must be followed.

25.1.3.2. Number of feeders shall be determined by the collection system. For feeder and switch designation naming see Table

25.1.3.3. A cold storage unit shall be installed as a separate unit. The unit shall provide approximately 200 square feet of storage.

Table 25.1: Feeder and switch designation naming.

34.5 KV Feeders:
Bus 1: 311 to 319
Bus 2: 321 to 329

25.1.3.4. A disconnect switch between the collector substation and the utility interconnection facilities is required.

25.1.3.5. High side breaker and associated switches or bus position with multiple breakers and associated switches for each transformer

25.1.3.6. Low side bus and equipment shall be installed in accordance with acceptable industry standards and practices. Main breakers, a bus-tie breaker and associated switches shall be installed where applicable or required by Owner.

25.1.3.7. One grounding transformer per two circuits shall be incorporated into the design of the collector substation. Breakers that incorporate ground switching shall not be utilized.

25.1.3.8. The substation shall be constructed with steel structures. Use of wood poles is not allowed.

25.1.3.9. Bus spans shall be limited by switch pad loading.

25.1.3.10. Switches shall be group operated.

25.1.3.11. Circuit breaker ratings shall be standard.

25.1.4. Fire Protection

25.1.4.1. Substation fire protection designs shall be in accordance with accepted industry standards and practices. IEEE 979 Guide for Substation Fire Protection shall be consulted for new facilities.

25.1.4.2. Protective firewalls or barriers should be considered whenever clearances from IEEE 979 cannot be achieved.

25.1.4.3. Electrical Equipment Enclosures shall have two exits on opposite sides or corners and the doors equipped with panic hardware. Fire extinguishers are to be provided at each exit of any enclosures within the substation.

25.1.5. Fault Duty Requirements

Design shall consider future fault values obtained from interconnecting utility for the worst-case value over a 30-year lifespan of the substation.

25.1.6. Environmental Requirements

25.1.6.1. Substation designs must be compatible with the environmental characteristics of the facility location. Table 25.2 gives typical design parameters for various regions. Particular sites within a given region may have different environmental conditions than that given in Table 25.2, the more stringent would apply. Additional environmental conditions for calculating bus conductor ampacity are in Table 15.3.

25.1.6.2. The existence of any unusual environmental conditions should be considered at each substation site. These conditions may include corrosive fumes or vapors, explosive mixtures of dust or gases, steam, magnesium chloride spray, and salt spray.

Table 25.2: Environmental design criteria.

	CO	MN/WI (South)[1]	MN/WI (North)[1]	NM	TX
Design Temperature Range (°C)	-40 to 40	-40 to 40	-50 to 40	-30 to 40	-30 to 40
Design Ice Loading[2] (inches, radial loading)	1 in	1 in	1 in	1 in	1 in
Elevation above mean sea level (feet/meters)	Min. design criteria is 5,900 ft (1800 m) Use 11,000 ft (3353 m) elev. at sites >8,500 ft (2591 m)	<3300 ft (1006 m)	<3300 ft (1006 m)	>=3700 ft (1128 m)	>=3700 ft (1128 m)

(1)The division between MN/WI north and south is roughly defined as the east-west line running between St. Cloud, MN and Eau Claire, WI.

(2)For issues related to structural design, including regional seismic zones, refer to the Civil/Structural Design Criteria.

Table 15.3: Design criteria for substation bus conductor and ampacity ratings.

	NSP	PSC	PSC ≥8500 ft	SPS
Summer Ambient Temp. (Deg. C)	40	40	35	40
Day of the Year	June 21 (172nd day)	June 21 (172nd day)	June 21 (172nd day)	June 21 (172nd day)
Temp. Rise (Deg. C)	45	45	50	45
Bus Temp. (Deg. C)	85	85	85	85
Emissivity Outdoors (*e*)	0.5	0.5	0.5	0.5
Emissivity Indoors (e)	0.35	0.35	0.35	0.35
Absorptivity (*a*)	0.5	0.5	0.5	0.5
Degrees N. Latitude	43	40	40	35
Time of Day	Noon	Noon	Noon	Noon
Atmospheric Conditions	Clear	Clear	Clear	Clear
Elevation	1,100 ft (336 m)	5,900 ft (1800m)	11,500 ft (3506 m)	>=3,700 ft (1128 m)
Wind Speed (ft/sec)	2	2	2	2
Wind Direction	90	90	90	90
Line Orientation	E/W (90˚)	E/W (90˚)	E/W (90˚)	E/W (90˚)

Note 1: For indoor calculations, solar heat gain should not be applied.
Note 2: When wind speeds are zero, forced convection heat loss rate should not be applied.

25.1.7. Bus layout criteria, clearances, etc.

25.1.7.1. A bus arrangement in substation should have “B” phase in the center. The phase sequence required for the transformers may fix the location of “A” and “C” phases. Coordination with the interconnecting utility is preferred. Tubular bus criteria — All tubular bus designs shall be in accordance with accepted industry standards and practices. The IEEE 605 - IEEE Guide for Bus Design in Air Insulated shall be followed in all cases.

25.1.7.2. Clearances – NESC C2 and ANSI C37.32 with any additional site-specific requirements shall be considered and either meet or exceed the minimum requirements for design clearances. All substation arrangements will be designed to allow safe maintenance and repair of adjacent equipment.

25.1.7.3. Ampacity Ratings

25.1.7.3.1. Substation bus conductors are to be sized based on the ampacity requirements of the substation and any future expansions noted upon commencement of design. All conductor ratings shall follow the applicable Environmental design requirements. Once the bus conductor sizes are determined, switches and breakers are sized to meet or exceed the bus conductor ampacity ratings. In some cases, the determining factor in sizing the bus conductors will be structural and mechanical requirements.

25.1.7.3.2. The minimum standard continuous current rating that will be used for transmission switches and breakers is 1,200A. A load flow study should be performed to confirm ratings impacts on detailed high side facilities (ring bus, breaker and a half) that have influence other current sources.

25.1.7.4. Aluminum bus conductor applications

25.1.7.4.1. All Aluminum Conductor (AAC) is used for substation strain bus and connections where flexibility is required, or rigid bus is not feasible. ACSR conductor can also be used where practical to gain rigidity in some special cable connections.

25.1.7.4.2. Aluminum tubing is used primarily to obtain structural rigidity in long unsupported spans of bus, usually in high voltage structures, and over designed in current carrying requirements is disregarded.

25.1.7.5. Bus Connections

25.1.7.5.1. All current carrying aluminum connections shall be thoroughly cleaned, coated and sealed with an oxide inhibiting agent. Aluminum oxide, which is a poor electrical conductor, forms rapidly on the surface of drawn or rolled aluminum. It must be removed and prevented from reforming after the connection is completed. This applies to all connections, whether bolted, clamp or compression type. Caution - Aluminum expands 30% (1.33 times) more than copper. Every connection involving a combination of aluminum and copper must be planned to avoid gradual loosening caused by large temperature changes. Unequal expansion of aluminum, copper and steel can cause extremely high pressure during hot conditions which stretches one or more of the metals leaving a loose connection when cold conditions occur

25.1.7.5.2. Bolted electrical connections shall be made on flat contact surfaces, completely cleaned with an oxidation inhibitor. This must be done by thoroughly scratch-brushing the contact surfaces through the inhibitor, leaving enough of it on the surface to control reformation of oxides. After the connection is completed, additional compound shall be applied and forced into every irregularity and opening in order to completely seal the joint against moisture and corrosion.

Aluminum to Aluminum connections shall be fastened with aluminum bolts, 2024-T4alloy with No. 205 alumalite finish and preferably NO-OX-ID coated. Nuts shall be of the same alloy and finish. Heavy series bolts and nuts (7/8" across flats) are preferred.

Aluminum to Copper connections shall be made only with flat contact surfaces. Dressing and sealing the connection with inhibitor is especially important where unlike metals are in contact. Care must be taken to place the aluminum above copper when in a horizontal plane so that corrosive copper salts do not flow onto the aluminum. The type of bolt used is also important because extreme temperature changes can cause a loose joint due to the expansion differential between copper and aluminum. Aluminum or bronze bolts will be used as specified below: (a) Use aluminum bolts if thickness of the aluminum conductor is the same or greater than the copper conductor. (b) Use bronze bolts (Everdur) if the copper conductor is thicker than the aluminum.

25.1.7.5.3. Cable terminations can be made with clamp, compression and welded type fittings; preferably welded or compression types. Welded fittings should be used only when there is enough other bus welding on the project to make it economical.

25.1.8. Ground Grid Criteria

25.1.8.1. The short-circuit design rating for a particular substation is selected based on the calculated maximum available fault current available at that location and takes into account the future growth of the substation and power system. Step and touch potential calculations may be based on the estimated future maximum fault current level. Substation grounding design is based on the IEEE 80 standard.

25.1.8.2. Ground Potential Rise (GPR) calculations may be required to support the local telephone company provider design needs.

25.1.8.3. The substation grounding system is a grid buried 18" below rough grade and made of 4/0 - 19 strand soft drawn copper conductor, ¾" threaded ground rods, and appropriate connector fittings. The conductor is run as a continuous loop when attaching to ground rods, fence, structures, and most equipment (transformers are the exception).

25.1.8.4. The fence and the fence counterpoise (a conductor buried 3' beyond the substation fence) are both connected to the ground grid.

25.1.8.5. All equipment must have provisions for grounding in accordance with OSHA codes. The ground grid shall be attached to equipment at two different points such as opposite corners of a transformer or each leg of a switch stand. The grid shall be bolted or welded to all steel structures and fence posts.

25.1.8.6. Electrical Equipment Enclosure grounding shall be tied to the substation grounding system in two places, at opposite sides of the enclosure.

25.1.8.7. Cable Trench Conductor grounding shall conform to the following:

25.1.8.7.1. One #4/0 bare copper conductor is to be laid in all precast or direct burial cable trench. The ground conductor is required to protect control cables from stray ground currents or signals usually present in high voltage installations by equalizing the potential along the length of the cables.

25.1.8.7.2. The trench ground conductor must be connected to the station grounding system at every intersection and at the ends of each trench. In the case of direct buried trenches, the ground conductor shall be incorporated into the system grounding design.

25.1.8.8. Switch Handle grounding on steel structures shall have the operating pipe be bonded to the steel using a flexible grounding jumper.

25.1.8.9. Ground wells and other enhancements are utilized when required.

25.1.9. Conduit and Cable Trench Criteria

25.1.9.1. Direct buried cables shall not be used. If conduit size is greater than 4 inches then use multiple conduits instead. Does not apply to feeder risers.

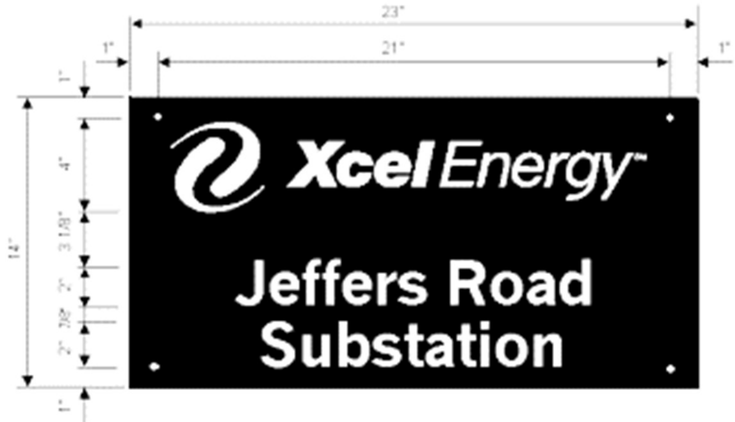
25.1.9.2. Cables within the substation shall be routed through a cable trench system extending from the Electrical Equipment Enclosure (EEE) to equipment located within the substation. The final route from the cable trench to the device shall be in schedule 40 PVC conduit for below grade portions of the conduit, and RGS conduit for bends / sweeps and above grade locations.

25.1.9.3. Cables shall be suitable for direct burial.

25.1.10. Outdoor Nameplate/Safety Sign Requirements

25.1.10.1. Each substation has a facility identification sign posted near the main entrance that gives the company name, substation name, and physical address. If there is a separate security gate installed at the entrance off of the public road, there will be a facility identification sign at this gate as well as at the main entrance. Additionally, warning signs are posted on each entrance gate and at intervals around the outside of the substation fence (typically every 50'). Within the substation, all power equipment and switches are labeled. Warnings signs are also posted for battery systems, buried cable, and areas of limited clearance. Substation signs must meet or exceed the requirements of the National Electric Safety Code.

25.1.10.2. Substation Identification Sign



14" x 23" sign

25.1.10.2.1. The sign should be placed on all substations unless this conflicts with local laws and ordinances.

25.1.10.2.2. The signs should be 6'-0" from grade to top of sign, placed adjacent to substation walk or drive gate and above the address sign.

25.1.10.2.3. Mount using a copper or aluminum wire tie in each hole.

25.1.10.2.4. Sign specifications:

Size: 14" x 23"

Material: 0.080 aluminum plate with 3M High Intensity Silver Scotchlite code #3870. Background to be silk-screened with 3M #845 black paint.

Text shall be 2" Helvetica Medium Upper and Lower Case. (example: Jeffers Road Substation).

Owner logo must be per company guidelines.

25.1.10.3. Substation Address Sign

25.1.10.3.1. The signs should be placed adjacent to substation walk or drive gate and under the Substation Identification Sign.

25.1.10.3.2. Mount using a copper or aluminum wire tie in each hole.

25.1.10.3.3. Sign specifications:

Size: 36" x 7" (vendor can make sign longer for longer addresses).

Material: 0.080 aluminum plate with 3M High Intensity Silver Scotchlite code #3870.

Background to be silk-screened with 3M #845 black paint.

Text shall be 3 ½" Helvetica Medium Upper and Lower Case.

25.1.10.4. Substation Safety Sign

25.1.10.4.1. The signs should be placed 2 to 3 times the readability distance of the message text (Table 1, ANSI Z535.2 "Minimum Letter Height Calculations"). In this case, 30 to 45 feet apart and no more than 15 feet from the corners of the enclosure.

25.1.10.4.2. Two signs should be placed on each drive gate, one on the inside and one on the outside (back to back). This is done so you can read the inside sign if the gate is open.

25.1.10.4.3. One sign should be placed on the outside of each walk gate.

25.1.10.4.4. The signs should be placed approximately 5'-0" form grade to top of sign.

25.1.10.4.5. Mount using a copper or aluminum wire tie in each hole.

25.1.10.5. Substation Battery Warning Sign

10" x 14"

25.1.10.5.1. Signs should be placed on the outside of all substation control house doors.

25.1.10.5.2. Sign is to be mounted to the door using sheet metal screws.

25.1.10.5.3. The signs should be placed approximately 5'-0" from the bottom of door to the top of the sign and centered on the door.

25.1.10.5.4. These signs are now required per the National Electrical Safety Code, Section 14, Part 146B.

25.1.10.6. Substation Buried Cable Sign

10" x 7" Sign

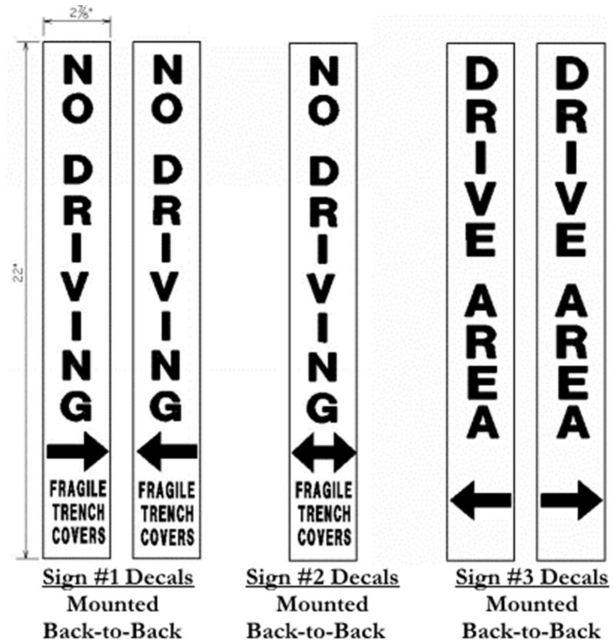
25.1.10.6.1. The sign should be placed at substations where cables are in the area and need to be marked to prevent accidental digging.

25.1.10.6.2. The signs should be mounted on each side of the substation fence fabric, back to back, at the location where cables pass under the fence.

25.1.10.6.3. Mount to fence using a copper or aluminum wire tie in each hole.

25.1.10.6.4. Outside of the substation fence this sign can be mounted to a steel channel post.

25.1.10.7. Substation Precast Cable Trench Signs



25.1.10.7.1. Vehicles cannot drive over precast cable trench without breaking covers. The warning signs shown above will be driven into the ground at strategic locations where vehicles could mistakenly drive over the precast cable trench.

25.1.11. Indoor Equipment and Panel Labels

25.1.11.1. All indoor equipment and devices shall be labeled.

25.1.11.2. Blocking bar switch handles shall be labeled with a white background, black lettered label describing where the other end of the wire is landed.

25.1.11.3. Every test switch shall have a trip switch index hung in a C-Line 46058 document protector on the relay panel where the test switch is located.

25.1.11.4. Labels shall be laminated phenolic plastic tags with the following color coding.

25.1.11.4.1. White with black lettering: all devices or items not specifically called out.

25.1.11.4.2. Yellow with red lettering: Operator switches; 43, 97, other control switches.

25.1.11.4.3. Red with white lettering: Test switches

25.1.11.4.4. Orange with black lettering: Lockout switches (86).

25.1.11.5. The font sizes and types show in

25.1.11.6.

25.1.11.7.

25.1.11.8. Table shall be used.

Table 25.4: Indoor equipment and panel labels labeling machine font size and type requirements.

Font Size	Application
36 pt Bold	Panel names (Front and Rear) ACT, APT Phase Designations
30 pt Medium*	97, 43, SS, 243, 283, Switches
24 pt Medium* (16 pt (8x2) where space is limited)	FT Boxes Individual Indicating Lights Metering Relays Annunciator Box Number Trip Switches In Rear
16Pt (8x2) Medium	Annunciator Point Numbers
12 pt.	Annunciator Labels Plug in and Draw Out Relays AC & DC Panel Circuit Descriptions Chrysler 8000 RTU: CKT Descriptions (On Panel)
16/8 pt. (Double Line)	Indicating Fuses DC Circuit Numbers In Fuse Cabinet

*If medium cartridge is not available use the "bold" function on the machine.

25.1.12. Site Lighting Criteria

25.1.12.1. Outdoor substation lighting shall be controlled from the interior of the Electrical Equipment Enclosure with a switch, or switches. Lighting contactors may be used with switching to turn the outdoor lights on and off.

25.1.12.2. Outdoor yard lighting for substation equipment shall provide an average of 2 foot-candles for safe operation/maintenance of equipment and for security. Remote areas of the substation yard shall have an average of 0.2 foot-candles.

25.1.13. Lightning Protection Requirements

25.1.13.1. All substation electric equipment, electric bus, and support structures shall be shielded from direct lightning strikes. Shield masts and shield wires are the preferred methods of lightning shielding within substations. When economical, it is preferred to not have shield wires directly over bus.

25.1.13.2. Two widely used methods for designing substation lightning shielding are i) “fixed angle zone of protection” or “traditional cone” and ii) “electro-geometric model” or “rolling sphere”. Although the traditional cone method is more commonly used, either method is acceptable. IEEE 998 standard shall be applied in the evaluation.

25.1.14. Wildlife Protection of Bushings

25.1.14.1. Outdoor bushings operating at 35KV and below shall have protection installed on them to reduce the potential for phase to ground or phase to phase faults caused by wildlife getting near the area of the bushings. The protection shall be applied on equipment such as transformer bushings, surge arrestors, circuit breakers, circuit switchers, auxiliary transformers, potential transformers, etc. The bushing protection shall be “Therm-A-Guard” or equal, and shall also include covers for conductors extending from the bushings.

25.1.14.2. Each bushing protector shall have two cable ties around it to ensure it stays in place.

25.1.15. Cable Raceway System

25.1.15.1. This Section describes the requirements for a complete and proper cable raceway installation for the substation, as shown in the Design Documents. Cable raceway systems shall include any system designed expressly for holding or routing wires and cables including excavated trenches.

25.1.15.2. Contractor shall install all direct buried conduit or duct, concrete encased conduit or duct, indoor and outdoor conduit, cable tray, cable trench and accessories required for embedded and exposed raceway systems. Conduit accessories shall include but not be limited to the following items: conduit fittings, conduit connectors, outlet boxes, outlet bodies, pull boxes, junction boxes, locknuts, bondnuts, bushings, materials for sealing joints and ends of conduits, panelboards, cabinets, tray hanger supports, bracket supports and clamps, excavation warning tape and all other material and devices required for a complete and proper electrical cable raceway system.

25.1.15.3. Referenced Codes and Standards

25.1.15.3.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard or code conflict with these Specifications Owner shall be notified at once and a remedy shall be determined.

25.1.15.3.2. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

25.1.15.3.3. National Electrical Manufacturers Association:

NEMA Publication 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

25.1.15.4. Materials

25.1.15.4.1. Conduit

Above grade conduit and conduit extending from above grade to below grade including below grade sweeps shall be rigid galvanized steel (RGS). Below grade conduit extending from RGS sweeps shall be schedule 40 -polyvinyl chloride (PVC) conduit.

Electrical Metallic Tubing (EMT) thin wall conduit may be used in indoor, non-hazardous or in embedded locations. EMT connectors and couplings shall be gland compression type. Set-screw type connectors shall not be used.

All flexible conduit shall be steel reinforced and liquid tight.

25.1.15.4.2. Raceway Accessories

Breaker panels, junction boxes and outlet boxes, together with associated items for attaching and making connections, shall be installed in conformance with the Design Documents and this Section.

All outdoor, surface-mounted outlet boxes shall be cast aluminum or cast iron, with gasketed steel or aluminum cover plates. Crouse-Hinds, Russel & Stoll or Owner approved equal shall be used. Formed metallic outlet boxes shall not be used in outdoor locations.

Junction boxes used in outdoor locations for splicing and terminating wires shall be NEMA Type 3R, 16 or 14 gauge galvanized steel or Owner approved equal, supplied without knockouts. The size of all enclosures shall be in accordance with all applicable codes. Connections to the top and sides shall be made with waterproof hubs. Connections to the bottom shall be made with a bushing and two (2) locknuts.

Formed metallic outlet boxes may be used in indoor, non-hazardous locations in accordance with the NEC. Cover plates shall be steel or aluminum.

25.1.15.5. Raceway Installation

25.1.15.5.1. All raceway shall be installed in accordance with the Design Documents and this Section.

25.1.15.5.2. Above-Grade Conduit

All above-grade exposed conduit shall be RGS unless otherwise stipulated. Where it is connected to buried conduit, the RGS conduit coupler shall extend to one (1) inch above finished grade, making the required bend radius into the horizontal run.

Where possible, conduit runs shall be parallel to the centerlines of structures or parallel to each other in the case of multiple runs. A run of conduit, embedded or exposed, shall not contain more than the equivalent of four (4) quarter-bends (360* total) between outlet boxes, outlet bodies, junction boxes and pull boxes., including bends located immediately at the outlet box, or junction box. All exposed conduit and conduit inside the control house shall be one-half (1/2) inch minimum.

Factory bends or bends made with a hydraulic power bender shall be used for conduit two (2) inch and smaller. The minimum bending radius of conduit shall be seven (7) times the nominal diameter of the conduit. All bends for conduit sizes above two (2) inches shall be factory bends.

All conduit runs shall be supported at least every five (5) feet. Fittings and outlets that are for conductor feed-through shall have the attached conduit supported within three (3) feet of the outlet. Place conduit supports within eighteen (18) inches of outlets that contain devices such as receptacles or boxes that support fixtures.

Where conduit enters a box, vault, cable trench or any other fitting or termination, a bushing shall be provided to protect the cable from abrasions. At all points where the conduit terminates, the bushing shall be grounding type to provide an effective connection to ground. The ends of conduit shall be protected to prevent the entrance of any foreign material.

All material and equipment shall be stored so as to be protected from deteriorating effects of the elements. All exposed ends of conduit shall be protected during construction to prevent the entrance of any foreign material or moisture. Touch-up paint shall be provided by Owner as required.

Burrs or sharp projections which might injure the cable shall be removed.

Round, flexible, nylon-covered tapes or nylon ropes shall be used for fishing and wire-pulling in conduit.

Pre-drilled holes (if furnished) shall be used for mounting boxes. Drilling through the top, sides or back of a junction box is not acceptable for NEMA Type 3 ratings or above. Drilling through the top or sides of junction boxes rated below NEMA Type 3 is not acceptable. Formed channels shall be used for mounting boxes unless otherwise indicated in the Design Documents.

25.1.15.5.3. Direct Buried Conduit or Duct

Horizontal runs of buried conduit shall be PVC conduit unless otherwise specified. Locate underground runs in accordance with the Design Documents. Pull boxes shall be installed to limit any run of conduit to (4) quarter bends (360° total). All conduit runs shall contain a cable pulling tape or rope.

Underground conduit runs shall be installed as shown in the Design Documents and as follows:

Excavated trench bottom shall be smooth or filled with clean sand as required to make it such.

Conduit shall be used for runs under roadways as shown in the Design Documents.

All bends, including those within or at the ends of PVC conduit sections, shall be made with RGS conduit. Adapter connectors shall be provided between PVC conduit and all RGS conduit sections.

Backfill around the conduit shall be in accordance with the Design Documents.

Conduits which enter manholes pull boxes or building foundations shall use end bells and be grouted in place. End bells shall be flush with the surface.

As soon as practical after conduit runs are completed and concrete forms are stripped, all conduit runs shall be swabbed free of foreign material. Plugs or caps shall be installed with greased threads and left in place until the wire is installed.

RGS conduit shall be used to make entrance connections into buildings or equipment foundations and vaults. The RGS conduit is to be extended a minimum of eighteen (18) inches beyond exterior walls for buried cables, or as shown in the Design Documents. All conduit entrances into the control building or into any outdoor enclosure or vault shall be sealed with Duxseal or other Owner approved material.

The 34.5kV collection feeder conduit shall be protected with concrete bollards. Contractor shall submit plans for protection to Owner for approval.

25.1.15.5.4. Concrete-Encased Conduit or Duct

Conduit, conduit fittings and conduit boxes to be embedded in concrete shall be held securely in position while the concrete is being placed.

The conduit shall rest on spacers to ensure that the spacing between conduit runs does not change during the placement of the concrete. The spacers shall be placed at regular intervals as specified in the Design Documents or as recommended by the manufacturer, whichever is less. Conduit shall be secured to the trench bottom to prevent flotation.

Concrete used for encased conduit or duct shall have a twenty-eight (28)-day compressive strength of at least 2000 psi. The aggregate shall be less than three-fourths (3/4) inch in diameter. Red Dye shall be incorporated into top of ductbank concrete or Caution Buried Electrical Line Below tape shall be placed 12” above top of ductbank. When the backfill above the concrete must be compacted, the concrete shall cure for seven (7) days before backfilling. When compaction of the backfill is not required, backfill can be placed twenty-four (24) hours after pouring.

After the forms are removed Contractor shall clean all concrete from the inside of conduit boxes and threads for attaching devices and covers.

25.1.15.5.5. Precast Concrete Trench

An assembled-component-type reinforced precast concrete cable trench system shall be installed in accordance with the Design Documents, this Section and the manufacturer’s recommendations.

Contractor shall excavate all substances encountered to a depth necessary to properly install the concrete trench system. All previously installed buried conduits, buried cables, copper ground grid wire and site drainage systems shall be located, by digging or other methods, prior to excavating in concrete trench locations. Ground grid wires interfering with the trench installation shall be spliced exothermically and buried six inches below the trench. The site drainage system shall not be modified in any way to facilitate the concrete trench installation and drain pipe back fill shall be restored to original condition if disturbed. Any damage to existing installations shall be repaired to the satisfaction of Owner.

Precast trench members shall be set only on firm, compacted earth, sand or gravel mix, such that the top of the sidewall will be at the elevation indicated in the Design Documents.

Excavations shall be kept free from water during the placement of concrete trench system components and during inspection.

Conduits entering the concrete trench system shall be laid beneath the sides of the trench and terminated with an angle deflection and bushing or acceptable conduit fitting to enter the trench.

Following the concrete trench installation, all excavation shall be backfilled and mechanically compacted to grade. Backfill along the trench system shall be performed according to the manufacturer's recommendations and shall not deflect the trench sidewalls.

Covers shall be placed on the concrete trench after installation of cables is completed.

The concrete trench system shall be protected against entrance of construction debris, rock and earth during the construction and after placement of the sand bedding. Contractor shall clean the concrete trench system of any such foreign material immediately prior to placing cables and just before final placement of covers.

25.1.15.5.6. Overhead Cable Tray System

An assembled, overhead, indoor cable tray system shall be installed in the control building in accordance with the Design Documents, this Section and the Manufacturer's recommendations.

Cable entrances to equipment enclosures and panelboards from a cable tray shall be made with conduit runs or via openings in the tray bottom. All cable entrance cutouts in the cable tray bottom, or equipment enclosure shall have grommets to protect the cable jacket from cuts or abrasions. Conduits entering the cable tray shall be securely fastened to the tray sidewall with hardware specifically used for that purpose.

The overhead cable tray shall be supported as shown in the Design Documents. The preferred method of support utilizes roll-formed uniform channel framing members attached to the floor and wall. An alternate method uses a trapeze-type support made of roll-formed channel with threaded rods fastened to the ceiling. All tray supports connected to the ceiling of a metal building shall be directly attached to roof purlins or to formed channel fastened to the nearest roof purlin. Tray supports in the ceiling of a masonry building shall utilize properly sized drilled expansion anchors.

Cable tray located above wall-mounted equipment shall be supported with brackets fastened directly to wall columns and specifically designed for that purpose.

25.1.15.6. See Cable Raceway System testing requirements.

25.1.16. Shielded Cable

25.1.16.1. Shielded control cable shall only be required if there is 230 kV or greater present in the substation.

25.2. Civil/Grading

25.2.1. All civil and earthwork shall meet the construction requirements and the testing and inspection requirements.

25.2.2. Fill Material Applications

25.2.2.1. Fill material shall meet the requirements

25.2.2.1.1. Common Fill

Used as backfill below frost line or in berms in the graded area.

25.2.2.1.2. Select Fill

Used as fill in the graded areas and as subbase for the access roads or subcuts required for shallow foundations.

25.2.2.1.3. Granular Fill

Shall meet the project requirements

Used as a top course of the fill placement as shown in the Design Documents and as bedding and backfill for drainage piping or culverts.

A type of granular material used as a separation layer in substations is four (4) inches of 3/4" diameter clean crushed rock.

Granular Fill applications are as follows:

GRADATION TYPE "A"

a) wet-caving condition - all soils
b) suitable for pole excavation below water table where casing of hole is necessary to prevent soil caving.

GRADATION TYPE "B"

a) wet and caving condition with saturated granular or cohesive soils
b) dry and caving condition with sandy soils
c) dry condition with dense moist granular soils or stiff hard cohesive materials

GRADATION TYPE "C"

a) Dry condition with dense moist granular soils or stiff hard cohesive materials

25.2.2.1.4. Base Material

Base material is used primarily for improving roadway stability and shall be used as a top course on all access roads and over the substation graded area. Adequate compaction as specified in the Design Documents is essential in providing adequate material stability and long term durability. This material shall meet the Road Base and Cap Aggregate specification in Section **Error! Reference source not found.**.

25.2.2.1.5. Lean Concrete Backfill

Lean Concrete Backfill may be placed around buried conduit in conjunction with underground substation construction where compaction of granular material around conduit or piping is difficult and/or impractical. This material is recommended where existing slabs or foundations are in danger of being undermined. This material shall meet the Lean Concrete Backfill specification.

25.2.3. Security Fence

25.2.3.1. The security fence shall adhere to the requirements provided.

25.2.4. Bollards

25.2.4.1. Bollards shall be placed around no drive areas and areas such as in front of feeder risers to protect them from damage.

25.2.5. Substation Access Road

25.2.5.1. Driveways should be designed with a minimum 50 foot inside radius and enough space to straighten a truck out before going through the gate. Driveway paths within the fenced substation should avoid crossing precast cable trenches if possible.

25.2.6. Finish Conditions

25.2.6.1. The substation shall be covered with 4” of clean crushed stone. The crushed stone shall extend ~~5~~ 3 feet outside of the substation fence and provide an electrical resistivity value of greater than or equal to 3,000 ohm-meters.

The conductor in each cable shall be sized to withstand 100% of the available phase fault current for a minimum of 9 cycles. The substation feeder breaker will be set for an instantaneous fault (with 5 cycle delay) and will clear a fault in 9 cycles for normal system clearing.

Normal Fault Clearing Time:

- 5 Cycle Delay on Relay Tripping
- 1 Cycle Relay Margin
- 3 Cycle Breaker Interrupting Time
- 9 Cycle Total Clearing Time

The concentric shield wires in each of the three cables (A, B, & C Phase) shall be sized to withstand 70% of available ground fault current for a minimum of 6 cycles. The substation feeder breaker will be set for an instantaneous ground fault and will clear a fault in 6 cycles or less for normal system clearing.

Normal Fault Clearing Time:

- 0 Cycle Delay on Relay Tripping
- 3 Cycle Relay Margin
- 3 Cycle Breaker Interrupting Time
- 6 Cycle Total Clearing Time

The system trench ground, routed with the collection system feeder cables, shall be sized to withstand 100% of available ground fault current for a minimum of 6 cycles. The substation feeder breaker will be set for an instantaneous ground fault and will clear a fault in 6 cycles or less for normal system clearing.

Normal Fault Clearing Time:

- 0 Cycle Delay on Relay Tripping
- 1-3 Cycle Relay Margin
- 3 Cycle Breaker Interrupting Time
- 6 Cycle Total Clearing Time

25.3. Structural

25.3.1. Structural Steel Erection

25.3.1.1. This section describes the requirements for the complete and proper erection of structural steel as shown in the Design Documents.

25.3.1.2. Structural steel consists of steel elements essential to support the design loads and includes but is not limited to the items listed below:

25.3.1.2.1. Anchor bolts.

25.3.1.2.2. Base plates.

25.3.1.2.3. Beams, girders, columns and posts.

25.3.1.2.4. Bracing.

25.3.1.2.5. Structural material for connecting structural element to structural element.

25.3.1.2.6. Fasteners.

25.3.1.2.7. Leveling plates and associated materials.

25.3.1.3. Referenced Codes and Standards

The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard or code conflict with these Specifications Owner shall be notified at once and a remedy shall be determined.

25.3.1.4. American Institute of Steel Construction:

25.3.1.4.1. AISC Steel Construction Manual

25.3.1.4.2. AISC Specification for Structural Steel Buildings.

25.3.1.4.3. AISC Code of Standard Practice for Steel Buildings and Bridges.

25.3.1.5. American Society for Testing and Materials

25.3.1.5.1. ASTM A36 Specification for Structural Steel.

25.3.1.5.2. ASTM A992 Standard Specification for Structural Steel Shapes

25.3.1.5.3. ASTM A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

25.3.1.5.4. ASTM A325 Specification for High-Strength Bolts for Structural Steel Joints.

25.3.1.5.5. ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

25.3.1.5.6. ASTM F959 Specification for Compressible-Washer-Type Direct Tension Indicators for use With Structural Fasteners.

25.3.1.5.7. ASTM E94 Guide for Radiographic Testing.

25.3.1.5.8. ASTM E142 Methods for Controlling Quality of Radiographic Testing.

25.3.1.5.9. ASTM E164 Practice for Ultrasonic Contact Examination of Weldments.

25.3.1.5.10. ASTM E165 Practice for Liquid Penetrant Inspection Method.

25.3.1.5.11. ASTM E709 Practice for Magnetic Particle Examination.

25.3.1.6. American Welding Society:

25.3.1.6.1. AWS D1.1 Structural Welding Code – Steel

25.3.1.7. Research Council on Structural Connections:

25.3.1.7.1. Specification for Structural Joints Using ASTM A325 or A490 Bolts

25.3.1.8. Welder Certification

25.3.1.8.1. Contractor shall submit AWS qualifications of welders performing welding on structural steel.

25.3.1.9. Structure Erection

25.3.1.9.1. Contractor shall perform the following tasks to properly and completely erect each steel structure:

25.3.1.9.2. Set structural steel accurately to lines and elevations indicated.

25.3.1.9.3. Align and adjust various members forming part of a complete frame or structure before permanently fastening.

25.3.1.9.4. Clean bearing surfaces and other surfaces which will be in permanent contact before assembly.

25.3.1.9.5. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

25.3.1.9.6. Level and plumb individual members of each structure.

25.3.1.9.7. Splice members only where indicated in the Design Documents.

25.3.1.9.8. Complete all structural connections with proper installation and torque requirements of fasteners.

25.3.1.9.9. Foundation Loading

Steel structures shall not be erected on concrete foundations until the concrete has achieved 75% of design strength. Steel structures shall not be loaded until foundation concrete has achieved 100% of design strength.

25.3.1.9.10. Surveys

Contractor shall check elevations of concrete bearing surfaces and locations of anchor bolts and similar devices before erection work proceeds and report discrepancies to Owner. Contractor shall not proceed with erection until corrections have been made or until compensating adjustments to structural steel work have been approved by Owner.

25.3.1.9.11. Temporary Shoring and Bracing

Contractor shall provide temporary shoring and bracing members with connections of sufficient strength to bear loads imposed during construction. All temporary members and connections shall be removed when permanent members are in place and final connections are made. Temporary guy lines may be used to achieve proper alignment of structures as erection proceeds.

25.3.1.9.12. Setting Base and Bearing Plates

Contractor shall set loose and attached base plates and bearing plates for structural members on wedges or other Owner approved adjusting devices. Anchor bolts shall be tightened after supported members have been positioned and plumbed.

25.3.1.9.13. Bolted Connections

Wrenches which may deform the nuts or cut or flake the galvanizing will not be permitted.

Multiple-Bolt, Moment Connections

The bolts shall be tightened in accordance with Manufacturer's guidelines.

Single-Bolt, Pinned Connections

The bolts shall be tightened until the bolt head and nut are snug against the outer plates and the nut locking device is fully engaged. The inner plate surfaces do not necessarily need to be in full contact with each other to obtain an acceptable connection.

Enlarging Bolt Holes

Holes in members shall not be enlarged without Owner approval. Holes which must be enlarged shall be reamed, under the direction of Owner, to accommodate the next larger size bolt. Holes shall not be enlarged by burning or by using drift pins.

Substitution of Bolts

Substitution of the bolt sizes and materials specified in the Design Documents must be approved by Owner.

25.3.1.9.14. Field Correction of Fabrication Errors

Contractor shall not use gas cutting torches to correct fabrication errors in primary structural framing members. Gas cutting will be permitted only on secondary members that are not under stress.

Field Welding

Field welds shall not be permitted without review by Owner. All approved field welding shall be performed in accordance with AWS requirements for weld material and prequalified joints and shall be performed by certified welders.

Contractor shall submit AWS qualifications of welders performing field welding on structural steel.

Field Drilling

Missing holes shall be added by drilling or punching. Flame cutting of holes shall not be used.

Field Repair of Galvanizing

All metal exposed as a result of field repair activities shall be re-coated.

25.3.2. Surface Coating Repair

25.3.2.1. Reference Codes and Standards

The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

25.3.2.1.1. Steel Structures Painting Council:

SSPC-PA1 Shop, Field, and Maintenance Painting.

SSPC-SP3 Power Tool Cleaning.

25.3.2.1.2. American Society for Testing and Materials:

ASTM A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

25.3.2.2. Equipment

25.3.2.2.1. Surfaces of most electrical equipment (such as panels, switchgear, transformers, circuit breakers, cabinets, junction boxes, etc.) are finished at the factory. Contractor shall exercise great care to prevent damage to this original finish during installation of the equipment and during construction work. If the factory finish is damaged during shipment, installation or the course of construction, the damaged surface area of the component shall be refinished. The refinished surface shall be equivalent in every respect to the original surface, including color, texture, gloss, and smoothness. Refinishing paint if furnished with the equipment may be used; otherwise, the paint shall be obtained from the equipment manufacturer.

25.3.2.3. Structural Steel

25.3.2.3.1. Contractor shall be responsible for repairing galvanized surfaces of structural steel damaged during shipment, erection, field modifications or during the course of construction and for applying an approved surface coating over any bare metal areas which were not galvanized during fabrication. All bare metal areas and bolted connections which are subject to corrosion and requiring galvanizing repair shall be cleaned and repaired in conformance with SSPC-PA1, ASTM A780 and the manufacturer’s instructions.

25.3.2.3.2. Immediately after structure erection has been completed, all field welds shall be ground smooth and the adjacent uncoated areas and any areas where the coating has been damaged shall be cleaned in conformance with SSPC-SP3.

25.3.2.3.3. All steel requiring galvanizing repairs shall be coated with an inorganic, zinc-rich coating in accordance with the following conditions:

a. The galvanizing repair paint shall be SSPC-Paint 20 or DOD-P-21035, with a dry film containing a minimum of 94 percent zinc dust by weight.
b. Surfaces to be coated shall be free of abrasives, oils, dirt or other contaminants.
c. Handling of coating equipment and the steel surfaces to be repaired shall be performed in a manner to avoid contamination prior to, during and following the application of the protective coat.
d. The surface temperature of the steel to be coated shall be 50°F minimum and at least 5°F above the wet-bulb air temperature reading.
e. The coating shall be allowed to cure prior to application of a second (or top) coating for at least the minimum time recommended by the coating manufacturer.
f. The coating thickness shall be 3.0 mils dry film thickness. The thickness shall be monitored by wet-film thickness measurements.
g. Areas with dry-film thickness of less than 1.7 mils or greater than 5.0 mils shall be corrected by additional surface coating or by wire brushing and recoating.

25.4. Electrical

25.4.1. Equipment Installation

25.4.1.1. Power Circuit Breakers and Circuit Interrupters

25.4.1.1.1. Contractor's external inspection, receiving and installation activities shall include but not be limited to the following:

a. Receive the breaker at the shipping point.
b. Examine the shipment and note any obvious signs of damage or rough handling.
c. Inventory the shipment and check it against the shipping list.
d. Report any shortages to the Manufacturer and Owner.
e. Place the power circuit breaker on the foundation.
f. Orient the breaker mechanism cabinet as shown in the Design Documents.
g. Install SF6 gas if required.
h. Fill to proper pressure per name plate requirements.
i. Perform a gas system moisture check. (The gas should be processed, and the breaker tank evacuated as need is indicated in the Manufacturer's instructions.)
j. Check for gas leaks.
k. Install bushings.
l. Install ground assemblies.
m. Install bus system connections
n. Install conduit runs into the equipment cabinet.
o. Make all secondary electrical power connections.
p. Terminate all control cables.

25.4.1.2. Power Transformers

25.4.1.2.1. Power transformer purchaser's activities shall include:

a. Delivery of transformer to site.

b. Offloading of transformer at site.

c. Assembly of transformer, including installation of all accessories that are shipped separately, filling of transformer with oil, oil processing, etc.

25.4.1.2.2. Contractor's installation activities shall include, but not be limited to:

a. Testing of transformer.

b. Install ground assemblies.

c. Install bus system connections.

d. Install conduit runs into the equipment cabinet.

e. Make all secondary electrical power connections.

f. Terminate all control cables.

25.4.1.3. Disconnect Switch and Fuse Installation

25.4.1.3.1. Contractor's installation activities shall include but not be limited to the following:

Install manual or motor operating mechanisms such that they affect a smooth and thoroughly controlled movement throughout the entire opening and closing cycles of the group operated switch. All rods, shafts, pipe linkages, connectors, operating levers, supports and fittings shall show no noticeable deflection when operating the switch.

Install group operated switches and operating mechanism such that the switch blades open and close simultaneously. All switches will be manually operated until approved by Owner. Adjust all cam, spare contacts and limit switches in accordance with the Manufacturer's installation and maintenance instructions.

Ground the switch handle as shown in the Design Documents. Arrange and align switch handles to ensure the proper switching of the unit from the operator's standing area. The switch operating mechanisms shall not be pierced until the installation has been inspected by Owner.

Install mechanical interlocks, electrical interlocks, or key interlocks in accordance with the Manufacturer's installation and maintenance instructions. Contractor shall be responsible for the final adjustment of the interlock schemes.

25.4.1.3.2. No drilling of any tubular member in the supporting structure to secure the switch-operating mechanism is allowed. All mounting assemblies shall require the approval of Owner.

25.4.1.3.3. Spare power fuse elements shall be stored by Contractor in the control building or other Owner approved shelter.

25.4.1.4. Lighting and Station Auxiliary Power

25.4.1.4.1. Contractor shall install the battery rack, install and test the battery cells, install intercell connectors and ready the battery terminals for Contractor connections.

25.4.1.4.2. Contractor's station auxiliary power installation activities shall include but not be limited to the following:

Locate fixtures and outlet receptacles as shown in the Design Documents and coordinate with other work in the same area to prevent interference between fixtures and piping or other equipment. Contractor shall relocate any fixture or outlet if, after installation, it is found to interfere with other equipment or is so located to prevent its practical and intended use.

Install all lighting and receptacle load centers, AC control power panel boards and DC control power fuse cabinets as shown in the Design Documents.

Each cabinet shall be installed, conduits connected, and wires pulled before the panel board interior is installed. Each panel board interior shall be carefully inspected, all connection and mounting screws tightened and mounted in the cabinet using all of the mounting provisions furnished. The panel board interior shall then be connected, with wires tightly secured in the terminals provided and with unnecessary lengths of wire eliminated. Wiring shall be neatly arranged in the gutters.

The circuit directory shall be accurately and neatly completed to permit ready location of the protective devices controlling circuit loads.

Install station service transformer(s), main disconnect safety switch(s) and automatic or manual transfer switch as shown in the Design Documents.

Install the battery charger as shown in the Design Documents.

25.4.1.5. Wall Mounted Equipment

25.4.1.5.1. All equipment located against the wall of the control building shall be secured by the following methods:

Equipment weighing less than 150 pounds shall be fastened to formed channel members that are secured directly to wall purlins or columns. The formed channel shall be configured in a neat arrangement utilizing the minimum number of members to mount all present and future equipment in the locations shown in the Design Documents.

Equipment weighing more than 150 pounds shall not be supported by the wall. Support stands, fabricated from formed channel and fastened to the floor, shall be used to transfer equipment load to the floor.

25.4.1.5.2. All field-fabricated equipment mounting arrangements shall be subject to Owner approval.

25.4.1.6. Reactive Compensation Equipment

25.4.1.6.1. The contractor shall evaluate the need for reactive compensation equipment as follows:

The facility shall be designed and constructed in accordance with FERC Order 827 as well as any Regional Transmission Organization (RTO) requirements. In the case of conflicting direction, the more stringent requirement shall govern.

The capabilities of the proposed turbines as outlined in the provided turbine supply agreement (TSA) document, as well as transmission line lengths and/or joint use assets (multiple facilities sharing an element) shall be factored in.

Any applicable requirements of an interconnect agreement (IA) and/or system impact study (SIS) shall also be upheld.

25.4.1.6.2. Based on the above factors, any necessary capacitor banks, reactor banks, dynamic VAR equipment, etc. shall be included in the substation design, including all necessary related equipment such as circuit breakers, circuit switchers, bus, foundations, protective relaying, and any other necessary items for the full operation of the VAR equipment.

25.4.1.6.3. Coordination, design, and checkout with the turbine manufacturer based on the TSA documentation shall also be included.

25.4.1.6.4. An interlock system shall be provided to prevent the opening of energized ground switches.

25.4.2. Grounding System

Contractor shall install a complete buried ground grid system and a grounding system for all equipment and devices including, but not limited to, switch operating mechanisms, overhead shield wires, surge arresters, circuit breakers, regulators, meter cabinets, cable termination cabinets, potential and current transformers, power transformers, auxiliary power transformers, structures, fence, control building, relay and control panels, cable trays, AC distribution panels, conduit bushings, shielded cables and cable trench.

25.4.2.1. Referenced Codes and Standards

25.4.2.1.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

25.4.2.1.2. ANSI/IEEE Standards:

a) IEEE Std. 80Guide for Safety in AC Substation Grounding.
b) American Society for Testing and Materials:
c) ASTM B3 Soft or Annealed Copper Wire.
d) ASTM B-8 Concentric-Lay Stranded Copper Conductor.

25.4.2.1.3. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

25.4.2.2. Installation

25.4.2.2.1. Grounding conductors shall be straight and free from kinks, breaks and other damage after installation. Connections shall be made in conformance with the manufacturer's instructions. Conductors shall be thoroughly cleaned prior to making connections. All junctions and splices of buried ground grid conductors shall be made at a ground rod location, wherever reasonably possible. Likewise, ground rods shall be installed at intersecting points of the ground grid conductors and at all equipment locations as shown in the Design Documents. Driving studs shall be utilized.

25.4.2.2.2. All bolted installations shall use lock washers. Paint, rust or other non-conducting material shall be completely removed from the contact surfaces until the bonding surfaces are clean and bright and these surfaces coated with an oxide-inhibitor compound such as Burndy "Penetrox A", Alcoa “No-Ox-Id”, Alcoa No. 2 or other Owner approved equal before making ground connections. Galvanized steel surfaces shall be cleaned with emery paper prior to the application of oxide-inhibitor compound. After the connection has been made any exposed metal subject to corrosion shall be coated.

25.4.2.2.3. Equipment and Structure Grounding

a) All equipment and all steel or aluminum structures shall be solidly connected to the buried ground grid system as shown in the Design Documents. Grounding conductor to loop up to the steel to be CAD welded rather than a pigtail coming up.
b) All neutral conductors, ground electrodes and groundable parts of equipment shall be interconnected as shown in the Design Documents

25.4.2.2.4. Fence Grounding

The fence system, that includes but is not limited to the fence gates, line posts, corner posts, top rail, fence fabric and barbed security wire, shall be solidly connected to the buried ground grid as shown in the Design Documents.

25.4.2.2.5. Electrical Equipment Enclosure Grounding

All ground bus bars in panels and on the interior walls and equipment within the control building shall be connected solidly to the ground grid as shown in the Design Documents.

25.4.2.2.6. Underground Power Circuits

All metallic conduits, metallic cable shielding and sheath and concentric neutral wires shall be effectively grounded at terminations only as shown in the Design Documents.

25.4.2.2.7. Ground Wells

Ground wells shall be located and installed as shown in the Design Documents. The Ground wells shall be installed after all other ground systems have been installed.

25.4.2.3. Grounding inspection and testing requirements.

25.4.2.3.1. All below-grade taps, junctions and splices shall be left uncovered until inspected by the Owner or owner's representative. All unsatisfactory ground connections shall be replaced at the Contractor's expense.

25.4.2.3.2. All exothermic welded connections shall not appear porous or deformed. All bolted ground connections shall be securely tightened.

25.4.2.4. Grid Resistance Test

25.4.2.4.1. The results of the ground grid resistance tests shall include a plan view diagram of the measurement area and a graph for each individual measurement. Appropriate dimensions shall be included on the plan view diagrams. A copy of each test result shall be forwarded immediately to the Owner.

25.4.3. Bus Systems

This Section describes the complete and proper installation of a substation bus system. All work described in this Section and shown in the Design Documents shall be thorough and performed in a neat and workmanlike manner. Bus systems shall include but are not limited to rigid buses, conductors, flexible strain and equipment jumper buses, cable jumpers, overhead shield wires, suspension insulators, station post insulators, fittings, and all hardware required to form a complete system of current-carrying paths connecting the equipment as shown in the Design Documents. Connectors shall include but are not limited to bolted devices, welded devices, clamps, strain clamps, dead-end fittings, terminal devices, and couplings as shown in the Design Documents.

25.4.3.1. Referenced Codes and Standards

The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

25.4.3.1.1. American Welding Society

c) Welding Handbook RP69
d) AWS D-1.2Structural Welding Code-Aluminum

25.4.3.1.2. American Society for Testing and Materials

ASTM B-8 Standard Specification for Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

ASTM B-230 Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes.

ASTM B-231 Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors.

ASTM B-232 Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated Steel-Reinforced (ACSR).

ASTM B 345 Standard Specification for Seamless Aluminum Pipe, 6063-T6 alloy.

ASTM B 49 Standard Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel-Reinforced (ACSR).

25.4.3.1.3. The Institute of Electrical and Electronic Engineers

IEEE 524; IEEE Guide to the Installation of Overhead Transmission Line Conductors.

25.4.3.2. Rigid Bus Installation

All tubular bus connectors shall be welded type unless otherwise noted in the Design Documents. Welding of buses and connectors shall conform to the Manufacturer's recommendations and these Specifications. Welded bus couplers shall be located and installed as shown in the Design Documents. End plugs or caps shall be installed at all open ends of bus tubing including bus ends within an expansion fitting.

25.4.3.3. Tubular Bus

25.4.3.3.1. Tubular bus conductor bends shall be formed using a hydraulic conduit bending tool. The inside radii of bends shall be no less than seven (7) times the nominal diameter of the bus. The bus shall be free of kinks, indentations and flattened surfaces.

25.4.3.3.2. One-fourth (1/4)-inch weep holes shall be drilled in all bus risers, bends, A-frames and horizontal runs at the lowest practical point to drain moisture accumulation. All holes shall be reamed to remove sharp edges.

25.4.3.4. Bolted Connections

25.4.3.4.1. Utmost care shall be exercised when installing clamps, connectors, and other bolted devices. The contact surface of the flat surface, clamp or connectors and the bonding surface of the wire or tubing shall be clean and bright and an oxide-inhibitor compound such as Burndy "Penetrox A", Alcoa “No-Ox-Id”, Alcoa No. 2 or other Owner approved equal shall be applied. Use a stainless-steel brush to clean mating surfaces by thoroughly scratch-brushing the contact surfaces through the inhibitor, leaving enough inhibitor on the surface to prevent reformation of oxides. Plated surfaces shall not be brushed. After the connection is completed, additional compound shall be applied and forced into every irregularity and opening to completely seal the joint.

25.4.3.4.2. Aluminum to Copper connections shall be made only with flat contact surfaces prepared as indicated above. The aluminum connector shall be located above the copper connector when placed in a horizontal plane. Bolts for aluminum to copper connections shall be used as specified below:

Aluminum bolts shall be used if the copper conductor is less than 1.5 times the thickness of the aluminum conductor.

Bronze (Everdur) bolts shall be used if the copper conductor is more than 1.5 times the thickness of the aluminum conductor.

25.4.3.4.3. Aluminum conductor shall not be used with bronze clamp-type equipment terminal lugs.

25.4.3.4.4. All bolted electrical connections shall be made with anodized aluminum hardware as shown in the Design Documents. Bolts shall be tightened firmly, but threads must not be over-stressed. Bolts in clamps over stranded conductor shall be tightened sufficiently to flatten the lock washers. Do not deform or damage the conductor. Bolts shall extend beyond the nut a minimum of one-half (1/2) bolt diameter. Aluminum bolts shall not be cut off and shall be tightened with a torque wrench per the following recommendations:

25.4.3.4.5. Required tightening torque for anodized aluminum 2024-T4 National Course thread bolts and nuts tightened against aluminum 2024-T4 washers and all parts being pre-coated with oxide inhibitor compound are as shown in

Table 25.5: Required tightening torque for anodized aluminum 2024-T4 National Course thread bolts and nuts tightened against aluminum 2024-T4 washers.

Bolt Size (in.)	Torque (ft.-lb.)
3/8	15
7/16	20
1/2	25
5/8	40
¾	60

25.4.3.5. Welded Connections

25.4.3.5.1. Welder Qualifications

All aluminum bus welds shall be performed and welded-type connectors shall be installed by a welder qualified per AWS D-1.2. The welder must be qualified for the following categories:

- Materials: No.23, aluminum base alloys.
- Weld: groove.
- Position: 6G.

A current welding certificate for each on-site welder must be submitted to Owner prior to task mobilization.

25.4.3.5.2. Preparation and Materials

All aluminum welding shall be done in strict conformance with the latest recommendations of the American Welding Society and the Aluminum Association in addition to the requirements stated herein. All surfaces to be welded shall be thoroughly cleaned to remove all moisture, grease, oil, grit and other foreign material prior to welding. Cleaning shall be performed as close to actual welding time as possible while still allowing sufficient time for complete drying of cleaning solvent. Surfaces shall then be wiped just prior to welding with a clean, dry cloth to remove solvent scum and any moisture that may be present. Surfaces shall be wire brushed immediately prior to welding.

The edges of the materials to be butt-welded together shall be prepared in conformance with the data tables and joint design drawings of Table 69.14, Table 69.16, and Figure 69.22 of Chapter 69, Welding Handbook RP69 of the American Welding Society. Where other than butt-weld joints are to be made, if joint details are not shown in the Design Documents, Contractor shall submit proposed joint designs for approval to Owner.

When the ambient temperature is below 40°F, the base metal shall be preheated for both tack welding and finish welding in such manner that the surface temperature of the parts to be welded are at or above 72°F for at least three (3) inches both laterally and in advance of the welding. Preheat temperature shall not exceed 400°F. Suitable enclosures shall be constructed as needed to protect the inert-gas envelope from interference by air currents or wind.

25.4.3.6. Bus Damping

25.4.3.6.1. External bolted-type tubular bus vibration dampers shall be installed on all horizontal bus spans in the locations shown in the Design Documents.

25.4.3.7. Strain and Jumper Bus Installation

25.4.3.7.1. Strain and jumper buses shall be installed in conformance with the Design Documents and manufacturer's recommendations. Cable for the strain and jumper buses shall conform to ASTM B-232. Each individual aluminum wire entering into the construction of the completed conductors shall conform to ASTM B-230.

25.4.3.7.2. Contractor shall install conductors, shield wire and accessories in accordance with the Manufacturer's recommendations and IEEE Std. 524-1992. This IEEE standard, covering conductor handling, grounding, stringing, sagging, dead-ending, splicing, equipment, installation of accessories and special conductors shall be followed in all respects with the exception of items defined in this Section.

25.4.3.7.3. Handling, stringing, sagging and clipping in of the conductor and shield wire shall be by methods which will prevent damage to the conductor, shield wire or line structures. Contact with the ground or other abrasive surfaces shall be prevented. Any remedial action regarding handling of the conductor will be at Owners direction, including replacing rejected material at no cost to Owner.

25.4.3.7.4. Jumper buses shall be smoothly formed and adjacent runs shall be similarly and symmetrically shaped to provide a uniform and pleasing appearance throughout. Stranded conductor shall be installed without twists “bird caging” or kinks and shall be handled to avoid abrasions or other damage. Splices shall not be allowed in overhead strain buses. Strain buses shall be sagged in conformance to sag tables supplied by Owner.

25.4.3.7.5. Contractor shall furnish Owner, at least two (2) weeks prior to intended use, the information detailed below. Failure to provide this information and receive approval shall be cause for the suspension of stringing operations.

A list showing the type, size, brand name and catalog number of all grips (including stocking type and come along) and/or other tools and equipment used for attachment to the conductor, shield wire and guys for the purpose of pulling and sagging conductors and shield wires and installing guys.

A list of the manufacturer and catalog numbers for all compressive type (hydraulic compression or implosive) dead-ends, splices, sleeving presses and dies.

25.4.3.7.6. Compression Connections

Cable connectors shall be compression or welded type as shown in the Design Documents.

All conductors at joints and fittings shall be clean and free of foreign matter. An oxide-inhibiting compound such as Burndy "Penetrox A", Alcoa “No-Ox-Id”, Alcoa No.2 or Owner approved equal shall be used on all aluminum conductor connections.

Compression type terminal lugs shall be made using a compression tool provided with a ratchet or toggle mechanism that ensures complete crimping before the tool can be removed.

Enough inhibitor must be in the barrel of each terminal lug such that it squeezes out around the conductor when inserted and compressed.

25.4.3.8. Insulator Installation

25.4.3.8.1. Station post insulators shall be installed in accordance with the Manufacturer's recommended procedures and the Design Documents.

25.4.3.8.2. All insulators shall be cleaned of oil, dirt, paper, tape or other foreign materials. Any insulator having the surface glaze damaged in any way shall not be installed.

25.4.3.8.3. Contractor shall be responsible for furnishing and installing all missing miscellaneous hardware necessary for a complete insulation system. Miscellaneous hardware can include but is not limited to bolts, nuts, lock washers, eye-bolts, shackles, clevis-pieces, etc.

25.4.3.9. Clearances

25.4.3.9.1. Clearances and spacing of bus work and conductors shall be equal to or greater than those shown in the Design Documents.

25.4.4. Panels and Instrumentation

25.4.4.1. Contractor shall install all mounting and attachment hardware for the panels and instrument racks. Instrument racks shall be securely attached to the floor with anchor bolts in accordance with the Design Documents.

25.4.4.2. Contractor shall install all components not installed by the panel fabricator and shall complete all internal panel wiring to these components.

25.4.4.3. Field Installation of Instruments

25.4.4.3.1. The installation of all field-added instruments, meters, terminal blocks, relays, switches, fuse blocks, terminal blocks, strip heaters and control devices shall conform to the Design Documents. In addition to the panel-front labels, device identification labels shall be placed on the back of the panels adjacent to, or on each device by the method described in the Design Documents.

25.4.4.3.2. All field cutting for the instrument mounting panel or enclosure shall be punched, drilled, or sawed. Contractor shall use the utmost care to avoid damaging the panel or enclosure finish. Thermal cutting shall not be used.

25.4.4.3.3. A minimum of a three (3) inch vertical space shall be maintained between all rear mounted test switches, blocking bar switches and fuse blocks. All rear mounted test switches, fuse blocks and devices shall be located on the wing pan near the relays or meters they are connected to.

25.4.4.4. Field Wiring

25.4.4.4.1. All wire installed in the field shall conform to the Design Documents

25.4.4.4.2. Internal panel wiring installed in the field shall be bundled, routed and secured adjacent to the side wing panels and back of the front panel using cable ties in a neat and workmanship like manner. The use of Panduit or other raceways will be accepted only on the side wing panels adjacent to terminal blocks as shown in the Design Documents or directed by Owner. The conductors shall not cross the width of the panel unsupported. The conductors shall be routed or secured in a manner that will not obstruct subsequent additional wiring, to the terminals of any installed component. Looping of excess wire in Panduit wireways is to be limited. Splicing of internal panel wiring will not be accepted.

25.4.5. Wiring Systems (600V and below)

25.4.5.1. Contractor shall install all indoor and outdoor lighting fixtures, panelboards, switches, indoor and outdoor outlets, wiring accessories and devices and all other electrical materials to complete the indoor and outdoor secondary electrical system. Contractor shall be responsible for all attachment materials to complete the installations. All materials and equipment to be used during installation of the wire and cable shall be stored so as to protect them from deterioration or damage. All control and power cables shall be unshielded, unless specifically stated otherwise in the Design Documents or this Specification.

25.4.5.2. Referenced Codes and Standards

25.4.5.2.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

25.4.5.2.2. National Electrical Manufacturers Association:

NEMA WC-3 Also known as ICEA S-19-81.

NEMA WC-7 Also known as ICEA S-66-524.

NEMA WC-8 Also known as ICEA S-68-516.

25.4.5.2.3. The Institute of Electrical and Electronic Engineers:

IEEE 383; Type Test of Class 1E Electric Cables, Field Splices and Connections

25.4.5.2.4. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

25.4.5.3. Installation

25.4.5.3.1. Wire and cable shall be installed in such a manner that the cable jacket is not damaged. Any wire or cable that is damaged during installation shall be removed and replaced at Contractor's expense.

25.4.5.3.2. Labeling

All wire terminations shall be labeled.

The labeling method chosen shall not cover the barrel of the terminal lug or otherwise interfere in any way with access to the barrel of the lug.

The wire identification number used with the labeling system shall match the identification number on the terminal block marking strip that it originated from.

Instrumentation and control cables and wires in the same circuit or grouping shall be identified by circuit numbers as indicated in the Design Documents. The circuit number shall be fastened to each cable or wire grouping at each terminal, cable trench, pull box, manhole, hand hole and junction point. Ty-Rap cable markers, type TY551M or TY-546, manufactured by the Thomas & Betts Co., or other Owner approved equal are required.

Contractor shall use accepted NEC code practices for providing the required colors at the wire ends of AC power circuits.

25.4.5.3.3. Splices

Cables or wires, except for lighting and receptacle cable, shall not be spliced.

Wire for lighting circuits shall be continuous from outlet to outlet. Splices shall be made in outlet or junction boxes. At least six (6) inches of free conductor shall be left at each outlet to make splices of joints, except where it is intended to loop through sockets, receptacles and other fixtures without splices or joints.

25.4.5.3.4. Terminations

Solderless-type terminal lugs and connectors shall be used for connecting #9 AWG wire and smaller stranded cable to studs.

Terminations shall be made with pressure-type terminal lugs using a compression tool provided with a ratchet or toggle mechanism that ensures a complete and positive crimp before the tool can be removed.

Terminations for wire sizes larger than #8 AWG shall have at least two (2) indentations.

Cables and wires used for all instrumentation and control connections shall be terminated with seamless, non-insulated, ring-type Burndy YAV hylug-type compression connectors. Substitute connectors must be submitted for Owner approval at the time of bid with the following documentation:

Type of connector proposed.

Sample of proposed connector for Owner inspection.

Documentation of the process used for making the terminations and quality control measures.

Wire strands shall not be removed from the end of a cable in order to reduce the conductor diameter. Appropriately sized terminal lugs must be used to maintain the same ampacity rating as the cable.

Sufficient length shall be left at all ends of wires and cables to conveniently make connections to equipment and devices. Spare conductors at the end of a multiconductor cable shall be coiled neatly and retained in a length equal to that of the longest single conductor at each end of the multiple-conductor cable. All cables entering a terminal cabinet, switchgear compartment, distribution board, or other such device from a conduit, cable slot, or cable trench shall be clamped securely at the opening. All exposed cable or wire runs shall be bunched and tied so as to prevent movement.

Cable connections to pad-mounted equipment shall have enough slack left in the cable to allow for thermal expansion and contraction. When pad-mounted equipment has a wiring compartment underneath, a full coil of cable shall be installed before the cable is terminated.

Cables and wires shall not be bundled in a cable tray or floor trench but shall be bundled and laced immediately after passing through an opening in the tray or trench cover at each instrument panel rack.

Spare conductors in a cable shall be neatly coiled with taped ends or terminated as shown in the Design Documents.

A threaded stud shall be used if more than two wires are landed on the same point on a terminal block.

25.4.5.3.5. Cable Pulling

A careful determination of the length of all wire and cable runs shall be made by Contractor prior to any cable installation in order to minimize pulling stresses. Cable pulling tensions shall not exceed those recommended by the cable vendor or supplier. Wire and cable shall be handled with care to avoid damage. Contractor shall carefully inspect all wire or cable for visible defects. Instances of damaged wire or cable shall be promptly brought to the attention of Owner or its representative, who shall determine the action to be taken to correct such defects.

A clean, dry, tight-fitting rag shall be drawn through the conduit immediately before installing the wire or cable. No wire or cable shall be installed in conduit unless it is free of all foreign material.

An Owner approved water-based lubricating material non-injurious to the insulation or jacket shall be used when necessary to prevent mechanical damage.

No cable shall be installed prior to the completion of the raceway system in which the cable is routed in.

25.4.5.3.6. Grounding of Shielded Wire and Cable

Shielded wire and cable shall have the shield grounded strictly in accordance with the Design Documents.

25.4.6. Fiber Optic Cable System

25.4.6.1. Contractor shall be responsible for supplying all attachment materials to complete the installation. All materials, equipment and accessories to be used during installation of the fiber optic cable shall be stored so as to protect them from deterioration or damage.

25.4.6.2. Referenced Codes and Standards:

25.4.6.2.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

25.4.6.2.2. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

25.4.6.2.3. Electronics Industry Association:

EIA-455 Series Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices

25.4.6.3. Installation

25.4.6.3.1. All fiber optic cable must be handled with care. The fiber optic cable must not be trampled upon, run over by vehicles or pulled over fences or metal fittings. Contractor shall not place any fiber optic cable without notifying Owner at least one working day prior to placement.

25.4.6.3.2. Fiber optic cable shall not be bent in a radius less than 16 times the outside diameter of the cable during the placing operations.

25.4.6.3.3. All open cable ends, either placed or remaining on a cable reel, shall have a cable cap placed on them. Cable caps shall be molded neoprene with adjustable stainless-steel band for tightening cap to cable.

25.4.6.3.4. Contractor shall install all fiber optic cable in direct buried non-conducting conduit.

25.4.6.3.5. Temporary bonds to ground the splice cases shall be established during the construction and subsequent splice maintenance work to mitigate any possible electrical shock.

25.4.6.3.6. Care must be exercised to ensure that a solid bond is established between the Optical Phase Ground Wire (OPGW) and ground clamps without crushing the optical fiber unit.

25.4.6.3.7. Fiber patch panel schedules shall be updated when fibers are spliced in the panel.

25.4.6.4. Splices

25.4.6.4.1. Splicing of fiber optic cables shall be performed using the fusion splicing method utilizing an electric arc. Chemical bonding or mechanical splicing methods shall not be used. Fusion splicing equipment shall have the following features:

a) Optical viewing to simplify pre-alignment.
b) A pre-fusion process to round the fiber ends to avoid bubble formations.
c) Controllable inward movement of the fibers to prevent necking at the joint.

25.4.6.4.2. Contractor shall provide all tools, and labor to connect, via fusion splicing, the optical fibers of the direct buried fiber optic cable to the optical fibers of the OPGW.

25.4.6.4.3. The splices are to be housed in an outdoor weatherproof housing supplied with the OPGW. Owner reserves the right to reject any splices with losses in excess of 1 dB.

25.4.6.4.4. All splicing of fiber optic cable shall be performed at ground level in accordance with the Manufacturer's recommendations.

25.4.6.4.5. All fusion splices shall be housed in splice trays.

25.5. Submittals

25.5.1. Control Drawings

25.5.1.1. Owner utilizes template drawings for most control schematics, panel elevations, and other protection and control related drawings which are called **CONTROL MASTER**. Contractor shall reference these master drawings in the development of the substation control drawings along with this specification, and drawings provided with this specification.

25.5.2. The following drawings to be submitted:

25.5.2.1. Topography Layout

25.5.2.2. Contour and Grading Layout

25.5.2.3. Foundation Layout

25.5.2.4. Electrical Equipment Enclosure Architectural Layout

25.5.2.5. Steel Details

25.5.2.6. Circuit Diagram

25.5.2.7. Substation Operating One Line

25.5.2.8. General Arrangement

25.5.2.9. Electrical Layout

25.5.2.10. Minor Material List

25.5.2.11. Grounding Layout

25.5.2.12. Control and Lighting Layout

25.5.2.13. Electrical Equipment Enclosure

25.5.2.14. Metering and Relaying Diagram

25.5.2.15. Panel Elevation

25.5.2.16. Schematic Diagram

25.5.2.17. Data Retrieval Schematic Diagram

25.5.2.18. External Connections

25.5.2.19. Major Material Vendor Drawings

25.5.3. Other Substation Studies and Information

25.5.3.1. AC Service Sizing calculations to include transformer and fuse sizing, fault levels, and voltage drop.

25.5.3.2. DC Service Sizing calculations to include battery and fuse sizing, fault levels, and voltage drop.

25.5.3.3. AC and DC Voltage Drop calculations

25.5.3.4. CT burden and fault current saturation calculations

25.5.3.5. Ground Grid calculations

25.5.3.6. Lightning Shielding Design

25.5.3.7. RTU Points List

25.5.3.8. Relay Settings

25.5.3.9. RTU Settings

26. Attachment 15: Electrical Equipment Enclosure

26.1. Design

26.1.1. The electrical equipment enclosure (EEE) shall be pre-manufactured and pre-wired prior to delivery.

26.1.2. The location and orientation of the (EEE) including accurate dimensions shall be indicated on the overall substation location plan. The EEE shall be located near the entrance gate.

26.1.3. Construction of the EEE shall be suited for its intended application. All material shall be new, of recent manufacture, and free from defects. The EEE shall be fully assembled and suitable for use upon completion of installation.

26.1.4. The EEE shall be designed to be installed in the environmental conditions typical for the substation location. Submittals shall indicate these design considerations, including but not limited to: insulation, snow loading, and HVAC capability.

26.1.5. The EEE furnished under this specification shall be designed in compliance with the latest published standards of the International Building Code (IBC), ANSI, IEEE, NEMA, NEC, NESC, MBMA, ASME, ASTM, and ASCE-7 unless otherwise noted. Any applicable local building codes for the location where the substation is being constructed shall be taken into account. If any of the requirements of this specification are in conflict with these standards, Contractor shall notify Owner immediately.

26.1.6. The EEE shall be at a minimum 14 feet x 40 feet (nominal). The EEE shall have space allocated for Owner supplied equipment such as floor standing server cabinets. The size of the EEE shall be appropriate to house all indoor equipment for the substation, including but not limited to:

26.1.6.1. Relay and control panels. Optimize the panel space to keep the EEE size to a minimum, up to three relays on a panel.

26.1.6.2. Fiber patch panels & other communication equipment

26.1.6.3. Wind turbine generator management equipment

26.1.6.4. Field termination cabinets

26.1.6.5. Station service equipment, including AC panel boards and automatic transfer switches

26.1.6.6. DC panel boards, batteries, and battery chargers

26.1.6.7. Eye wash station

26.1.6.8. Lighting contactor for control of substation lighting

26.1.6.9. HVAC equipment

26.1.6.10. Interior and exterior lights and receptacles, including exterior receptacles for servicing HVAC units.

26.1.6.11. Small desk for operators

26.1.6.12. Hot-stick

26.1.6.13. Additional space for equipment not provided by Contractor

26.1.7. Stairs leading up to the entry/exit doors of the EEE. A three-foot landing as wide as the door shall be provided.

26.1.8. A ground bus shall be provided in the EEE to provide grounding for all control, SCADA, and AC and DC panels. Ground location shall be indicated on submitted drawings.

26.1.9. Building alarms such as fire alarms, intrusion alarms, and temperature alarms shall be submitted for review. Note that the standard Owner termination cabinet includes temperature alarms for the EEE.

26.1.10. The eye wash station shall be located immediately adjacent to the area designated for the substation battery.

26.1.11. Cellular phone booster shall be included.

26.1.12. The following minimum requirements shall be met:

26.1.12.1. Steel Framing Members

26.1.12.1.1. Structural steel framing members 1/4 inch and thicker shall be of ASTM A36 or A572 steel. Hot rolled steel shall conform to ASTM A36, A500, A529, A570, A992 or A572, as required by design.

26.1.12.1.2. Structural steel framing members less than 1/4 inch thick shall be steel conforming to ASTM A446 Grade B (37,000 psi minimum yield strength) zinc-coated per ASTM A525 coating designation G90.

26.1.12.2. Fasteners

26.1.12.2.1. Structural framing shall utilize high strength bolts. Bolts shall conform to ASTM A325, Type 1 and shall be galvanized per ASTM A153, Class C or ASTM B695, Class 50.

26.1.12.2.2. Other bolts, nuts, and tap bolts shall conform to ASTM A307, Grade B, and shall be galvanized according to ASTM A153, Class C.

26.1.12.2.3. Sheet metal screws and/or self-tapping screws shall be zinc or cadmium-plated steel conforming to ANSI B-18.6.4, or equal.

26.1.12.2.4. Exposed wall and fascia panel fasteners shall have color-coated hearts to match the panel and washers for weather tightness.

26.1.12.3. Roof System

26.1.12.3.1. The Roof system shall include a 20-year warranty on material and weather tightness, and shall carry an Underwriters Laboratory (UL) Class 90 listing in accordance with UL 580.

26.1.12.3.2. The roof covering shall include exposed metal roof panels of 12 gauge (minimum) commercially pure aluminum coated steel, “Galvalume”, or coated steel (Galvanneal) with a color finish. As a minimum, base metal panels shall conform to the physical requirements of ASTM A446, Grade B. Panels shall be of such configuration to provide the load carrying capability and meet the deflection requirements specified herein. The coating shall have a 20-year warranty against rust perforation, a 20 year warranty against fading and chalking, and a 25 year warranty against flaking and peeling. Exterior color finish of roof, walls, doors shall be tan in color. Paint samples to be submitted for Owner approval.

26.1.12.3.3. Roof panels shall be “standing-seam interlocking” design and shall be secured to the roof purlins with a concealed structural fastening system. The concealed system shall provide minimal through penetration of the roof surface and allow the roof covering to move independently of any differential thermal movement by the structural framing system. Except at the concealed fastener, there shall be no thermal contact between the roof panels and supporting purlin. The standing seams shall have a factory-applied, non-hardening sealant.

26.1.12.3.4. Roof covering shall be properly designed with a sealing system provided at all roof and wall seams to provide a watertight building. The ridge, eaves, and openings together with necessary fascia and trim shall be caulked and sealed to provide a weather tight system.

26.1.12.3.5. Properly sized attic space ventilation shall be provided. All attic openings shall be screened to prevent entrance of bees, large insects, or birds.

26.1.12.4. Exterior Wall System

26.1.12.4.1. The exterior walls shall be comprised of galvanized steel panels with a PVDF resin-based finish. Exterior siding panels shall be overlapped and installed with appropriate self-tapping fasteners with integral gaskets and shall be removable without any disturbance to internal panels. The wall covering shall include a minimum 15-year warranty on paint. As a minimum, the panels shall be galvanized according to ASTM A525, coating designation G90.

26.1.12.4.2. Manufacturer's standard exterior base flashing shall be provided with the building. Material shall be zinc-coated steel conforming to ASTM A446, Grade B and ASTM A525, coating designation G90. Flashing shall be manufacturer's standard white in color and have a baked silicon polyester (or equivalent) enamel coating.

26.1.12.4.3. Butted seams are not permissible.

26.1.12.4.4. All openings in the walls are to be structurally framed, sleeved, trimmed, and provided with external drip caps.

26.1.12.4.5. Repair or replacement of external panels must be able to be done entirely from the exterior of the EEE structure.

26.1.12.5. Interior Liner Panels

26.1.12.5.1. The EEE interior walls shall be lined with flush-fit with a minimum of 16-gauge, roll-formed liner panels. Liners shall be zinc-coated steel conforming to ASTM A446, Grade B and ASTM A525, coating designation G90. Liners shall be provided with base and ceiling trim. Panels shall be manufacturer's standard white in color and have a baked silicon polyester (or equivalent) enamel coating.

26.1.12.5.2. Liner panels shall be fully reinforced with concealed fasteners.

26.1.12.5.3. The EEE interior shall feature a complete trim system, including base, jamb, header, and ceiling trim.

26.1.12.6. Floor System

26.1.12.6.1. The EEE floor shall have a hot-rolled welded steel framework, comprised of hot-rolled steel or steel tube supports with a maximum deflection of L/240 under required loads. Cold formed joists shall be sized and spaced to meet design loads. The steel framework shall be supported on concrete piers, spacing, anchorage requirements, and layout to be indicated by the building designer. Steel floor members shall be hot-rolled steel that meets a minimum standard ASTM-A36. All galvanized steel shall meet ASTM-A653.

26.1.12.6.2. Steel floor shall be a welded steel top surface of at least ¼" thickness to handle floor design loads with a maximum deflection of L/240. The floor shall have a painted, slip-resistant finish. The bottom of the floor shall have a rodent and moisture barrier of recessed 26-gauge sheet galvanized steel. Floor welding standards shall meet all AWS recommended practices.

26.1.12.6.3. The floor framework and floor deck plates shall be fully cleaned, primed, and painted with a self-priming coating system designed to provide a durable finish, suitable for heavy resistance to fading. Paint is to have a minimum Dry Film Thickness per coat of 3-5 mils. Color is to be ANSI 61. A non-slip texture shall be added to the paint.

26.1.12.7. Insulation

26.1.12.7.1. Floor shall be insulated with fiberglass batt insulation between the joists and rigid polystyrene insulation between joists and fully hot-dipped steel rodent and insect barrier. The insulation shall be at least R-13 for the floors and walls and R-19 for the roof, or a higher specific insulation value called out in applicable state and local codes. The entire Electrical Equipment Enclosure shall be insulated to thermal transmittance value of no more than 0.05 for walls and 0.03 for roofs when tested in accordance with ASTM C236.

26.1.12.8. Exterior Doors

26.1.12.8.1. There shall be two doors in the EEE, at least one of which is a 72-inch wide double door to facilitate the installation of equipment. Both doors shall have the same access key. Enclosure doors shall comply with Steel Door Institute directive SDI-100 and SDI-107. Doors shall have an insulated core and be constructed of no less than 18-gage steel-faced leafs with stiffeners and 16-gauge door frames. Doors and frames are to be hot-dipped galvanized to ASTM-A294 and ASTM-A653, then factory primed and painted with epoxy enamel to match the enclosure or trim.

26.1.12.8.2. There shall be three stainless steel ball bearing hinges per door.

26.1.12.8.3. A drip cap shall be provided on the exterior top and bottom of each door.

26.1.12.8.4. Each door shall have Sergeant 2828F low-profile rim device type panic interior openers, with cylinder lock keyed entry and thumb latch exterior.

26.1.12.8.5. A door closer with hold open arm shall be installed on each door.

26.1.12.8.6. Shock absorbing restraints shall be provided on the doors to prevent damage from high wind conditions.

26.1.12.9. HVAC

26.1.12.9.1. Heating, ventilating, and air conditioning (HVAC) equipment shall be sized and provided. HVAC equipment size shall be based on maintaining an interior temperature range of 60-80 degrees F, taking into consideration the heat load of present and future equipment and the site conditions. HVAC equipment shall consist of self-contained wall mount units, complete with supply and return grilles, lockable circuit breaker or disconnect switch, manual thermostat, barometric fresh air damper, and a disposable air filter. The following controls shall be supplied: high-pressure controls, low pressure controls, low ambient control, compressor anti-cycle relay, and alarm relay.

26.2. Civil/Grading

26.2.1. Erection Requirements

26.2.1.1. Defective material, such as bent, buckled, or scarred panels, shall not be erected. If such panels are erected, they shall be removed and replaced. The siding, roofing, corners, closures, and flashings shall be without wrinkles, buckles, or dimples.

26.2.1.2. Any and all marks, scrapes, scratches, etc. on each building component shall be repaired, at Contractor's expense prior to building acceptance, with the manufacturer's recommended coating matching the component's original color.

26.2.1.3. After the work has been completed, the surface of the sheeting shall be inspected for integrity of the coating. Where the coating is scratched or scraped off, Contractor shall touch-up such places with a coating of identical color compatible with the shop finish. Sheeting scratched, dented, or otherwise damaged which, after repair and touch-up, does not present a uniform appearance from the closest ground or public approach shall be replaced.

26.2.2. The Electrical Equipment Enclosure structure shall be designed for a minimum of 30-year life. The structure shall be designed and detailed in a manner which produces a weather tight, draft proof, and aesthetically pleasing building. The interior shall be fully lined with no exposed columns. All ceiling and wall surfaces shall be detailed and furnished flat, to allow for attachment of additional materials such as cabinets and equipment support.

26.2.3. The Electrical Equipment Enclosure structure shall be the design of a manufacturer regularly engaged in the fabrication of pre-engineered structures conforming to the recommendations of the MBMA Manual.

26.2.4. Contractor shall provide all static and dynamic loading calculations and analysis for the EEE as well as all mounting information.

26.2.5. The EEE manufacturer shall supply plans and calculations stamped by a Registered Professional Engineer for the state where the EEE is to be installed and is responsible for obtaining all State Industrial Building Commission Approvals and Third Party Inspections that are required by the state in which the EEE is to be installed.

26.2.6. Heavy duty lifting plates or similar hardware shall be supplied and mounted to the EEE as needed for lifting the enclosure.

26.2.7. The EEE shall have a minimum internal ceiling height of 10'-0" to allow for adequate equipment clearance below the cable tray.

26.2.8. The enclosure shall be able to be shipped via a semi-trailer method. The enclosure may be separated into two or more sections for shipment as required. If shipping splits are necessary, they shall be documented on all drawings and any wiring that is split shall be tagged and marked for easy field assembly. Any field installed wiring across shipping splits shall be done in ceiling mounted J-boxes.

26.2.9. The EEE roof shall be pitched to 2 inch in 12 inches or greater and shall be comprised of mechanically-seamed standing-seam roofing with a minimum seam height of 2".

26.2.10. Cable Tray shall be installed to facilitate external and internal connections.

26.2.10.1. The cable tray shall contain a 4/0 copper ground conductor as a ground bus for the cable tray and equipment to which it connects. Conductor shall be bonded to each cable tray section and all panels and cabinets per NEC requirements.

26.2.10.2. Cable tray shall be sized for all anticipated cables plus 50% margin.

26.2.10.3. Cable tray shall contain a 4" x 4" fiber tray for fiber optic cables. Fiber tray shall be installed in such a manner that the radius in corners shall not reduce the cable trays' capacity for copper cables.

26.2.10.4. The fiber tray shall utilize a trumpet spillout device above each panel to provide an appropriate radius vertical transition into each panel.

26.2.10.5. Cable tray shall be designed for an ultimate load of 100 pounds per foot.

26.3. Structural

26.3.1. Structural steel shall be designed according to the AISC Specification. Cold formed members shall be designed according to the AISI Specification.

26.3.2. The EEE shall have an internal, self-supporting structural steel frame that meets all structural loads without relying on exterior, interior, or roof panels for structural strength.

26.3.3. The EEE shall be designed to support roof live and dead loads that account for ice, snow, and wind loading, ceiling live and dead loads, wall loads, floor loads, and seismic requirements.

26.3.3.1. Dead loads - weight of permanent construction

26.3.3.2. Snow load - Design in accordance with ASCE 7.

26.3.3.3. Roof Live Load – minimum 20 lbs/sf.

26.3.3.4. Wind load - Design for basic wind speed per ASCE 7 in a terrain Exposure C (unless otherwise noted) in accordance with International Building Code Section 1609 or ASCE 7-10.

26.3.3.5. Suspended Systems from interior roof members - 10 psf.

26.3.3.6. Construction Maintenance load - concentrated weight of 250 lbs placed at any point on the roof.

26.3.3.7. The building shall be designed to withstand lifting loads during delivery, unloading, storing or erection of the building.

26.3.3.8. Floors – Equipment Area – Loading shall be rated at least 200 lbs/sf while on the foundation.

26.3.3.9. Floors – Battery Area – The area of the floor designated as the battery area on the control house layout shall be reinforced to 400 lbs./sf minimum while on the foundation.

26.3.3.10. The above loads or combination of loads shall be applied in conformance with the recommendations of the MBMA Manual.

26.3.3.11. Deflection Criteria - Deflection of primary structural framing members shall not exceed L/240. Deflection of secondary framing members and exterior wall and roof panels shall not exceed L/180.

26.3.3.12. Lateral deflection criteria – not exceed L/120 of eave height

26.4. Electrical

26.4.1. Wiring

26.4.1.1. All grounding, workmanship and materials shall conform as a minimum to the latest version of the National Electrical Code (NEC).

26.4.1.2. All wiring shall run tight to and parallel with walls and ceiling. All required wiring between equipment located within the Electrical Equipment Enclosure shall be installed at the factory.

26.4.1.3. Interior conduit shall be electrical thin wall EMT, all interior junction boxes NEMA 1, with flexible metallic conduit used for motor and fixture connections. Do not run conduit horizontally along walls, use cable tray or run along ceiling.

26.4.1.4. All conductors installed from the EEE field termination cabinets to the substation cable trench system shall be installed in RGS conduit. Ends of conduits shall be sealed following installation of conductors to block rodents from entering the conduits.

26.4.1.5. Duplex receptacles with weatherproof covers, and GFI protection shall be provided on the exterior of the enclosure near each entrance, and for service use at each HVAC unit.

26.4.1.6. Power wiring for 120V lighting and receptacles shall be single conductor THHN/THWN 600V insulation in EMT conduit with a minimum size of #12 AWG.

26.4.2. Electrical equipment enclosure lighting shall be in accordance with accepted industry standards and practices. The National Electric Safety Code (ANSI C2) shall be followed in all cases. Sufficient lighting is required for safe operation and testing in front and back of all control panels.

26.4.2.1. Exterior Lighting shall be provided above each personnel door. Exterior lights shall be wall mounted LED suitable for use in wet locations and have automatic dusk to dawn photo control.

26.4.2.2. Emergency lighting shall be a self-contained battery powered unit with two directionally adjustable illuminating heads. The units shall switch on automatically upon loss of AC power and provide 1.5 hours of continuous illumination, and then turn off automatically and recharge when AC power is restored.

26.4.3. AC and DC Station Service Criteria

26.4.3.1. AC Auxiliary Service:

Every substation shall include an AC auxiliary supply system for lighting, heating, maintenance, and other electrical loads. Additionally, each substation that has primary and secondary protective relays and a battery system should have two AC auxiliary sources. An automatic transfer switch will be included to switch between the two sources (preferred and emergency).

The sources for auxiliary power are usually transformer tertiary windings or medium voltage busses. If these sources are not available or are not economically feasible, auxiliary power may be obtained from the local distribution company, an emergency generator, or a voltage transformer connected to a transmission bus. No distribution load from the tertiary windings shall be outside of the substation yard.

The standard AC auxiliary system rating is 120/240V single-phase, and this is used with auxiliary equipment rated up to 400Amp. However, for substations that would require auxiliary equipment rated higher than 400Amp with a 120/240 single-phase system, a three-phase auxiliary system should be considered.

The AC Auxiliary System shall be in accordance with accepted industry standards and practices. The National Electric Safety Code shall be followed in all cases.

26.4.3.2. Primary Fusing and Switching

26.4.3.2.1. Fused Disconnects

Substation auxiliary power transformers shall be fused on the high side using S&C SM5 fused disconnects and fuses. The fuse sizes are selected by choosing the smallest rating, which is at least 150% of the high-side full load ampere current. In order to promote standardization of fuses 5E and 10E, standard time-rated fuses are used in the system, sizes 3E and 7E are not typically used.

26.4.3.2.2. Current-limiting Back-up Fuses

Some substations may have available fault currents greater than the interrupt rating of the fused disconnect. In these cases, current-limiting back-up fuses should be used in series with the fused disconnect. The current-limiting back-up fuse will limit the fault current and also provide for clearing of faults up to its interrupt rating. Note that the interrupt rating of the current-limiting back-up fuse must be greater than the available fault current. If it is not, then this approach is not sufficient and further engineering will be necessary (possibility of needing current-limiting reactors)

The back-up fuse should be placed downstream of the fused disconnect; in this way, the back-up fuse can be replaced by opening the fused disconnect, and without de-energizing the source. The design should make sure, to the greatest extent possible, that there is adequate clearance to replace the back-up fuse without de-energizing the source.

With this configuration, there is an accepted risk of a fault occurring in the lead between the two fuses which could not be cleared by the fused disconnect. This would be a bus fault, and would have to be cleared by the station relaying.

26.4.3.3. Secondary Fusing and Switching

26.4.3.3.1. AC Load calculations shall be provided. The station service and associated equipment will be sized in accordance with these calculations.

26.4.3.3.2. Automatic Transfer Switch

The Preferred and Emergency supplies to the electrical equipment enclosure shall brought into an Automatic Transfer Switch (ATS) before going to a Main Breaker Panelboard.

26.4.3.4. DC Auxiliary Service

26.4.3.4.1. The DC system supplies power for the circuit breakers, motor operated switches, instrumentation, emergency lighting, communications, fire protection system, annunciators, protective relaying and fault recorders at substations and includes a 125VDC battery bank and battery charger.

26.4.3.4.2. The DC Auxiliary System shall be accordance with accepted industry standards and practices. The National Electric Safety Code shall be followed in all cases.

26.4.3.4.3. Consideration of any applicable regulations regarding redundant battery systems shall be given. NERC and RTO regulations may be applicable. A redundant battery shall not be used except where required.

26.4.3.4.4. The Battery system and charger shall be sized to recharge the battery to 95% of full capacity within 12 hours. The battery sizing criteria is summarized below:

Summary of Battery Sizing

Beginning event	Loss of battery charger occurs, but no tripping event
Time which battery must carry continuous load (without battery charger)	8 hours
Final event, which battery must be able to supply	Worst case tripping event occurs, including one breaker failure event.

Notes:

- The tripping event that causes the most current to be drawn from the battery is considered the “worst case” event.
- Continuous loads are loads that the battery would have to carry throughout the duty cycle once the battery charger quits operating (Examples: indicating lights, relays).

26.4.3.4.5. DC Continuous Load Calculations shall be provided. The battery system and charger will be sized in accordance with these calculations.

26.4.3.4.6. Main Battery Fusing

The battery main fuses protect the battery against faults in the cable between the battery and the DC fuse cabinet or against faults on the bus in the DC fuse cabinet. These fuses shall not be considered as backup protection for the branch fuses. The main fuses are sized to allow all but a solidly bolted fault to cause them to operate. This is to avoid the nuisance of blown fuses and keep DC power operating the control systems as long as possible. The fuse is also used as a disconnect point to isolate the battery when necessary.

26.4.4. Relaying and Protection Criteria

26.4.4.1. See WIND FARM EEE AND PANEL ELEVATIONS and WIND FARM ONE LINE METERING AND RELAYING.

26.4.5. SCADA / RTU / Communication requirements.

26.4.5.1. See WIND FARM EEE AND PANEL ELEVATIONS and WIND FARM ONE LINE METERING AND RELAYING.

26.5. Submittals

26.5.1. Design documents shall be stamped by a professional engineer registered in the state where the building will be installed. Calculations shall be submitted for review with the approval drawings.

26.5.2. Submittals for the EEE shall include an overhead layout and elevations which clearly identify all equipment by bubble numbering. Drawings shall be accompanied by a spreadsheet which details each item number.

26.5.3. The building manufacturer shall prepare design and shop drawings and shall include the following:

26.5.3.1. Physical outlines as required to show the overall size and space requirements including doors, clear heights and floor area.

26.5.3.2. Cross sections and details as required demonstrating framing details and that components conform with specification requirements. It shall also include design and physical arrangements such as horizontal and vertical clearance.

26.5.3.3. Erection drawings and anchor bolt plans including foundation loads.

26.5.3.4. Cross sections and details as necessary to provide a complete and finished structure.

26.5.3.5. Item identification marks shall be included. Equipment identified by such marks shall be detailed in tabular format.

26.5.3.6. Manufacturer’s submittals for fans, louvers, door frames, hardware and doors shall be provided with the Design Documents.

26.5.3.7. One reproducible set of “record” drawings, incorporating any approval comments and certified by a registered engineer, shall be submitted to Owner prior to shipment of the building.

27. Attachment 16 Availability Test

27.1. Purpose

27.1.1. The Availability Test will verify the inverters are fully commissioned and ready for commercial operation by demonstrating all inverters are able to operate for at least 3 consecutive days. The Availability Test may run in parallel to other performance related tests, provided the other tests do not negatively impact the inverter or plant operation.

27.2. Definitions

27.2.1. Availability Test – A short term, plant wide test meeting the requirements of this Exhibit [ ] and a condition to Substantial Completion used to verify all inverters are fully commissioned and ready for commercial operation.

27.2.2. Availability Test Calculator– An Excel file provided by the Owner to be used to calculate the Measured Availability during the Availability Test Measurement Period.

27.2.3. Availability Test Measurement Period – A three (3) day period during which the Availability Test is conducted to verify inverter operation, as such period may be extended as permitted in paragraph 5 of the Procedures set forth in this Exhibit.

27.2.4. Availability Test Procedures – A detailed plan for administering the Availability Test to be provide by Contractor 45 Business Days prior to Availability Test, which plan shall meet all of the requirements therefor set forth in Appendix 1 to this Exhibit [ ] and include, at a minimum, all points to be monitored and identification of key personnel and parties.

27.2.5. Availability Test Report – A summary report of the Availability Test results, conditions during the test, the Inverter Availability Test Procedures, and calibration certificates of equipment used in the test, which report shall meet all of the requirements therefor set forth in this Attachment.

27.2.6. Eligible Time Intervals – Total number of time intervals during Availability Test Measurement Period where the plane of array irradiance is greater than 400 W/m2. The selected time interval shall be 5 minutes.

27.2.7. Guaranteed Availability –99.0%

27.2.8. Inverter Operational Time Intervals – For each inverter, the total number of Eligible Time Intervals during Availability Test Measurement Period when the inverter is producing power at all possible inverter stages, taking into account the incident irradiance.

27.2.9. Measured Availability – A percentage (rounded up or down to the nearest 0.1%), calculated as the quantity of Inverter Operational Time Intervals divided by the quantity of Eligible Time Intervals, multiplied by the number of inverters.

27.2.10. Multiple Measurements – Any measurement device or sensor where multiple devices or sensors measure the same parameter.

27.3. Procedure

27.3.1. No less than 45 Business Days prior to the first day of the scheduled Availability Test Measurement Period, the Availability Test Procedures shall be submitted to the Owner by the Contractor for Owner's review and comment. Contractor shall incorporate all of Owner's reasonable comments into the final Availability Test Procedures and resubmit the same for Owner's review and approval (such approval not to be unreasonably withheld or delayed).

27.3.2. The Contractor shall give written notice to the Owner 5 Business Days prior to the start of the Availability Test (including any re-performance thereof).

27.3.3. Contractor shall perform the Availability Test in accordance with the final approved Availability Test Procedures.

27.3.4. During the Availability Test Measurement Period the Contractor shall record all inverter power, revenue meter, and plane of array irradiance data in accordance with the Data Quality and Instrumentation Requirements set forth in this Attachment. Such date shall be made available during and after the test as requested by Owner.

27.3.5. During the Availability Test, the Contractor shall document all inverter or plant-related interruption events, including the identification of the event, the reason for the interruption, the time and duration of the event and any corrective actions undertaken. In the event that inverter or plant-related interruptions do occur, the Contractor has the option to restart the Availability Test, provided that Contractor shall notify Owner thereof and provide detailed documentation of identified issues and proposed resolution to rectify such issues prior to re-performing the Availability Test.

27.3.6. During the test, the Contractor shall document all interruption events caused by grid operations, including the identification of the event, the reason for the interruption, and the time and duration of the event, and any corrective actions undertaken. To the extent that such interruption event was not caused by the Project, such events are excusable, and the test shall be extended by the amount of excluded time on a minute-by-minute basis in order to achieve 5 complete days of data.

27.3.7. The result of the Measured Availability shall be calculated as follows:

$$\frac{The\ Sum\ of\ All\ Inverter\ Operational\ Time\ Intervals}{Eligible\ Time\ Intervals * Total\ Number\ of\ Inverters}$$

27.3.8. The Project must be capable of continued operation, without intermittency or downtime during the Availability Test Measurement Period except for excused events described in paragraph 6 above. If the Measured Availability of the Project does not meet or exceed the Guaranteed Availability, the Contractor shall identify and promptly resolve the source of the problem and promptly perform the Availability Test again in accordance with these procedures (other than Paragraph 1 hereof) until the Measured Availability of the Project achieves the Guaranteed Availability.

27.4. Availability Test Report

27.4.1. No later than five (5) Business Days following the end of the Availability Test Measurement Period in respect of a Successfully Completed Availability Test, a draft Availability Test Report will be submitted to the Owner by the Contractor. Owner shall have five (5) Business Days to accept or reject the results of the draft Availability Test Report, and provide in writing any comments of Owner on such draft Availability Test Report. In the event that Owner rejects all or any part of the draft Availability Test Report, Contractor shall, within five (5) Business Days thereafter address any comments of Owner and re-submit the draft Availability Test Report to Owner. This procedure shall continue until Owner accepts the draft Availability Test Report. Any dispute regarding the results of the Availability Test or the Availability Test Report shall constitute a Dispute as described in the Agreement.

27.4.2. The Availability Test Calculator, along with all raw data and QC disposition for each input data record, shall be provided electronically to the Owner with the Availability Test Report.

27.5. Appendix 1: Additional Requirements

27.5.1. Test Plan

27.5.1.1. The Availability Test Procedures shall include (at a minimum) the following information:

27.5.1.1.1. The test procedure set forth herein.

27.5.1.1.2. Identification of key personnel and parties to be involved in the test

27.5.1.1.3. Identification of the Project under test (at a minimum)

- Number and make/model of PV modules
- Array orientation
- Location (latitude, longitude, street address)
- Racking type and tilt
- Tracker range of motion (if applicable)
- Number and make/model of Inverters
- Row to row spacing (ground coverage ratio)

27.5.1.1.4. Identification of all data points to be monitored during the test

27.5.1.1.5. The scheduled starting and ending dates of the Availability Test Measurement Period.

27.5.1.1.6. Table of all sensors and transducers to be used, including cut sheets, calibration records, map of sensor locations with sufficient detail to allow observers to locate the sensors and transducers. This includes sensors required for all applicable input parameters (MET station sensors, inverters, and Revenue Meter).

27.5.1.1.7. MET station and pyranometer quality assurance and/or commissioning documentation (as an appendix).

27.5.1.1.8. Identification of SCADA nomenclature for data channels, and any SCADA calibration parameters (default or custom) for those data channels

27.5.1.1.9. Identification of SCADA data channels intended for use as auxiliary measurements

27.5.1.1.10. Identification of known data quality concerns, such as time intervals when inter-row shading may be expected to occur

27.5.1.1.11. Time-stamp convention and data logger averaging technique/interval to be used in reporting data

27.5.1.2. Measured data are to be made available to the Owner upon request during the Availability Test Measurement Period, for use in evaluating the progress of the Availability Test.

27.5.2. Availability Test Report

27.5.2.1. The Availability Test Report shall contain:

27.5.2.1.1. The Availability Test Procedures, including all requirements as outlined herein.

27.5.2.1.2. The actual start and end date/times of the Availability Test Measurement Period

27.5.2.1.3. Comments on environmental conditions during the Availability Test Measurement Period that affect the results of the test

27.5.2.1.4. Summary of data quality control results for all data records

27.5.2.1.5. Summary of test results

27.5.2.1.6. All calibration certificates for pyranometers, temperature sensors, and revenue meters used in the test

27.5.2.2. Raw data used as input to the Availability Test, along with QC disposition for each input data record, shall be provided electronically (via CSV, XLS, or XLSX formats) to the Owner with the Availability Test Report.

27.5.3. Data Quality and Instrumentation Requirements

27.5.3.1. Data quality shall be identified as one item from a set of quality categories for each data record analyzed. Only data from records where all input parameters are valid and within specified limits shall be used in computing capacity estimates.

27.5.4. Sensor Requirements

27.5.4.1. Irradiance sensors shall be at a minimum "High Quality" classified pyranometer(s) as defined in ASTM2848-A1.2 (Secondary Standard per ISO 9060). Pyranometers shall include device-specific characterization data that shall, at minimum, include cosine and temperature response. Alternative pyranometers may only be used if approved by the Owner.

27.5.4.2. Pyranometers shall be used only within their valid calibration period and shall be cleaned at the start of the Availability Test Measurement Period and cleaned daily during the test if the Availability Test Measurement Period extends beyond one (1) week.

27.5.4.3. All measurement devices and sensors shall meet the minimum accuracy requirements and range requirements set forth in the table below:

Sensor Requirements

Table 2 Sensor Requirements

Measurement	Instrument Type	Test Function	Range	Accuracy
Irradiance	Pyranometer (Global Horizontal Irradiance (GHI))	Primary for Energy Performance Test	0 to 1600 W/m^2 285 to 2800 nm	±2.0% daily
	Pyranometer (Plane of Array (POA))	Primary for Capacity Test and Availability Test		
Ambient Air Temperature	Temperature Probe	Primary for both Capacity Test and Energy Performance Test	-40°C to +60°C	±1°C
Wind Speed	Sonic Wind Sensor	Primary for Capacity Test and Energy Performance Test	0 – 60 m/s	±5%
PV Plant Power	PV Power Revenue Meter	Primary for both Capacity Test and Energy Performance Test primary for Capacity Test	0 to PV Power Plant size +20%	ANSI C-12.20
Inverter Power	Inverter Meter	Primary for Availability Test and Capacity Test	determined from inverter data sheet	determine d from inverter

				data sheet
Soiling	Soiling Monitoring System (SMS)	Primary for Energy Performance Test	0 to 100%	±0.2%

27.5.5. Multiple Measurements

27.5.5.1. Multiple Measurements shall be recorded for all environmental data throughout the Site in order to capture the operating conditions for all regions of the array. There is a high probability that there will be periods of time in which portions of the Project are exposed to significantly different irradiance conditions than other portions, e.g. due to isolated clouds.

27.5.6. Below are the main measurement devices and sensors to be used in the Availability Test:

27.5.6.1. Plane of Array Irradiance (POA): A minimum of one sensor shall be installed for each orientation (within ±2°). Multiple orientations or large arrays shall require Multiple Measurements. For projects or unique project Blocks within a project with potentially different irradiance conditions (like change in azimuth, tilt, or tracking range of motion) greater than 5 MW, at least 3 POA sensors shall be installed.

27.5.6.2. Inverter Meter: The power reading for each inverter.

27.6. Appendix 2: Availability Test Calculator

27.6.1. The table below provides the file names for all files needed for the Availability Test Calculator. Contractor shall provide the Availability Interval Data file once the test is complete.

Table 3 Availability Test Calculator Files

File Name	File Type	Comments
Availability Test Calculator	.xlxs	Used to log all raw measured data, Inverter Interval Data, and calculate the availability
Availability Interval Data	.csv	Interval values of measured Inverter Power Output, plane of array irradiance (POA), and Revenue Meter.

28. Attachment 17: Capacity Test

28.1. Purpose

28.1.1. The Capacity Test will verify the plant is fully operational and ready for commercial operation by achieving the Guaranteed Capacity.

28.2. Definitions

28.2.1. Capacity Test – A short term, plant wide test meeting the requirements of this Attachment and a condition to Substantial Completion used to verify the plant is fully commissioned and ready for commercial operation.

28.2.2. Capacity Test Calculator – An Excel tool provided by the Owner to be used to calculate the Target Capacity and Measured Capacity during the Capacity Test Measurement Period.

28.2.3. Capacity Test Measurement Period – The period when the Capacity Test is performed, which period shall be at least 2 days, and shall continue until for consecutive additional days until the Minimum Irradiance has been met, which may be up to a total of 15 days depending on weather conditions during the test.

28.2.4. Capacity Test Procedures –A detailed plan for administering the Capacity Test to be provide by Contractor 30 Calendar Days prior to the first date of the scheduled Capacity Test Measurement Period, which plan shall meet all of the requirements therefor set forth herein and include, at a minimum, all points to monitored and identification of key personnel and parties.

28.2.5. Capacity Test Report – A summary report of the Capacity Test results, conditions during the test, the Capacity Test Procedures, Data Quality and Instrumentation Plan and applicable calibration certificates for equipment used in the test, which report shall meet all of the requirements therefor set forth herein.

28.2.6. Capacity Test Bifacial Gain (CTBG) – The bifacial gain as calculated using the CTBG procedures outlined herein.

28.2.7. Guaranteed Capacity – A Measured Capacity Ratio of at least 98.0% or greater.

28.2.8. Minimum Guaranteed Capacity – A Measured Capacity Ratio of at least 95.0% or greater.

28.2.9. Minimum Datapoints – Occurs when at least 150 allowable data points meeting the requirements set forth in this Exhibit [ ] are recorded after all data filtering has occurred as outlined herein. If the Minimum Irradiance criteria set forth is causing a delay in the test and pushing it beyond the Guaranteed Project Substantial Completion Date, the test procedure may, subject to prior agreement by both parties, be modified to allow fewer data points.

28.2.10. Minimum Irradiance. 400 W/m2.

28.2.11. Measured Capacity – The measured capacity as calculated using the procedures outlined herein.

28.2.12. Measured Capacity Ratio – The Measured Capacity divided by the Target Capacity, calculated to the nearest 0.1%.

28.2.13. Monthly Reporting Conditions – The plane of array irradiance (POA), ambient temperature, and wind speed calculated for each month using the Project Model and P50 weather file as agreed to by the Parties and recorded in Table 4 of Appendix 2 attached herein.

28.2.14. Project Model – The Contractor PVSYST generation model for the Project, including post-processing that occurs outside of the program.

28.2.15. Project Capacity Model –The Project Model as adjusted to remove assumptions for snow, availability, and module degradation losses.

28.2.16. Revenue Meter – The revenue meter for the Project as agreed by the Parties.

28.2.17. Capacity Test Bifacial Gain (CTBG) – The bifacial gain as calculated using the CTBG procedures outlined herein.

28.2.18. Target Capacity – The target capacity as calculated using the procedures outlined herein.

28.3. Procedure

28.3.1. No less than 45 Business Days prior to the first day of the scheduled Capacity Test Measurement Period, a draft Capacity Test Procedures shall be submitted to the Owner by the Contractor for Owner's review and comment. Contractor shall incorporate all of Owner's reasonable comments into the final Capacity Test Procedures and resubmit the same for Owner's review and approval (such approval not to be unreasonably withheld or delayed).

28.3.2. The Contractor shall give written notice to the Owner 12 Business Days prior to the start of the Capacity Test (including any re-performance thereof).

28.3.3. Contractor shall perform the Capacity Test in accordance with the final approved Capacity Test Procedures.

28.3.4. Capacity Test Procedures shall identify the final Monthly Reporting Conditions and Target Capacities using the Project Capacity Model, and data filters described below.

28.3.5. The Capacity Test Measurement Period shall last no less than two (2) consecutive days. If the Minimum Irradiance requirement is not met during such 2-day period, the Capacity Test Measurement Period shall be extended for consecutive days until the Minimum Irradiance requirement is met.

28.3.6. The following input parameters shall be measured during the Capacity Test (collectively, the "Input Parameters"):

28.3.6.1. Plane-of-Array Irradiance (POA): An estimate of the average irradiance incident upon the PV array in the Project. No provision is allowed for shading, so any significant shading during any aggregation interval is causing to exclude that data record from the regression.

28.3.6.2. Ambient Temperature: As recorded by the Project meteorological stations as defined in Appendix 1 to this Exhibit H.

28.3.6.3. Wind Speed: As recorded as recorded by the Project meteorological stations as defined in Appendix 1 to this Exhibit H.

28.3.6.4. CTBG Parameter: Power measurement from the bifacial reference modules and monofacial reference modules

28.3.6.5. Revenue Meter Energy Generation: Energy as recorded by the Revenue Meter during the Capacity Test Measurement Period.

28.3.6.6. Inverter-Level Energy Generation: AC output data for each inverter shall be provided for the purposes of identifying periods of inverter clipping.

28.3.7. During the Capacity Test Measurement Period, irradiance data shall be sampled at no greater than five (5) second intervals. Irradiance data shall be reported at no greater than five (5) minute intervals, consisting of averaged five (5) second sampled data. Power generation data shall either be sampled and reported at the intervals required for irradiance, as noted above. Other data shall be sampled at no greater than one (1) minute intervals and shall be reported at no greater than five (5) minute intervals, consisting of averaged one (1) minute sampled data. All data shall be reported in time-synchronized intervals.

28.3.8. Data shall be averaged and filtered in accordance with the procedures below:

28.3.8.1. Missing Data: Missing records shall be marked as missing with a non-numeric identifier. Missing records shall not have a value included in the analysis, but shall be documented.

28.3.8.2. DAS Equipment Malfunction: Data records with invalid Input Parameters (e.g. all sensor readings reported as out of range by the DAS) shall also be marked as invalid.

28.3.8.3. Below Minimum Irradiance: To avoid large uncertainty in results due to increased impact of variable losses at low irradiance, all records with a minimum plane-of-array irradiance input parameter of 400 W/m^2 or less shall be marked as irradiance too low.

28.3.8.4. Unstable irradiance: Irradiance measurements shall be deemed stable if i) all individual sensor readings are within 25 Watts per meter squared of the average of all the sensor readings and ii) the average of all sensor readings is not more than 10% greater or less than the previous interval reading. If both conditions above are not met, the irradiance will be deemed unstable, flagged and the data will not be used in the test.

28.3.8.5. Inverter clipping: Any intervals where the power output of one (or more) inverters is greater than 98.0% of the rated or programmed power limit.

28.3.8.6. Power Factor: Any intervals where the inverter power factor is less than ±0.98 will be excluded from the test data.

28.3.8.7. Array shading by internal (array self-shading) or external (nearby objects). A schedule of expected shade times shall be defined in the Capacity Test Procedures. This schedule may be altered during the Capacity Test. Records occurring during these shade intervals identified during testing shall be marked as shaded and excluded from the test. Photographic evidence of array conditions shall be provided.

28.3.8.8. Array shading by environmental conditions (e.g. frost, snow or debris). Onsite observers shall record time intervals when such conditions exist as the Capacity Test progresses. Photographic evidence of array conditions shall be provided.

28.3.8.9. Wind Speed: Any intervals where average wind speed is greater than 15 meter per sec will be excluded from the test data.

28.3.9. Data will be collected for a minimum of 3 days until at least 150 allowable data points are collected.

28.3.10. Using the Capacity Test Calculator and the data filtering described herein, calculate the linear regression coefficients and Measured Capacity.

28.3.11. Calculate the Measured Capacity Ratio using the calculated Measured Capacity and appropriate monthly Target Capacity identified in the Table 4 of Appendix 2 attached herein.

28.3.12. If the Measured Capacity Ratio of the Project does not meet or exceed the Minimum Guaranteed Capacity, the Contractor shall identify and promptly resolve the source of the problem and promptly perform the Capacity Test again in accordance with these procedures (other than Paragraph 1 hereof) until the Measured Capacity of the Project achieves the Minimum Guaranteed Capacity. If the Measured Capacity Ratio is more than the Minimum Guaranteed Capacity but is less than the Guaranteed Capacity, then Contractor shall be responsible for the liquidated damages as set forth in the Agreement.

28.4. Capacity Test Bifacial Gain Calculation Procedure

28.4.1. This will be calculated by directly comparing the irradiance measured from the mono-facial reference modules to that of the bifacial reference modules. The calibrated reference modules shall be used in this test and their serial numbers shall be recorded to correlate to flash test data.

28.4.2. The power will be measured in 5-minute intervals from these reference modules at each MET station. The data shall be filtered as follows:

28.4.2.1. Dataset shall be limited to allowable data points of the Capacity Test.

28.4.2.2. Bifacial gain shall be calculated for each MET station and instances where the gain differs more than 5% from the average gain shall be excluded

28.4.2.3. Missing, unavailable, or NaN (Not a Number) data points will be excluded.

28.4.3. The CTBG for each module type shall be calculated as follows:

$$CTBG_i = \frac{\sum_{i=1}^{n} \frac{Power_{bi}/Power_{bi,STC}}{Power_{mono}/Power_{mono,STC}}}{n}$$

Where:
$CTBG_i$ = Capacity Test Bifacial Gain of module type i (%)
n = total number of filtered 5-minute data points (unitless)
$Power_{bi}$ = Power measured by the bifacial reference module (Watts)
$Power_{bi,STC}$ = STC Power of the bifacial reference module (Watts)
$Power_{mono}$= Power measured by the monofacial reference module (Watts)
$Power_{mono,STC}$= STC Power of the monofacial reference module (Watts)

28.4.4. Both the mono-facial and bifacial modules shall be cleaned prior to the Capacity Test. The CTBG shall be calculated specifically for the duration of the Capacity Test. For example, if the Capacity Test takes place from April 10 to April 20, the CTBG shall be calculated for all the filtered 5-minute data points in that time period.

28.5. Capacity Test Report

28.5.1. No later than three (3) Business Days following the end of the Capacity Test Measurement Period of a Successfully Run Capacity Test, a draft Capacity Test Report will be submitted to the Owner by the Contractor. Owner shall have five (5) Business Days to accept or reject the results of the draft Capacity Test Report, and provide in writing any comments of Owner on such draft Capacity Test Report. In the event that Owner rejects all or any part of the draft Capacity Test Report, Contractor shall, within five (5) Business Days thereafter address any comments of Owner and re-submit the draft Capacity Test Report to Owner. This procedure shall continue until Owner accepts the draft Capacity Test Report. Any dispute regarding the results of the Capacity Test or the Capacity Test Report shall constitute a Dispute as described in the Agreement.

28.6. Appendix 1: Additional Requirements

28.6.1. Test Plan

28.6.1.1. The Capacity Test Procedures shall include (at a minimum) the following information:

28.6.1.1.1. Identification of key personnel and parties to be involved in the test

28.6.1.1.2. The Project Model

- For the purposes of the Capacity Test, the Project Model shall exclude array soiling loss, module/system degradation and assume 100% availability
- Meteorological data used for calculation of the Monthly Reporting Conditions

28.6.1.1.3. Identification of the Project under test (at a minimum)

- Number and make/model of PV modules
- Array orientation
- Location (latitude, longitude, street address)
- Racking type and tilt
- Tracker range of motion (if applicable)
- Number and make/model of Inverters
- Row to row spacing (ground coverage ratio)

28.6.1.1.4. Identification of all data points to be monitored during the test

28.6.1.1.5. The Monthly Reporting Conditions and Target Capacity values

28.6.1.1.6. The starting and ending dates of the scheduled Capacity Test Measurement Period.

28.6.1.1.7. Table of all sensors and transducers to be used, including cut sheets, calibration records, map of sensor locations with sufficient detail to allow observers to locate the sensors and transducers. This includes sensors required for all applicable Input Parameters (MET station sensors, inverters, and Revenue Meter).

28.6.1.1.8. MET station and pyranometer quality assurance and/or commissioning documentation (as an appendix).

28.6.1.1.9. Identification of SCADA nomenclature for data channels, and any SCADA calibration parameters (default or custom) for those data channels

28.6.1.1.10. Identification of SCADA data channels intended for use as auxiliary measurements

28.6.1.1.11. Identification of known data quality concerns, such as time intervals when inter-row shading may be expected to occur

28.6.1.1.12. Time-stamp convention and data logger averaging technique/interval to be used in reporting data

28.6.1.2. Measured data are to be made available to the Owner upon request during the Capacity Test Measurement Period, for use in evaluating the progress of the Capacity Test.

28.6.2. Capacity Test Report

28.6.2.1. The Capacity Test Report shall contain:

28.6.2.1.1. The Capacity Test Procedures, including all requirements as outlined herein.

28.6.2.1.2. The actual start and end date/times of the Capacity Test Measurement Period

28.6.2.1.3. Comments on environmental conditions during the Capacity Test Measurement Period that affect the results of the test

28.6.2.1.4. Summary of data quality control results for all data records

28.6.2.1.5. Summary of test results

28.6.2.1.6. Regression coefficients used to calculate Target Capacity and Measured Capacity

28.6.2.1.7. Comparison of test results with Minimum Guaranteed Capacity and Guaranteed Capacity

28.6.2.1.8. All calibration certificates for pyranometers, temperature sensors, and revenue meters used in the test

28.6.2.2. Raw data used as input to the Capacity Test, along with QC disposition for each input data record, shall be provided electronically (via CSV, XLS, or XLSX formats) to the Owner with the Capacity Test Report.

28.6.3. Data Quality and Instrumentation Requirements

28.6.3.1. Data quality shall be identified as one item from a set of quality categories for each data record analyzed. Only data from records where all input parameters are valid and within specified limits shall be used in computing capacity estimates.

28.6.4. Sensor Requirements

28.6.4.1. Irradiance sensors shall be at a minimum “High Quality” classified pyranometer(s) as defined in ASTM2848-A1.2 (Secondary Standard per ISO 9060). Pyranometers shall include device-specific characterization data that shall, at minimum, include cosine and temperature response. Alternative pyranometers may only be used if approved by the Owner.

28.6.4.2. Pyranometers shall be used only within their valid calibration period and shall be cleaned at the start of the Capacity Test Measurement Period and cleaned daily during the test if the Capacity Test Measurement Period extends beyond one (1) week. Bifacial reference modules (same batch from the field) shall be installed to measure bifacial plane of array and monofacial reference module to measure plane of array irradiance.

28.6.4.3. All measurement devices and sensors shall meet the minimum accuracy requirements and range requirements set forth in the table below:

Table 4 Sensor Requirements

Measurement	Instrument Type	Test Function	Range	Accuracy
Plane of Array Irradiance	**Front Pyranometer** **Rear Pyranometer** **Bifacial reference module** **Monofacial reference module**	Primary for Capacity Test	0 to 1600 W/m^2 285 to 2800 nm	**±2.0% daily**
Global Horizontal Irradiance	**Pyranometer**	Secondary for Capacity Test	0 to 1600 W/m^2 285 to 2800 nm	**±2.0% daily**
Ambient Air Temperature	Temperature Probe	Primary for Capacity Test	**-40°C to +60°C**	**±1°C**
Wind Speed	Sonic Wind Sensor	Primary for Capacity Test	0 – 60 m/s	±5%
PV Plant Power	PV Power Revenue Meter	Primary for Capacity Test	**0 to PV Power Plant size +20%**	ANSI C-12.20
Inverter Power	Inverter Meter	Primary for Capacity Test	**determined from inverter data sheet**	determined from inverter data sheet

28.6.5. Multiple Measurements

28.6.5.1. Multiple Measurements shall be recorded for all environmental data throughout the Site in order to capture the operating conditions for all regions of the array. There is a high probability that there will be periods of time in which portions of the Project are exposed to significantly different irradiance conditions than other portions, e.g. due to isolated clouds.

28.6.5.2. Below are the main sensors to be used in the Capacity Test:

28.6.5.2.1. Plane of Array Irradiance (POA): Plane of Array readings shall be averaged from sensors installed as outlined in SOW (MET Spec). To be clear, MET station will include front pyranometer, back pyranometer, bifacial reference module and monofacial reference module.

28.6.5.2.2. Ambient Air Temperature: Ambient temperature readings shall be averaged from sensors installed as outlined in SOW (MET Spec).

28.6.5.2.3. Wind Speed: wind speed sensors shall be averaged from sensors installed as outlined in SOW (MET Spec).

28.6.5.2.4. Inverter Meter: The power reading for each inverter.

28.6.5.2.5. PV Plant Meter: The power reading of the Revenue Meter.

28.7. Appendix 2: Project Capacity Model and Reporting Conditions Definition

28.7.1. Project Capacity Model

28.7.1.1. The requirements for the Project Capacity Model to be used for evaluating the Measured Capacity is detailed in this Exhibit. This section outlines all input parameters required to create the PVSYST simulation, in the event that PVSYST electronic project files are no longer available. This section shall be populated and submitted with the Capacity Test Procedures.

28.7.2. PVSYST Model Files

28.7.2.1. The table below provides the file names for all model files necessary to run the PVSYST simulation in the PVSYST version specified in the subsequent section. Contractor shall provide all Project Capacity Model files to the Owner.

Table 1: PVSYST File Names

Table 5 PVSYST File Names

PVSYST File Type	**File Name**
Project file [PRJ, VC0] Including all variants	
Meteorological file [MET]	
Site file [SIT]	
Module file [PAN]	
Inverter file [OND]	
Shade file [SHD]	
Horizon file [HOR]	

28.7.3. PVSYST Input Parameters

28.7.3.1. In the event that data files are lost or corrupted, all PVSYST inputs and assumptions have been documented in this section. The table below provides many of the PVSYST inputs required in the simulation.

Table 2: PVSYST Input Parameters

Input Parameter	**Value**	**Comment**
PVSYST Software Version		
Transposition Model		
Meteorological File		It is critical that the time stamp and other parameters are accurately accounted for when

Input Parameter	Value	Comment
		importing meteorological data. Data import files and techniques shall be documented and provided with the Performance Test Report.
Latitude / Longitude		
Altitude [m]		
Ground Albedo		
Array Orientation (PVSYST Field Type)		
Tilt		
Azimuth		0° is due South
Tracker Backtracking		
Min / Max Rotation Angle		
Number of sheds		
Ground Cover Ratio (GCR)		
Pitch [m]		
Collector width [m]		
Inactive band, Left (m)		
Inactive band, Right (m)		
Near Shading Type		
Electrical Effect		
Number of strings in row width		
Horizon		
Module Type		
Qty. of modules		
Qty. of modules per string		
Qty. of parallel strings		
Inverter Type		
Qty. of inverters		
Heat Transfer: Constant loss factor		
Heat Transfer: Wind loss factor		
DC circuit ohmic loss at STC		
Module Bifaciality factor	Off	Gain from bifacial module as per manufacturer specsheet
Module Quality	MQ - CTBG	CTBG is calculated during the capacity test and MQ is typical module quality factor that is used in the modeling

Input Parameter	Value	Comment
Mismatch [%]		
LID – Light Induced Degradation [%]		
Soiling Loss [%]	1%	1% soiling to be assumed for test unless a soiling station is installed. Then the soiling station soiling will be used.
Incidence Angle Modifier Factors or ASHRAE b0 value		User defined profile
AC circuit ohmic loss at STC		If modeled in PVSYST
External Transformer No Load Loss [%]		If modeled in PVSYST
External Transformer Full Load Loss [%]		If modeled in PVSYST
External Transformer Nighttime disconnect		If modeled in PVSYST

28.7.3.2. There are many additional settings required to recreate PVSYST files such as meteorological data import techniques, module file [PAN], inverter file [OND], etc. PVSYST version and model files will be placed in escrow to perform simulation. The files to be included in escrow include (a) all files listed in Table 2 of this Appendix 2 of Exhibit [ ], and (b) a copy of PVSYST version X.

28.7.4. Additional Losses (Post-Processed Loss)

28.7.4.1. There are multiple losses associated with an operating Project that may not be accounted for in PVSYST. Such losses include night-time demand of inverters, as well as auxiliary loads including but not limited to HVAC, lighting, security, SCADA, etc.

28.7.4.2. These losses have been included in the modeled power generation, the details of which are defined in the table below.

Table 3: Model Additional Loss

Parameter	Value	Comment
AC circuit ohmic loss [%]		
External Transformer Iron loss [%]		
External Transformer Resistive loss [%]		
External Transformer Nighttime disconnect		
Availability loss [%]		Not Included in Project Capacity Model

Parameter	Value	Comment
Curtailment loss [%]		Not included in Project Capacity Model
Auxiliary Loads [%]		
Nighttime Loads [%]		

28.7.5. Reporting Conditions and Target Capacities Identification

28.7.5.1. The Monthly Reporting Conditions and Target Capacities are to be specified below. Table 4 will be completed by Contractor and approved by Owner once the Project Capacity Model is complete. The following algorithm is recommended for identifying Reporting Conditions.

28.7.5.1.1. The Reporting Conditions shall be determined based on measured data set. Data records shall include the measured POA irradiance, ambient temperature and wind speed input parameters, as well as any simulated auxiliary parameters necessary for marking data records according to the primary data exclusion criteria.

28.7.5.1.2. Apply the primary data exclusion criteria identified in Section 8 of this procedure to the measured data records. (The secondary data exclusion is not applied.)

28.7.5.1.3. Grouping the remaining data records by month, compute the median values of incident plane-of- array irradiance, ambient air temperature, and wind speed. The reporting condition for plane-of-array (POA) irradiance shall not be less than 500 W/m².

28.7.5.1.4. Round median irradiance to the nearest integer W/m², median temperature to the nearest °C, and corrected median wind speed to the nearest 0.1 m/s. Use values as reporting conditions in Table 4.

28.7.5.1.5. Procure PVSyst hourly output from the Project Capacity Model. Project Capacity Model shall include following parameters:

- Soiling, Availability and Curtailment Losses shall be assumed 0%
- Module Quality Factor shall be adjusted with Capacity Test Bifacial Gain (CTBG) for bifacial modules
- Bifaciality factor in PVSyst simulation shall be turned off

28.7.5.1.6. The PVSyst hourly output, after post-processing, must contain at a minimum the plane of array irradiance, the ambient temperature, wind speed, inverter energy output, modeled power generation, shade loss, and clipping loss (GlobInc, TAmb, WindVel, EOutInv, POI Limited, ShdBLss, and IL Pmax) respectively.

28.7.5.1.7. Apply the data exclusion criteria identified in Section 8 to the simulation data records.

28.7.5.1.8. Compute regression coefficients and Target Capacity for the month(s) of the test. If the Capacity Test overlaps two months a weighted average based on the proportion of Qualifying Data points for each month will be used to calculate the Target Capacity.

Table 4: Example Monthly Reporting Conditions and Target Capacities Table

Month	Reference POA Irradiance (W/m^2)	Reference Ambient Temperature (°C)	Reference Wind Speed (m/s)	Target Capacity (kW)

28.8. Appendix 3: Capacity Test Calculator

28.8.1. The table below provides the file names for all files needed for the Capacity Test Calculator. Contractor shall provide the Project Capacity Model Hourly Data file once the Project Capacity Model is complete. If the Project design changes significantly, the Project Capacity Model Hourly Data shall be updated by the Contractor to reflect the As Built design and such updated Project Capacity Model Hourly Data shall be submitted to the Owner for review and approval. All Changes to Project Capacity Model shall be documented and approved by the Owner.

Table 1: Capacity Test Calculator Files

File Name	File Type	Comments
Capacity Test Calculator	.xlxs	Used to calculate reporting conditions, regression coefficients, Measured Capacity, and Target Capacity values
Project Capacity Model Hourly Data	.csv	Hourly Plane of Array (Global Incident in PVSYST), Ambient Temperature, Wind Speed, and Energy (after post processing, as necessary)

Xcel Energy		EEC 7.970W01
Energy Supply Engineering & Construction Policy System		**Revision: 1.6**
TITLE:	Drawing Deliverable Standards (PSCo, NSP, SPS)	Page 1 of 15

Revision History

Date	Revision Number	Change
12-16-08	1.0	New
7-10-09	1.1	Updated Logo
7-15-10	1.2	Review for 2010 Audit, Minor formatting changes made
10-11-11	1.3	Modified for capital project requirements
3-27-14	1.4	- Revised for 2014 Audit. Minor formatting changes made. - Revised Section 1.2 – Added O&M Manual Deliverable information.
8-18-15	1.5	Consolidated Regional Drawing Deliverable Standard WI's into one applicable for all Operating Regions.
6.15-18	1.6	Triannual Review complete, removed names replaced with titles, cleaned up regional references, linked TitleBlock standards,

Content Owner: Brian Hanawalt	Revised by: Design Services Team	Approved by: /s/ Kim Randolph (electronic approval on file)
Effective Date: Same as approval date	Date: 6-15-18	Approved Date: 7-5-18

Caution: Any hard copy reproductions of this policy should be verified against the on-line system for current revisions.

1.0 REQUIREMENTS

1.1 GENERAL

The Engineering and Construction (E&C) division of Xcel Energy's Energy Supply unit provides multi-discipline Engineering (ENG), Design (DS), Construction, and Document services (EDS) for Xcel Energy Power Generation facilities throughout Xcel's Operating regions as defined below:

1.1.1 **Public Service Company of Colorado (PSCo) Operating region**: PSCo Power Plants located within the state of Colorado.

1.1.2 **Northern States Power (NSP) Operating region:** NSP Power Plants located within the states of Minnesota, Wisconsin, South Dakota, and North Dakota.

1.1.3 **Southwestern Public Service Company (SPS) Operating region:** SPS Power Plants located in the states of Texas and New Mexico.

Engineering and Construction includes the following departments:

EDDS – Engineering, Design, & Document Services
ENG – Engineering
DS – Design Services
EDS – Engineering Document Services

1.2 **Existing Drawing Checkout:** - The Architectural/Engineering (A/E) firm or Vendor shall request from Engineering & Construction's (E&C) EDDS department drawings needed for revision or changes using the EDS Media Request form or via e-mail to the respective EDS e-mail address (reference EEC 7.955 Engineering Document Management). The A/E firm or Vendor shall clearly request the drawings needed and any CAD files required. EDDS will perform a verification of the information on the Media Request form including status of the requested drawing (CAD or Manual) and check out the electronic drawing file(s) to the A/E firm or Vendor per request. If the drawing is manual, E&C Design Services (DS) will convert the drawing to electronic format (CAD/Tif Hybrid) for modification. Once E&C DShas completed checkout, a copy of the requested CAD files shall be placed on the project SharePoint Site and released for work to the A/E firm or Vendor. It is the A/E firm's or Vendor's responsibility to maintain the integrity and availability of the original electronic drawing file(s).

A redraw of an existing drawing shall only be done if it is faster to recreate the drawing versus making the revisions. If a drawing is redrawn, ALL information including existing revisions shall be carried over to the new file. This shall include, at minimum, all revision triangles as shown on the existing drawing as well as revision descriptions in the revision block. Both the existing original drawing and the new redrawn original drawing shall be sent to EDDS.

1.3 New Drawing Request/Checkout: - The Architectural/Engineering (A/E) firm or Vendor shall contact Engineering & Construction's (E&C) EDDS department for all new drawing requests. EDDS shall provide the following to the A/E firm or Vendor for all new drawings, per the Operating Region requirements:

- A unique drawing
- Standard Borders

Please contact the DS Supervisor for the Standard Border requirements.

In order to provide the new drawing number, EDDS will need the A/E firm or Vendor to provide the following information:

- Plant
- Unit Number
- Plant System and Sub-system Code
- Discipline Category
- Drawing Type

Once the above information is received, E&C DS will coordinate with E&C EDS to assign all new drawing numbers and properly reserve the drawing numbers in ProjectWise. Once reserved, EDDS shall communicate all new drawing numbers to the A/E firm or vendor via e-mail to the respective EDS e-mail address. All new drawings shall be identified as new.

1.4 DRAWING ISSUE PACKAGE:

When outside A/E firms or Vendors issue drawings, the following items shall constitute an issued package and shall not be considered complete unless all the deliverables are included, without exception. At time of issue, EDS shall be included on all transmittals and shall receive all items included in a drawing issue package. All drawing issue packages shall consist of the following items:

PDF of each Manual – One (1) unsecured pdf copy of all equipment manuals such as original equipment manufacturer (OEM), operation & maintenance, instruction and/or installation manuals. All final manuals must conform to, and include, all construction

As-Built information.

Hard Copy of each Manual – Company's plant or project manager will identify quantity of required equipment manuals such as OEM operation & maintenance, instruction and/or installation manuals. All final manuals must conform to, and include all construction As-Built information.

Hard Copy Original Record Drawings: (See Requirements per Operating Region below)

- **PSCo Operating Region**: – No hard copy record drawing required.

- **NSP Operating Region**: The hard copy original record drawing with all initials/signatures of approval included. These initials/signatures shall be in BLUE ink so identification of the original can be done quickly. These drawings shall match exactly with the image file provided. If required, the Hard Copy Original Drawing shall have a wet stamp by a registered professional engineer (PE) for the statein which work is being designed.

- **SPS Operating Region: -** Professional Surveyor (PS) (New Mexico) or Registered Professional Land Surveyor (RPLS) (Texas) Stamped Drawing – If required, one (1) hard copy original of each drawing shall be provided wet stamped by a Professional Surveyor (PS) or a Registered Professional Land Surveyor (RPLS) licensed within the state where the subject of the Work has been constructed or is being constructed. Where allowed by the appropriate State Licensing organization CAD seals are acceptable.

Image File of Drawing Being Issued – An unsecured image file of the official record drawing shall be provided. This image shall be created electronically from the native file, if possible. This image shall bethe correct drawing size, clear, legible, and shall not be rotated and match the Hard Copy Original Record Drawing exactly. If this image file is not of the utmost quality, the drawing issue package will be rejected and the A/E firm or Vendor will be asked to provide quality images with no additional charge to Xcel Energy. This shall also include record drawings submitted as As-Built and record drawings stamped by a P.E. See 1.5 DRAWING FILE FORMATS for acceptable image file format.

CAD File – A CAD file, shall be provided on all initial drawing issues as well as final "As-Built" issues. Each CAD drawing file shall have its own separate CAP Drawing file and not combined into one CAD drawing File. Each CAD file(s) shall correspond to the current revision of the official record drawing being issued. If the drawing requires further revisions, a copy of the current CAD file shall be made and provided. See **"FORMATS"** for acceptable CAD file formats. Below are the requirements that must be included in the CAD file:

- ✓ Initials/Signatures typed in the titleblock of all originators, checkers, approvals, etc. This includes the titleblock as well as the revision block.
- ✓ Detailed descriptive reason of the revision in the revision block.
- ✓ All CAD drawings shall be drawn in such a manner that quantities may be correctly derived from the CAD file or an identified referenced 3D Model file.
- ✓ Clouds shall be placed around all the areas where the drawing was changed.
- ✓ Provided CAD files shall include all associated CAD references and 3D models used in the design. All Cad files and 3D models shall be in native format used to create the drawing files. Acceptable formats are Microstation (.dgn) and AutoCAD (.dwg).
- ✓ All seed files associated with 3D model and CAD files.
- ✓ All CAD drawings shall include any customized fonts used on the provided drawings.

If drawings, 3D models, seed files, or borders are referenced in the working drawing, then they should be submitted with all associated CAD files used in the design and shall be included as part of the Drawing Issue Package. Drawings should not be bound prior to submitting to Xcel Energy.

<u>Transmittal</u> – One (1) transmittal shall be provided for every drawing issue. The transmittal shall include the following:

- ✓ If applicable, the name of the Project Manager for the project which the drawings are being issued.
- ✓ The A/E firm or Vendor's Project Manager
- ✓ The A/E firm or Vendor's Administrative person who created the transmittal
- ✓ EDDS personnel
- ✓ The recipients of the drawings being issued
- ✓ Clear and concise description of what the drawings are being issued for (Preliminary, Bid Issue, Construction, Not to be Used for Construction, Demolition Sketch, As-Built), any specific instructions, or information pertinent to the drawings
- ✓ All drawings shall be collated to match the transmittal, if issued hard copy.

<u>Design Services Review of Vendor Submitted Drawings:</u> – Upon transmittal of a

drawing package by an A/E firm or Vendor, Design Services (DS) shall review the package for compliance with E&C Design/Drafting standards. This review shall be performed in parallel to any Engineering review of the drawing package. All comments shall be forwarded to the Project Manager or Project Lead to be incorporated along with any Engineering comments and returned to the A/E firm or Vendor for correction and revision.

When all the drawings are agreed upon as complete, and are in As-Built or final status, the “DDI Import Form” (reference Attachment A) for the Xcel specific operating Region shall be completed by the A/E firm or Vendor. This shall be completed at the end of the project or may be deemed necessary by the Project Manager at any time during the project. This information is required so Xcel E&C can easily import drawing information into Xcel Energy’s drawing management system. Drawing information entered on the DDI Import Form shall be as descriptive as possible. The A/E firm or Vendor is responsible for adding this information relating to all columns and rows within the spreadsheet (examples can be provided if requested).

1.5 DRAWING FILE FORMATS:

During the project, PDF image files and/or CAD files may be requested. The following are acceptable electronic files to be delivered to E&C. The A/E firm or Vendor shall inquire of the DS and EDS departments as to current versions being used by E&C. All other formats shall be approved by E&C prior to being used and/or As-Built submitted.

Acceptable CAD File Formats:

DWG – AutoCad 2013 or newer - all files in Native Format
DGN – Bentley Microstation V8i - all files in Native Format

Acceptable Image File Formats:

PDF – Adobe Acrobat Format version 9.0 (Unsecured, electronically searchable, not a hard copy scanned document)

1.6 FILE NAMING

1.6.1 PSCo File Naming: All new engineering drawings shall be drawn in CAD and shall have a unique PSCo drawing number assigned. EDDS will provide this unique number to the A/E firm or Vendor. All file names shall be identical to the assigned drawing number. The A/E firm or Vendor shall not change or alter any part of the drawing number/file names received from EDDS. No two (2) drawings will be assigned the same PSCo drawing number. The A/E firm or Vendor shall formally request from EDDS these assigned numbers.

1.6.2 **NSP File Naming:** All new engineering drawings shall be drawn in CAD and shall have a unique NSP drawing number assigned. EDS will provide this unique series number. All file names shall be identical to the assigned drawing number. The A/E firm or Vendor shall not change or alter any part of the drawing number/file names received from EDS. No two (2) drawings will be assigned the same NSP drawing series number. The A/E firm or Vendor shall formally request from EDS these assigned series numbers.

1.6.3 **SPS File Naming:** All new engineering drawings shall be drawn in CAD and shall have a unique SPS drawing number assigned. EDDS will provide this unique number. All file names shall be identical to the assigned drawing number. The A/E firm or Vendor shall not change or alter any part of the drawing number/file names received from EDDS. No two (2) drawings will be assigned the same SPS drawing number, even if the drawing prefixes (referring to dwg size) differ. The A/E firm or Vendor shall formally request from EDDS these assigned numbers.

1.7 DRAFTING STANDARDS

1.7.1 Standard Drawing Templates: Drawings created will use standard templates/seed files to setup the drawing. A/E firms or Vendors shall contact the appropriate Regional Supervisors for the standard templates/seed files.

1.7.2 TitleBlock and Revision Attributes: All checked and approved names/initials with complete dates shall be typed on all revisions and titleblocks on the electronic CAD files. A/E firms or Vendors shall contact the appropriate Regional Supervisors for the TitleBlock standards.
NSP TitleBlock
PSCO TitleBlock
SPS TitleBlock

1.7.3 Drawing Scale: All drawings shall be drawn full scale in Model space and plotted in Paperspace with the titleblock inserted at a scale of 1:1.

1.7.4 Standard Text Fonts: Only standard AutoCad and Microstation text font styles shall be used.

1.7.4.1 AutoCAD standard text shall be text style "ARIAL" except for electrical drawings. Electrical Drawings shall use text Style "TIMES NEW ROMAN".

1.7.4.2 Microstation standard text shall be text style "ARIAL" except for electrical drawings. Electrical Drawings shall use text Style "TIMES NEW ROMAN".

1.7.5 Standard Text Height:

1.7.5.1 PSCo Drawings:

- 3/32" (.100") shall be the Standard Text Height for PSCo C,D, or E-Size drawings.
- 1/8" (.125") shall be used for all sub-titles that require Medium-Height Bold Text such as Equipment Specifications or Designations, Titles for Notes and Highlighted Text.
- 5/32" (.150") – shall be used for all Prominent Titles that require Large-Height Bold Text such as Equipment Titles, Detail Titles, Section Titles, Plan or Elevation View Titles, etc.
- 5/64" (.08") - shall be used when space limitations on the drawing require deviation from the Standard Text Height. In this case the Standard Text Height for the entire drawing will be .08 consistent throughout the drawing ; subtitles and equipment designations will be .100" and Bold text, Prominent Titles will be .125 and Bold text.
- 5/64" (.08") shall be the Standard Text Height for PSCo A or B-Size drawings.

1.7.5.2 NSP Drawings:

- 3/32" (.100") shall be the Standard Text Height for NSP A, B, or C-Size drawings. Lineweight = 1

- 1/8" (.125") shall be the Standard Text Height for NSP D or E-Size drawings. Lineweight = 1
- 5/32" (.150") – shall be used for all Prominent Titles that require Large-Height Bold Text such as Equipment Titles, Detail Titles, Section Titles, Plan or Elevation View Titles, etc. Lineweight = 2

1.7.5.3 SPS Drawings:

- 3/32" (.100") shall be the Standard Text Height for all SPS A, B, C, or D-size drawings.

1.7.6 Drawing Units:

1.7.6.1 AutoCAD drawing units shall be Decimal, Engineering, Architectural, and Fractional. Use the appropriate drawing units for the type of drawing that is being created.

1.7.6.2 All Microstation CAD files shall have the following working units:
Master Unit = FT, Label = ‘; Sub-units = IN, Label = “.
Coordinate Readout: Master Units, Accuracy: 0.12
Angles – Format: DD.DDDD, Mode: Conventional, Accuracy: 0.123

1.7.6.3 Land Surveys & Topographic drawings shall have the following Drawing Units:
Master Unit = FT, Label = ‘; Sub-units = IN, Label = “.
Coordinate Readout: Master Units, Accuracy: 0.12
Angles – Format: DD MM SS, Mode: Bearing, Accuracy: 0

1.7.7 Dimensions:

1.7.7.1 All drawings shall have dimension units shown in feet, inches, and fractions of inches with the exception of civil engineering drawings. Civil engineering drawings shall be dimensioned in feet and hundredths of a foot.

1.7.7.2 Dimensions on drawings shall be associative and shall not be exploded or dropped. Never override the default measurement on a dimension unless it is a hybrid drawing with an image file.

1.7.7.3 Dimension Precision shall be set to 0'-0 1/128" or 0'-0 1/256".

1.7.7.4 Dimension text shall be the same size as all other text on the drawing and shall be configured to plot the same width as all other Standard text on the drawing. (See section 1.7.5 – Standard Text Height).

1.7.7.5 Dimension text shall be placed above the dimension line and centered between the extension lines except when the text will not fit. Then move text to the right or left.

1.7.7.6 Dimension, extension, and leader lines shall not cross each other unless absolutely necessary. A dimension line shall not be broken. Extension lines or leader lines shall not run through a dimension nor shall they be broken except where they pass through or are adjacent to arrowheads.

1.7.7.7 Sufficient dimensions shall be shown in the view that clearly define the size, shape, and position of the component. Dimensions shall be given as to minimize the need to calculate, scale, or assume any dimension during the construction or fabrication process.

1.7.7.8 Place dimension lines across the top of an object and along the left side. If additional dimensions are required to clearly dimension an object, they can be placed along the bottom and right side of an object.

1.7.8 Sections & Details:

1.7.8.1 PSCo Drawings: Sections and Elevations shall be labeled with Alpha characters. Details shall be labeled with Numeric characters.

1.7.8.2 NSP Drawings: Sections and Elevations shall be labeled with Alpha characters. Details shall be labeled with Numeric characters.

1.7.8.3 SPS Drawings: Sections and Elevations shall be labeled with Numeric characters. Details shall be labeled with Alpha characters.

1.7.9 Drawing Notes:

1.7.9.1 General notes affecting all the sheets per that drawing number shall be placed on the first sheet and always be placed in the upper right hand corner of the drawing. They may serve any of several purposes; it may be a note that would become repetitive if placed at each point of application, a note that applies to the drawing in general, or a lengthy note that would occupy excessive space on the drawing.

1.7.9.2 All notes shall be equally spaced with a space equivalent to the one line of text between each note. Note text shall be indented from the note number.

1.7.9.3 General notes shall be presented in a sequence that corresponds to the construction process.

1.7.9.4 Local notes are placed on the drawing, normally outside the outline of the affected object and as near as practicable to the affected region of the object. Information presented in these notes normally applies to a particular portion of the overall drawing.

1.7.10 North Arrow:

1.7.10.1 North arrows shall always be located in the upper left hand corner of all plan views.

1.7.10.2 The north arrow should never be positioned pointing down.

1.7.11 Symbology:

1.7.11.1 Symbols and nomenclature used to create the drawings shall conform to the existing nomenclature sheets established for that particular plant, or with Xcel Energy's standard symbology sheets.

- Mechanical – Reference Mechanical Symbology & Nomenclature sheets.
- Instrumentation - Reference Instrumentation Symbology & Nomenclature sheets.
- Electrical – Reference Electrical Symbology & Nomenclature sheets.

1.7.12 Drawing Revisions:

1.7.12.1 When revising existing drawings, use existing layers/levels and colors.

1.7.12.2 Revisions shall be made by modifying the latest electronic version of that particular drawing.

1.7.12.3 Drawing revisions shall be clouded, being careful not to cross any text, dimensions, or notes. Clouds will be erased with the next revision, and the new changes will be clouded.

1.7.12.4 All revisions formally transmitted shall be routed and reviewed by appropriate E&C personnel. All drawings formally transmitted "Issued for Comments" shall have an alpha character as a revision. Once all comments have been reviewed, addressed, and incorporated by the proper personnel, the drawings are ready to be transmitted for "Issued for Construction" and shall have numeric revisions starting with revision 0.

1.7.12.5 When drawings are being "Issued for Construction," all previous preliminary revisions are removed from the revision block and shall only show Revision 0. All approvals shall be hand initialed in blue ink with the exception of the date and the drafter/designer which is typed on the original. After having the approvals hand written, these signatures/initials shall be typed in the electronic CAD file so they may be kept electronically.

1.7.12.6 Drawing revisions will be made by adding, deleting, crossing out the information, or by redrawing the drawing. The revision status is identified by a numeric revision number beginning with the number 0 (zero), and used in sequential order. Revisions to drawings shall be consistent with the original workmanship.

1.7.12.7 Once all drawing changes are As-Built and the drawing status is "Issue For Record," the revision block shall have "Issue For Record" typed into the description along with the Project Name, and Project Number. When issuing drawings as "Issue For Record," there shall be no clouds on the drawings; only a revision triangle shall be used to identify the As-Built changes unless clouds are specifically requested. All signatures/initials shall be typed in the electronic CAD file so they may be kept electronically.

Xcel Energy	EEC 7.970W01
Energy Supply Engineering & Construction Policy System	**Revision: 1.6**
TITLE: Drawing Deliverable Standards (PSCo, NSP, SPS)	Page 14 of 15

ATTACHMENT A

DDI FORM

Xcel Energy

Energy Supply - Engineering & Construction Dept.

Drawing and Instruction Manual Submittal Form

Plant / Substation / Transmission-Line:

Plant Name Here

City State

Todays Date:

Consultant / Vendor Name & Address:

Consultant / Vendor Project Transmittal #

Xcel Project #

Maximo Work Order #

Submitted Date:

USE CURRENT VERSION

Submitted By: Phone #: Mobile #:

Xcel Energy TS Coordnator: Phone #: Mobile #:

Project Title \ Description:

Comments \ Instructions:

Attached Files Created On: Delivery Method:

Total Drawings: 0

Total Manuals: 0

FORM NUMBER: TS 12 07 Rev. A

PSCO - DDI Form.xls

Content Owner: Brian Hanawalt	Revised by: Design Services Team	Approved by: /s/ Kim Randolph (electronic approval on file)
Effective Date: Same as approval date	Date: 6-15-18	Approved Date: 7-5-18

Xcel Energy	EEC 7.970W01
Energy Supply Engineering & Construction Policy System	**Revision: 1.6**
TITLE: Drawing Deliverable Standards (PSCo, NSP, SPS)	Page 15 of 15

Plant ID	MICROFILM #	MFR. Name	MFR. Dwg #	Sht.	Rev.	Rev. Date	Contract/PO #	Unit	System Code	Sub-System Code	(Top Line) SYSTEM DESCRIPTION	(Middle Line) COMPONENT DESCRIPTION	(Bottom Line) DRAWING TYPE	DWG. Size	Discipline

Xcel Energy		EEC 7.970W01
Energy Supply Engineering & Construction Policy System		**Revision: 1.5**
TITLE:	Drawing Deliverable Standards attachment (NSP) Title Block Standard (Referenced from 1.7.2.2)	Page 1 of 6

1.7.2.2 TITLEBLOCKS

Standard title blocks are created and shall be used on all Xcel drawings and shall not be altered. The Design Services Manager shall approve any changes required prior to being used.

Drawing Sizes

NSP, Architectural Engineering firm, or Consultants drawings are considered domestic, and are prefixed by an "N", and an identifier corresponding to the physical size of the end product. This identifier has a direct relationship to better known international standard sizes.
Vendor or Manufactured originated drawings and manuals
are prefixed with "**NX**"

(Example) "NX-12345-1-1. Vendor prefixes have no relationship to the drawing size.

PREFIX		SIZE(Height x Width)	NSP FILE SIZE CODE
NL	=	11 X 8.5	A
ND	=	11 X 17	B
NQ	=	17 X 22	C
NH	=	22 X 34	D (preferred size for P&ID's and Schematics)
NF	=	34 X 44	E (preferred size for GA, Site, UG Utilities)
NX	=	Vendor Only Various	A thru E

* **Obsolete** Industry Standard, do not use with new drawings, except to add to an existing series of that size.

***NE/DE**	=	11 X 34	D
***B**	=	18 X 27	C
***A**	=	24 X 36	E
***E**	=	34 X 48	E
***AA**	=	30 X 42	E

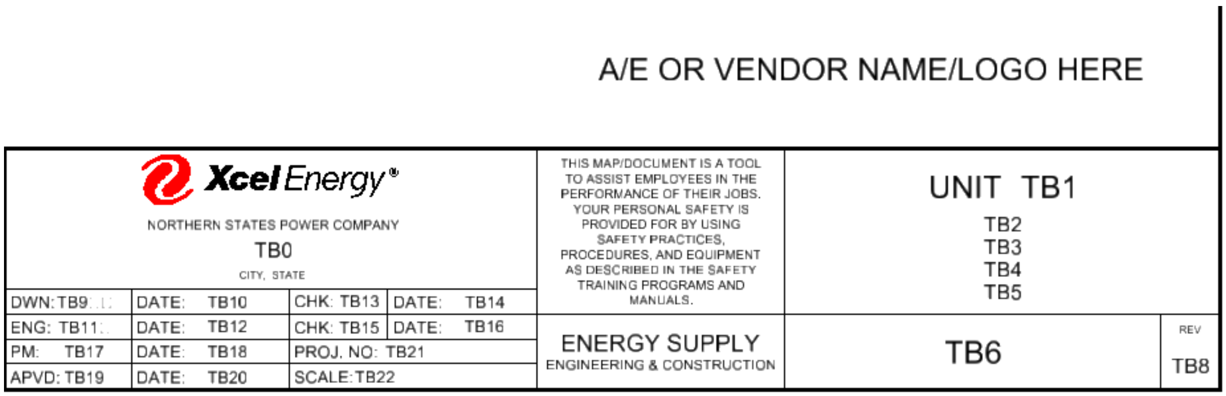
Borders: Shall be scaled to 1:1 only.

Do Not Re-name Borders block name or tag set .
Do Not Reference Borders into drawings into drawings.

The **lower left** corner of all drawing borders will reside at **XY="0,0"**, unless a UTM or USDS coordinate system is used.

Xcel Energy®		**EEC 7.970W01**
Energy Supply Engineering & Construction Policy System		**Revision: 1.5**
TITLE:	Drawing Deliverable Standards attachment (NSP) Title Block Standard (Referenced from 1.7.2.2)	Page 2 of 6

Key Elements of Drawing Titleblock Information



The following information shall be input into all NSP plant project title blocks. It is the responsibility of the A/E firm's or Vendor's drafter/designer to include the correct information on the title block.

TB0 – PLANT NAME

This is the plant name for which the drawing content is to be located.

TB1 – UNIT#

This is the unit number for which the drawing content is to be located. If the drawing(s) relate to more than one unit, then the number (UNIT 0) zero is entered representing all units.

TB2 – SYSTEM

The system the drawing pertains to shall be input on this line. For example, if the project is for dust suppression, then DUST SUPPRESSION is entered. For a new instrument air compressor, INSTRUMENT AIR is entered.

TB3 – EQUIPMENT DESCRIPTION

The equipment the drawing pertains to shall be input on this line. For example above, for a new instrument air compressor, INSTRUMENT AIR COMPRESSOR would be entered.

TB4 – FURTHER DESCRIPTION

This is used if further equipment description is needed. If this is not needed, then this line is blank.

TB5 – DRAWING TYPE

This is the type of drawing. For example, if it is a wiring or connection diagram, then WIRING DIAGRAM is entered. If it is plan and sections, PLAN & SECTIONS is entered.

TB6 – DRAWING NUMBER

This is the NSP Drawing number. Xcel Energy's EDS Dept. assigns ALL drawing numbers. Architectural Engineers (AE's) to follow **example** "NH-200000-1-1" (First NH-is the prefix for "D" size followed by a 6 digit series number, then followed by dash and or sheet number if needed).

TB8 – CURRENT REVISION NUMBER

This is the current revision of the drawing. All revisions shall be numeric.

TB9 – DRAWN BY

This is the initial of the person who created the drawing. Two (2) or three (3) initials are required.

TB10 – DATE DRAWN

This is the date the drawing was created. The date should be designated with separation by a dash and not a slash, for example, 00-00-00.

TB11 – ENGINEERED BY

This is the engineer or designer who designed the system or worked on the drawing. Two (2) or three (3) initials are required.

TB12 – DATE ENGINEERED

This is the date the drawing was engineered or designed. The date should be designated with separation by a dash and not a slash, for example, 00-00-00.

TB13 – DRAFTING CHECKED BY

This is the initials of the person who checked the drafting of the drawing. Two (2) or three (3) initials are required.

TB14 – DATE DRAFTING CHECKED

This is the date the drafting was checked. The date should be designated with separation by a dash and not a slash, for example, 00-00-00.

Xcel Energy		EEC 7.970W01
Energy Supply Engineering & Construction Policy System		**Revision: 1.5**
TITLE:	Drawing Deliverable Standards attachment (NSP) Title Block Standard (Referenced from 1.7.2.2)	Page 4 of 6

TB15 – ENGINEERING CHECKED BY

This is the initials of the person who checked the engineering. Two (2) or three (3) initials are required.

TB16 – DATE ENGINEERING CHECKED

This is the date the engineering was checked. The date should be designated with separation by a dash and not a slash, for example, 00-00-00.

TB17 – PROJECT MANAGER (If Applicable)

This is the initials of the person who was the Project Manager. Two (2) or three (3) initials are required.

TB18 – DATE PROJECT MANAGER (If Applicable)

This is the date the Project Manager approved the drawing. The date should be designated with separation by a dash and not a slash, for example, 00-00-00.

TB19 – DRAWING APPROVED BY

This is the initials of the person who approved the drawing. Two (2) or three (3) initials are required.

TB20 – DATE APPROVED

This is the date of the person who approved the drawing. The date should be designated with separation by a dash and not a slash, for example, 00-00-00.

TB21 – XCEL PROJECT NUMBER

This is the Xcel Energy project number assigned to the NSP project. This field will not change with revisions of the drawing.

TB22 – DRAWING SCALE

This is the scale of the drawing. Drawings that are drawn to scale will indicate the scale, (for example, 3” = 1’-0”). Drawings that are not drawn to scale will indicate the scale as NONE.

TB23 – OPERATING COMPANY

This relates to the Minnesota/Wisconsin/South or North Dakota operating regional company, used is Northern States Power.

TB24 – OPERATING STATE

This relates to the City and State location of which the work is being performed at.

PROFESSIONAL ENGINEERS SEAL SECTION
This section is reserved for the Professional Engineer's Seal or Professional Architect's Seal if required by the Projects. This section may be turned off by layer or level if using a seal in lieu of the Minnesota engineering verbiage This section may be turned off by layer or level if using a seal in lieu of the Minnesota engineering verbiage.

Key Elements of Drawing (Revision) Block Information

NO.
This is the current revision of the drawing. All revisions shall be numeric.

REVISION
This is a short, clear, and concise description of the revision. Abbreviations can be used however they need to be clear and easily understood. Multiple lines can be used if required. Occasionally, a drawing revision will have new project number for which the revision was created. The new project number will be incorporated in the revision description. If the drawing was redrawn on CAD then this shall be the first item noted in the revision description.

ZONE
D-size and E-Size drawings are subdivided into zones. The zones are indicated by alphabetical and numerical entries along the border. The alphabetical entries are found along the top edge of the border and the numerical entries are found along the left edge of the border. The revision zone shall be entered with the alphabetical designation first, followed by a "dash", followed by the numerical designation corresponding with the area of the drawing that was revised.

DATE
This is the date the drawing was revised. The date should be designated with separation by a dash and not a slash, for example, 00-00-00.

BY
This is the initials of who made the revision to the drawing. Two (2) or three (3) initials are required.

CHK
This is the initials of the person who checked the revision to the drawing. Two (2) or three (3) initials are required.

ENG
This is the engineer or designer who designed the system or worked on the drawing revision. This can also be the person who approves the revision. Two (2) or three (3) initials are required.

Key Elements of Drawing (Reference) Block Information

DRAWING NUMBER.
This is the drawing number of the drawing being referenced.

MANUFACTURER
This is the manufacturer, vendor, or Company name of the drawing being referenced.

DRAWING TITLE
This is the title of the drawing being referenced.

Preface

P.1. Scope and Purpose

This document describes the fundamental design criteria for substation facilities within Xcel Energy. It covers the construction of new facilities, modification, or extension of existing facilities, and to some extent, the rehabilitation of existing facilities.

P.2. Applicability

This document is a standard and shall be followed by all employees with XCEL Company for new substation installations. Any exceptions to following this standard need to be requested in writing and approved by the manager or director of engineering.

P.3. Responsibilities

P.3.1 Substation Engineering and Design

This document is to be used as reference for Substation Engineering and Design Engineers when constructing or modifying an Xcel Energy Substation.

P.4. Work Flow

P.4.1 Approval

The Xcel Energy Standards Council has approved this document.

Date	Name
2015/04/06	Jensen, Mike C
2015/04/02	Watkins, Diane
2015/04/03	Gragg, Jim
2015/04/06	Gutzmann, Mark G
2015/03/30	Bellinghausen, Alan L
2015/04/24	King, Mike
2015/04/02	Lorentz, Brian R
2015/04/03	Munsell, Kenny
2015/03/30	Hui, Ming-Wa

P.4.2 Creation

The following committee wrote this document.

Name	Title
Barry Gustafson	Principal Engineer, System Sustainability
David Miller	Principal Engineer (Ret), Substation Engineering Design
David Stamm	Consultant, High Energy Incorporated
Don Simpson	Principal Engineer, Substation Engineering Design
Jim Gragg	Manager, Substation Engineering Design
Mike Ibold	Manager, Substation Engineering Design
Sue McNelley	Consulting Engineer, Substation Engineering Design
Dick Bush	Principal Engineer, Substation Engineering Design
Joe Gravelle	Principal Engineer, Substation Engineering Design
Timothy Lougheed	Staff Engineer, Substation Engineering Design
Mike Jensen	Supervisor, Substation Engineering Design
Heather Malson	Staff Engineer, Transmission & Substation Standards

P.4.3 Version History

The personnel listed above have approved the following changes.

NOTE: The most recent changes to this document are highlighted in yellow throughout the document.

Date	Version Number	Change
6/17/2003	1	Initial Version
12/1/2011	2	Initial Revision for Review
6/8/2012	2.1	Updated Format of Document
8/28/2012	2.2	Updated document based on review comments
9/11/2012	2.3	Document reviewed by Substation Standards Council
9/28/2012	2.4	Changes made to document based on Council review
11/14/2012	2.5	Document updated and sent to Engineering for review
1/24/2013	2.6	Document sent to Substation Standards Council for review
3/25/2013	3.0	Document approved by Standards Council and set to “Released”
4/1/2013	3.1	Draft to make changes based on additional comments submitted during previous reviews
5/22/14 – 3/30/15	3.2-3.82	Team Revisions, open review and send to council for approval
5/11/15	4.0	Council approval
5/11/15-7/15/15	4.1	Update links and minor modification with team and council approval – set to release

Table of Contents

1 General

1.1. Introduction

This document describes the fundamental design criteria for transmission and distribution substation facilities within Xcel Energy. It covers the construction of new facilities, modification or extension of existing facilities, and to some extent, the rehabilitation of existing facilities. Civil and structural design criteria are provided in XEL-STD-Criteria for Eng & Design of Civil & Structural Performance.

This document is located in ProjectWise here: XEL-STD-Criteria for Eng & Design of Substations - Physical

When substantial additions to existing facilities are planned, they shall be in accordance with current criteria. The interface between the new and the old will be designed to satisfy existing and economically practical future technical requirements but not necessarily to satisfy current standards. It is the design engineer's responsibility to build a consensus on the balancing of trade-offs between economics, practical solutions, and standards when faced with upgrade decisions.

When deficiencies are discovered, the merits of correcting the deficiencies should be decided based on safety, budget, timing, and technical merit. A project in one area of a substation does not necessarily require bringing the entire facility up to current criteria. Rehabilitation projects often are limited in their ability to match current standards.

It is recognized that each substation project will have unique requirements and constraints and that these criteria cannot or should not be followed in all situations. In all cases, current criteria shall be used as a guide to a practical design with a goal to achieve as much standardization as possible.

1.2. Industry Standards

All substations designs shall be in accordance with IEEE standards and accepted industry standards and practices. IEEE C2-The National Electric Safety Code ("NESC") and the National Electrical Code (NFPA 70) should be followed to the extent that is possible and practical.

1.3. Glossary

General Arrangement – drawing showing the major electrical and physical components of a substation, including but not limited to breakers, transformers, bus, and lines

Ultimate Build Out/Ultimate Design – fully envisioned future size and arrangement of a substation

Buchholz relays – For transformers with a conservator type oil preservation system, a Buchholz relay is specified. This relay serves as a protective device and provides two functions. It acts as a sudden pressure relay (SPR) or rapid pressure rise relay (RPRR) and also provides a gas detection function for slower development of gases. These are alarmed separately, with the sudden pressure function wired to controls to trip the transformer. Buchholz relays were named after their inventor, Mr. Max Buchholz (1875-1956) in 1921.

Bulk Electric System (BES)* – Unless modified by the lists shown below, all Transmission Elements operated at 100 kV or higher and Real Power and Reactive Power resources connected at 100 kV or higher. This does not include facilities used in the local distribution of electric energy.

Inclusions:

- I1 - Transformers with the primary terminal and at least one secondary terminal operated at 100 kV or higher unless excluded by application of Exclusion E1 or E3.
- I2 – Generating resource(s) including the generator terminals through the high-side of the step-up transformer(s) connected at a voltage of 100 kV or above with:

a) Gross individual nameplate rating greater than 20 MVA. Or,

b) Gross plant/facility aggregate nameplate rating greater than 75 MVA.

- I3 - Blackstart Resources identified in the Transmission Operator's restoration plan.
- I4 - Dispersed power producing resources that aggregate to a total capacity greater than 75 MVA (gross nameplate rating), and that are connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage of 100 kV or above.

Thus, the facilities designated as BES are:

a) The individual resources, and

b) The system designed primarily for delivering capacity from the point where those resources aggregate to greater than 75 MVA to a common point of connection at a voltage of 100 kV or above.

- I5 –Static or dynamic devices (excluding generators) dedicated to supplying or absorbing Reactive Power that are connected at 100 kV or higher, or through a dedicated transformer with a high-side voltage of 100 kV or higher, or through a transformer that is designated in Inclusion I1 unless excluded by application of Exclusion E4.

Exclusions:

- E1 - Radial systems: A group of contiguous transmission Elements that emanates from a single point of connection of 100 kV or higher and:

a) Only serves Load. Or,

b) Only includes generation resources, not identified in Inclusions I2, I3, or I4, with an aggregate capacity less than or equal to 75 MVA (gross nameplate rating). Or,

c) Where the radial system serves Load and includes generation resources, not identified in Inclusions I2, I3 or I4, with an aggregate capacity of non-retail generation less than or equal to 75 MVA (gross nameplate rating).

Note 1 – A normally open switching device between radial systems, as depicted on prints or one-line diagrams for example, does not affect this exclusion.

Note 2 – The presence of a contiguous loop, operated at a voltage level of 50 kV or less, between configurations being considered as radial systems, does not affect this exclusion.

- E2 - A generating unit or multiple generating units on the customer's side of the retail meter that serve all or part of the retail Load with electric energy if: (i) the net capacity provided to the BES does not exceed 75 MVA, and (ii) standby, back-up, and maintenance power services are provided to the generating unit or multiple generating units or to the retail Load by a Balancing Authority, or provided pursuant to a binding obligation with a Generator Owner or Generator Operator, or under terms approved by the applicable regulatory authority.

- E3 - Local networks (LN): A group of contiguous transmission Elements operated at less than 300 kV that distribute power to Load rather than transfer bulk power across the interconnected system. LN's emanate from multiple points of connection at 100 kV or higher to improve the level of service to retail customers and not to accommodate bulk power transfer across the interconnected system. The LN is characterized by all of the following:

a) Limits on connected generation: The LN and its underlying Elements do not include generation resources identified in Inclusions I2, I3, or I4 and do not have an aggregate capacity of non-retail generation greater than 75 MVA (gross nameplate rating);

b) Real Power flows only into the LN and the LN does not transfer energy originating outside the LN for delivery through the LN; and

c) Not part of a Flowgate or transfer path: The LN does not contain any part of a permanent Flowgate in the Eastern Interconnection, a major transfer path within the Western Interconnection, or a comparable monitored Facility in the ERCOT or Quebec Interconnections, and is not a monitored Facility included in an Interconnection Reliability Operating Limit (IROL).

- E4 – Reactive Power devices installed for the sole benefit of a retail customer(s).

Note - Elements may be included or excluded on a case-by-case basis through the Rules of Procedure exception process.

*Source: http://www.nerc.com/files/glossary_of_terms.pdf

NOTE: Additional information may be found for topics in this standard by using resources at the following: https://www.ieee.org/index.html, http://pes-psrc.org/, http://www.ieee-pes.org/, or search tools like https://www.google.com/

2 Facility Planning

2.1. Site Selection and Preparation

Selecting a location for a new substation or a substation expansion generally requires input from the following groups: siting and land rights (for permitting and site acquisition), local customer service (for permitting and public relations), substation and transmission engineering (for site requirements, site selection, and permitting), operations, environmental, trouble service, and others as appropriate (e.g. law.). Refer to IEEE 1127 for community acceptance and environmental compatibility guidelines. New facilities require a name, a GPS location, an address or 911 address (if applicable), and other region-specific identifiers (e.g. substation mnemonic, functional unit number, or four-character identification). Project engineers should submit a suggested mnemonic when submitting a Capital Asset Accounting form for all new substations.

When purchasing land for a new substation, a site shall be chosen and acquired which can accommodate the ultimate substation requirements. Ultimate General Arrangement and One-Line drawings shall be created with Engineering's and Planning's input. If economically justified, the ultimate site may be graded and fenced during the initial development. For a first approximation, a 100-foot buffer from the outside of the fence is allowed for grading, drainage and landscaping. Drainage and landscaping requirements vary greatly with local ordinances and these need to be reviewed during the siting and land acquisition process.

Typical items that should be considered when selecting a site are:

- Physical requirements of the ultimate facility including a preliminary location plan, major structures, electrical equipment enclosure, driveways, road curve radius (if necessary), and drainage criteria such as storm water detention or retention ponds
- Transmission and distribution line route
- Topography of site and grade, including cost of necessary earthwork and grading
- Regulatory requirements such as planned unit development, archaeological surveys and considerations, special use permit, rezoning, watershed district, building codes, and building permits
- Special environmental conditions or concerns like unusual climate, flood plains, wetlands, endangered species, atmospheric conditions such as salt or corrosive conditions, environmental risks relative to oil spill potential, noise, and unusual adjacent land uses

- Aesthetic requirements such as landscaping, special wall or building requirements, and lighting
- Encumbrances such as easements, existing utilities, setbacks, sidewalk, driveway, and landscaping constraints
- Underground facilities such as duct lines, pipelines, manholes, telephone, gas, sewer, and water
- Enclosures required - chain link fence, wall, or unusual screening features
- Additional fencing around the perimeter of owned land may be necessary to protect land property. Land Rights and jurisdictional laws should be consulted when designing additional fence layouts
- Soil investigations to determine suitability of soil for substation structures, equipment foundations, and grounding
- Presence of hazardous materials in soil or existing structures (e.g. petrochemicals, PCBs, asbestos) and cleanup costs
- Accessibility to railroad/highways for large equipment moves under all weather conditions

General site preparation includes:

- Sites will be cleared and graded according to the civil design, including provisions for a stabilized surface and site drainage
- The substation will be fenced or otherwise enclosed
- The surface will be covered with four inches of crushed rock aggregate surfacing as part of the grounding design and as a finished surface to control dust and storm water run-off
- Storm Water Pollution Prevention Plan (SWPPP) is prepared and in place before constructions begins as needed by local jurisdictions

2.2. Jointly Owned Substations

Special care needs to be taken when Engineering and Designing a new or adding to a Jointly Owned Substation. The Engineer should obtain and fully understand any agreements that are currently in place with other utility (ies) involved in the substation.

Due to the FERC Compliance requirements for BES facilities, there could be compliance issues with Xcel owned BES facilities in a jointly owned substation where Xcel does not control access or may not own some of the equipment such as batteries, AC station service, EEE and the land. Xcel Energy could be held responsible and fined due to improper or lack of maintenance on the shared equipment owned by the other utility.

In a jointly owned substation, consideration should be given to Xcel Energy providing all of the necessary equipment for operation of the BES and having a physical boundary between the other utility's equipment. This may require Xcel Energy to provide a separate EEE which would include the AC and DC station service, all necessary protection and communications equipment and a fence to physically separate the Xcel owned BES equipment from the other utility's equipment. Separate access points should be considered. Minimal Xcel Energy equipment would be housed in the other utility's substation yard and EEE. The other utility would be able to house only minimal equipment in Xcel Energy's substation yard or EEE if separation exists.

2.3. Substation Yard Layout

2.3.1. Basic Layout

The electrical equipment enclosure (EEE) will normally be located near the substation fence to avoid drive paths near bus and equipment. The EEE should not obstruct access to transformers or other major equipment, or be located under a power line or substation conductor. The length of control and power cable to substation equipment should also be considered. EEE location should be selected so the EEE at least 50 feet from a transformer and if possible uphill of an anticipated oil spill to avoid installation of firewalls where possible.

Substation designs include drivable areas. Drivable access is provided to the electrical equipment enclosure, to large equipment, and around the inside perimeter of the fence. Drivable areas should avoid crossing concrete cable trench. When drive areas cross cable trench, traffic-rated trench covers will be provided. Non-drivable areas should be clearly identified with marker posts and chain barriers.

Drive lanes should be designed such that backing maneuvers can be avoided and equipment can be easily accessed. In some cases, this may require more than one gate. Drive areas should have adequate width and space for turning at corners. The standard practice is to provide a minimum of 30 feet, but an absolute minimum of 15 feet, from the perimeter fence to any structure inside the fence to allow for equipment access, maintenance, and snow removal requirements. In existing substations, or in special cases where this standard cannot be met, the fence clearance must meet the requirements of the NESC. The NESC requires fence clearances greater than 15 feet from fence to live parts at higher system voltages, and these requirements must be followed (refer to IEEE C2 for specific requirements).

2.3.2. Access to Equipment

Substation designs should provide for access to all equipment so that operation, maintenance, and removal of the equipment can be accomplished without significant extra work, additional outages, or relocations. Transformers, circuit breakers, reclosers, regulators, and other major equipment should have planned drive-alleys for removal and maintenance vehicle access.

Consideration should be given to operators needs for work space including room for an operator to move while switching (consider lengths of switching equipment/handles and hot sticks), an emergency escape path from any space requiring manual switching, room for maintenance trucks to drive next to equipment that requires regular maintenance, and access to lighting fixtures. In some cases, this may exceed regular phase spacing.

Drive aisles for access to equipment should be a minimum of 14ft wide, and 20ft is recommended. In addition, the drive aisles shall be provided with adequate vertical clearance to any overhead bus or conductors for a vehicle height of 12.5ft. Additional drive space may be required for removal of large station equipment, such as transformers or oil filled reactors, and should be considered during the design. Drive lanes near large power equipment normally require a minimum turning radius of 50 feet for tractor-trailer access and preferably a full path back to the site entrance without having to back out.

2.3.3. Driveways, Gates, and Locations

A minimum of one drive gate will be provided in each substation. Walk-in gates will not normally be provided, but this should be reviewed depending on specific area requirements. Larger substations or substations with special circumstances may require more gates. However, it is preferred to have only one gate for smaller substations as additional access points to roads or highways increase costs or may be limited.

Especially important considerations are the drive gate and driveway placement for moving transformers or other large equipment. Transformers require room for staging and for large truck and trailer access. All access roads require a minimum turning radius (specified XEL-STD-Criteria for Eng & Design of Civil & Structural Performance) to allow for delivery of large substation equipment.

2.3.4. Mobile Transformer Allowances

2.3.4.1 Transmission Substations

Xcel Energy has mobile transmission transformers with ratings of 115-69kV and 161-69kV. Mobiles are not available for other transmission transformer ratings.

Substation designs should include allowance for mobile transformers in those cases where a suitable mobile is available. This allowance must include adequate room to get the mobile in and out, and to make both the high and low side connections. The mobile installation may require the installation of temporary poles and bus work. Consideration should be given in the design to make the mobile installation as fast and as simple as possible. The installed location of the mobile should not hinder installation of a new transformer or removal of a failed one.

Xcel Energy does not provide mobile transformers for higher system voltages because of their large size, weight, and cost. For cases where mobiles are not available, transformer failures will be repaired or replaced as quickly as practical or an in-service transformer may be brought in from a less critical facility.

2.3.4.2 Distribution Substations

Xcel Energy has mobile distribution transformers/substations available for various distribution applications. Provisions for the connection of a mobile transformer are required in all standard distribution substation designs. This, includes grounding and land/space provisions and may include high and low-side switches. Consideration should also be given in the design to make the mobile installation as fast and simple as possible. Driveways and gates must allow for access of the mobile equipment as well as adequate room to get the mobile in and out. The installed location of the mobile should not hinder installation of a new transformer or removal of a failed one.

2.3.5. Transmission and Distribution Interface

The transmission and distribution parts of a substation may be designed and constructed by different groups. In these cases, the interface between the transmission and distribution parts of the substation must be carefully coordinated. A physical point may be required to define the boundary between the transmission substation and the distribution substation.

The boundary point between transmission and distribution equipment is often an air disconnect switch for the distribution equipment. Distribution equipment shall include medium voltage equipment, the power transformer, and the transformer high-side protector. For breaker-and-a-half and ring-bus configurations, it is preferred that distribution transformers be provided with a dedicated position. A dedicated position means that a distribution transformer will not be tied to a main bus that must remain in service (ring bus, single string breaker and a half, radially fed lines, etc.) or a shared position. This configuration is undesirable because of outage constraints, unnecessary outages to the load on the transformer, and protection concerns. Shared positions of elements need approval from the Director of Engineering.

A substation will be classified as a transmission substation if it has three or more transmission sources unless the number of distribution elements (transformer banks) exceeds the number of transmission sources. In addition, if the substation does not have Xcel Energy owned distribution, the substation will be classified as transmission.

A substation will be classified as a distribution substation if it has less than three transmission sources or the number of distribution elements (transformer banks) exceeds the number of transmission sources.

If the substation is radial and terminates on a distribution element, the substation will be assigned to that element. For further information, refer to the Capital Asset Accounting – Procedure Guidelines, Asset Separation – Funtionalization of Substations.

2.4. Substation Switching Configuration

Substation switching configuration is one of the most fundamental elements of substation design. It is the primary factor in determining the substation's construction cost, maintenance cost, and reliability. Operations, Planning, and Asset Management will specify or provide guidance as to which configuration to use based on the substation requirements and budgetary constraints. Transmission line structures that support multiple circuits outside of the substation require consideration of the configuration for the single contingency of a structure failure.

2.5. Transmission Substation Configuration

The transmission system should be designed, where practical, to allow for any one element to be out of service without loss of load (single contingency or "n-1" planning). Some areas will need to be designed to operate with even more contingencies because of greater reliability requirements. The choice of substation configuration should be made with consideration for single contingency planning requirements and operational flexibility.

The substation configuration is the choice of how many interrupting devices (such as circuit breakers) and isolating devices (such as switches) will be used, and how they will be laid out with respect to one another and the elements to be connected.

Increased reliability can be achieved by separating elements by circuit breakers, so that a problem with one element does not cause an outage to other elements in the substation. Increased operational flexibility can be achieved by connecting elements to the substation through more than one path (circuit breaker), so that an outage of one circuit breaker does not require taking an outage to the connected element. The location of line and transformer terminations in the configuration also affects reliability and operations. For instance, transformer terminations should be separated by two circuit breakers where possible, so that the failure of one circuit breaker does not lead to the simultaneous outage of both transformers. Similarly, two-breaker separation should be provided between sources and between loads as much as possible so that a circuit breaker failure does not cause a simultaneous outage for two sources, for loads, or for parallel lines.

In general, greater reliability and flexibility requires more circuit breakers and switches. Configurations with more circuit breakers and switches typically require more bus work, more instrument transformers, more equipment foundations, and more control and relay equipment. Ultimately, increased reliability and flexibility comes with increased cost.

The switching configuration must also take into account the present and future requirements of the substation. Consideration should be given for both the electrical configuration and the physical layout of the substation. Expandability of the substation should be planned in the initial layout so it can be performed in a simple manner without extended outages.

Xcel Energy has established standard transmission substation configurations and these are to be used except in special circumstances. This standardization provides numerous advantages in design, construction, and operation. Xcel Energy's standard transmission substation configurations are Single Bus, Double Breaker/Double Bus, Ring Bus, and Breaker-and-a-Half Bus.

Transmission substations are substations with a primary function for the transmission system (see Capital Asset Accounting – Procedure Guidelines, Asset Separation – Funtionalization of

Substations). The Xcel Energy standard transmission substation configurations are shown in the figures below. Each configuration is shown with three lines and one transformer to make comparison easier.

The breaker-and-a-half scheme is the ultimate standard layout for substations at voltages 115kV and above. The single bus (straight bus, SB) and the ring bus (RB) configuration should both be considered as a preliminary version of an ultimate breaker-and-a-half bus scheme (BHB). Whenever a ring-bus configuration is used, it should be designed to allow for the easiest possible upgrade to BHB. Whenever a single bus configuration is used, it should be designed to allow for the easiest possible upgrade to a ring-bus and ultimately BHB. A substation might initially be constructed as a straight bus with two or three elements, later developed into a ring bus with four or five elements, and finally upgraded into the ultimate BHB configuration with six or more elements. The conversion would be relatively easy if the basic BHB layout was used during all stages of substation development.

Xcel Energy standard configurations are described in the sections below. They are listed in order of increasing cost and (what is generally agreed to be) increasing reliability and operational flexibility. Table 1 gives standard substation switching configurations for each voltage level. Each substation project must be considered on an individual basis to confirm that the standard configuration is the best. In all cases other than double breaker-double bus (DBDB), the substation should be configured and laid out to allow for expansion to an ultimate BHB.

Standard Transmission Substation Configurations

Number of ultimate elements/positions	69kV	115kV	230kV	345kV
2	SB	SB	SB	SB
3	SB	SB or RB*	RB or BHB	RB or BHB
4	SB Variation	RB or BHB	RB or BHB	RB or BHB
5	SB Variation	RB or BHB	RB or BHB	RB or BHB
6	SB Variation	RB or BHB	RB or BHB	RB or BHB
7+	SB Variation	BHB	BHB	BHB

Table 1

*Note1: SPP requires all TO's in the SPP footprint to use a RB configuration for voltages of 100kV and above with 3 or more elements. SPS must comply with this requirement.
Note 2: 138kV and 161kV voltages follow the 115kV column configurations

2.5.1. Single Bus (SB)

In the single or straight bus configuration, all of the lines and transformers are connected to a single bus. There is one circuit breaker or less per line or transformer. The single bus configuration is the simplest and least expensive configuration, as it has the fewest number of circuit breakers and switches and the smallest footprint. It is also the least reliable and least flexible configuration. For instance, a fault on the bus will lead to an outage of the bus and the disconnecting of all of the elements connected to it. Bus maintenance work also requires a multi-terminal outage.

The SB scheme is used for almost all 69kV substations. The reason for this is due to the added complexity associated with the relay scheme with the other configurations. There are many variations on the single bus scheme. One type of single bus substation is the tap configuration in which a transmission line is connected to the substation through a radial tap. In this scheme, the line does not go through the substation. The substations at each end of the line provide the protective relays and circuit breakers for the transmission line. The tap configuration is typically used in single transformer or capacitor bank situations. An SB scheme variation is abbreviated as “SB Variation” in Table 1.

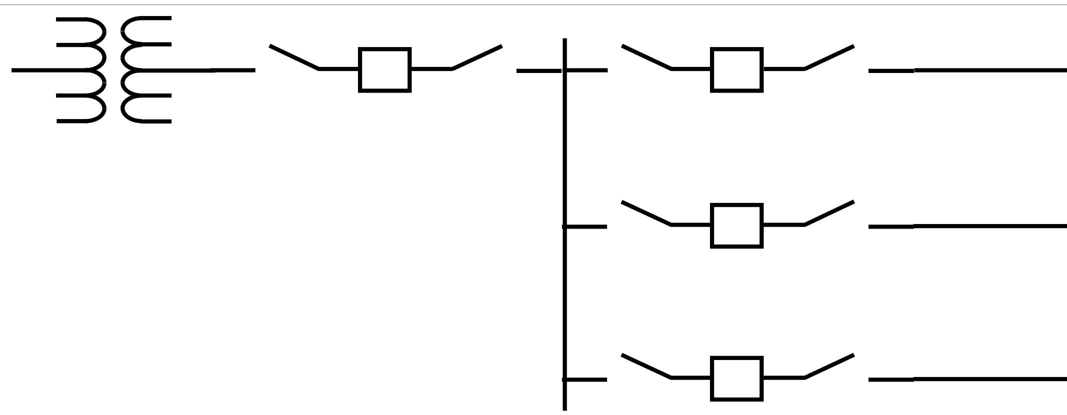


Figure 1: Single Bus

2.5.2. Main and Transfer Bus (MTB)

The main and transfer bus configuration is similar to the SB design, in that all of the lines and transformers are connected to the main bus. The MTB is considered a SB variation, as noted in Table 1. However, the MTB layout also features a transfer bus and transfer breaker, which provides much greater operational flexibility. For instance, a line breaker can be taken out of service without a line outage, because the line may be connected to the transfer bus and fault clearing can be provided by the transfer breaker. The main and transfer bus configuration is higher in cost than the single bus configuration, as it generally requires an additional circuit breaker, additional bus, and more disconnect switches. The reliability of the MTB is similar to that of the SB scheme, since a bus fault will still cause a complete bus outage and the disconnection of all the elements connected to the bus. Care must be exercised in operating the disconnecting switches in the proper sequence when transferring loads between the main and transfer buses. For added security, they may be interlocked to prevent opening under load. The MTB configuration is not commonly used for new transmission substations. An existing sub that is expanded may result in a MTB design.

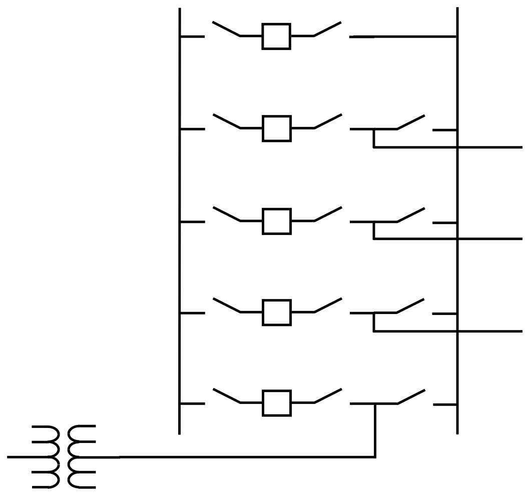


Figure 2: Main and Transfer Bus

2.5.3. Ring Bus (RB)

The ring bus is a common configuration for transmission substations. It is used when there are not enough lines or transformers to justify a BHB. Substations with up to six circuit breakers may be laid out in a RB configuration.

The ring bus configuration has considerable advantages in reliability and flexibility compared to the SB and MTB schemes. It is more flexible, as it allows opening of one circuit breaker at a time without de-energizing a line or other element, and with no loss of protection. It is more reliable, as a fault on one section of the bus can be isolated and cleared at just that section, and does not require de-energizing the entire bus. However, once one circuit breaker has been opened, the flexibility and reliability of the configuration is significantly reduced.

A line disconnect switch is required on all transmission line terminal positions connected to a ring bus configuration at voltages of 115kV, 138kV, and 161 kV. For voltages at 230 kV and higher, a case-by-case approval from the Director of Engineering is required based on the cost and reliability benefit of installing the switches at the prospective site. Once the ring bus has been converted to a breaker and a half configuration, no other line disconnect switches need to be added. The existing line disconnect switches do not need to be removed. The purpose of the line disconnect switch is to allow the adjacent circuit breakers to be closed in order to complete the ring after the faulted line has been disconnected. When line disconnect switches are installed, MOD's with SCADA controls will be installed.

The number of circuit breakers in a RB configuration equals the number of positions and each position shares two circuit breakers. Each position normally consists of one element. Compared to SB, the RB configuration has more bus work, potential transformers, and control and relay requirements. The RB is presently used for transmission substations 115kV and above.

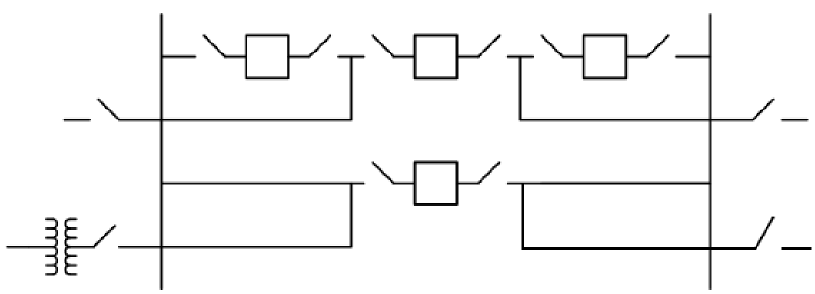


Figure 3: Ring Bus

2.5.4. Breaker-and-a-Half Bus (BHB)

The breaker-and-a-half bus configuration is the standard design for large yards at 115kV and above. A new substation configuration with six or more circuit breakers is built as a BHB. A BHB row provides for two line or transformer positions using three circuit breakers (1½ per element or position) located between two main buses. The two-main buses of the BHB design can be expanded as needed to serve more elements than the standard RB configuration.

The BHB scheme is a more expensive standard configuration than the RB since it requires 1½ circuit breakers and three switches per element (the RB only requires one circuit breaker and two switches per element).

Although more expensive, the BHB has significant advantages in flexibility and reliability. With a circuit breaker out for maintenance, each circuit still has breaker protection (same as in the RB scheme). However, in the BHB scheme with a circuit breaker out, a fault on a line can be cleared without affecting any adjacent elements. In the RB scheme, depending on which circuit is faulted, this may not be the case. Additionally, the BHB allows for multiple circuit breakers to be taken out of service simultaneously, with almost no loss in reliability, as long as they are not located in the same row.

For BHB substations, special attention needs to be given to the layout to ensure that equipment can be accessed for maintenance purposes. This may require additional drive aisles within the substation. When the ultimate layout requires only a six-position configuration, a fourth row shall be added for maintenance purposes.

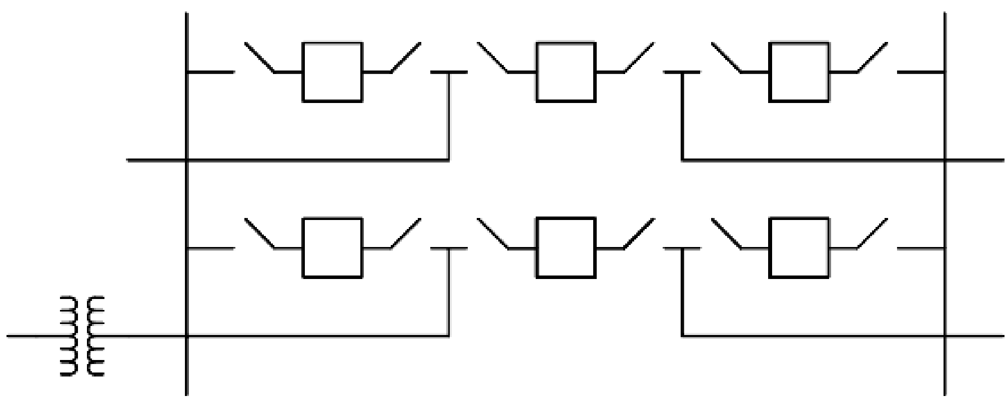


Figure 4: Breaker-and-a-Half Bus

2.5.5. Double Breaker – Double Bus (DBDB)

The double breaker–double bus configuration is the most expensive of all the standard configurations since it requires two circuit breakers and four switches per circuit element. However, in return for this high cost, it provides the best service reliability, continuity, and flexibility. A circuit breaker or bus may be taken out of service at any time without loss of circuit protection, and the remaining circuit breakers do not carry the load of more than one circuit. Thus, no circuit breaker operation can affect more than one circuit. This configuration is used only in the most critical locations, such as generating plant switchyards.

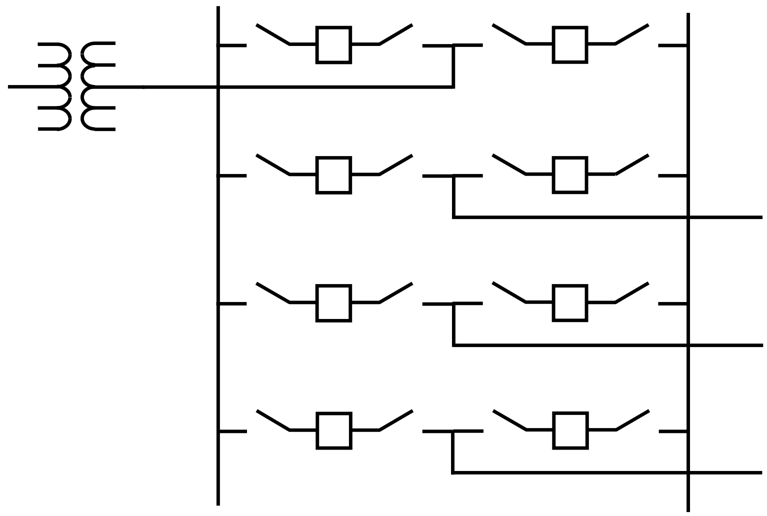


Figure 5: Double Breaker-Double Bus

2.5.6. Element Positions

When choosing a substation configuration, the number of elements to be connected (e.g. transformers, lines, VAR support) should be defined for the initial build and what is known or reasonably expected for future expansion. These elements may include autotransformers, distribution transformers, transmission lines, capacitor banks, or shunt reactors. Each element should be provided with a dedicated position in the substation configuration. However, Transmission Planning may dictate when an element can be installed on the bus, provided the element can be configured into a row position and removed from the bus during future expansion. The following sections elaborate on which elements shall be installed in a dedicated position versus allowing for installation on a bus position.

2.5.6.1 Auto-Transformer Positions

Auto-transformers shall be installed between breaker-positions in ring-bus and breaker-and-a-half configurations.

2.5.6.2 Shunt Capacitors and Reactors Positions

Shunt capacitors and shunt reactors should also be installed between breaker-positions in ring-bus and breaker-and-a-half configurations. However, these elements may be installed on a bus position, with an accompanying circuit breaker or interrupter, if Transmission Planning dictates. Primary consideration for not allowing installations on a bus is due to the inability to take an outage on the bus in order to maintain the associated interrupting device.

Multiple capacitor banks may also be installed from a single element position. This determination should be made by Transmission Planning's understanding of what the system can tolerate with a loss of the position.

2.5.6.3 Distribution Transformers Positions

Distribution transformers, along with a high-side manual or motor-operated disconnect switch, shall be installed between breaker-positions in the ring-bus and breaker-and-a-half configurations. In addition, a transformer high-side interrupting device shall be installed so that the distribution equipment can be removed from service without causing interruption to the transmission system (see next section for exceptions). A high-side interrupting device shall always be installed when a distribution transformer shares a position with a line termination.

2.5.6.4 Exception Process for Installation of a High-Side Transformer Interrupting Device

It is generally accepted, from a non-discriminatory access standpoint, that any transmission connected to end use loads will adhere to Xcel Energy Company's Interconnection Guidelines for Transmission Interconnected Customer Loads whether they be for 3rd party interconnections or for internally generated interconnections.

Therefore, as an interim process, prior to exceptions on projects being made from the Interconnection Guidelines document, guidelines are established and shall be adhered to for new capital substation projects.

For capital substation projects where a new power distribution transformer equal to or greater than 14MVA is to be installed, the following guidelines should be adhered to unless an acceptable documented exception to the guideline is provided. The documented exception should be provided upon creation of the Scoping Estimate or soon thereafter, but well before the Appropriation Estimate package is developed.

1. If installing a new distribution power transformer, then a new interrupting device is to be installed on the high-side of the new transformer.
2. If upgrading an existing distribution power transformer to a larger (increased MVA) transformer, then a new interrupting device is to be installed on the high-side of the new transformer.
3. If replacing an existing distribution power transformer with a similar size (same MVA) transformer, then a new interrupting device does not need to be installed on the high-side of the new transformer.

4. If there is no associated transformer installation or replacement, then it is not necessary to address the installation of a new interrupting device for any existing transformer.

For each of the exceptions listed above, an associated high side, motor-operated disconnect switch is also to be installed.

This policy provides internal consistency with Xcel Energy's Transmission-to-Load Interconnection Guidelines which require an interrupting device on the high voltage side of the transformer. The latest interconnection guidelines would not apply to existing installations which would be grandfathered into a blanket agreement. However from a FERC perspective, transformers upgraded to a higher capacity would necessitate a new interconnection agreement with Xcel Energy and would also need to adhere to the Transmission-to-Load Interconnection Guidelines.

2.6. Outages

All substation designs should take into consideration the required outages to build and maintain the facility. Construction of temporary facilities or staged construction planning may be required to minimize outages. Outage planning should be carried out well in advance with System Operations. All outages need to be reviewed by system protection in advance to maintain the integrity of protection for all lines and devices that remain in service during an outage.

If it is known or expected that new equipment will be added in the near future, switches may be added on the initial installation to avoid future bus outages. This is applicable in ring bus or breaker-and-a-half designs as well as for distribution system transformer switches and bus-tie switches.

2.7. Environmental Conditions

There may be significant differences in environmental conditions between various sites. Substation designs must be compatible with the environmental characteristics of the facility location. Table 2 gives typical design parameters for various regions. Particular sites within a given region may have different environmental conditions than that given in Table 2. Additional environmental conditions for calculating bus conductor ampacity are located in Table 7.

Environmental Design Criteria

	CO	MN/WI (South)[1]	MN/WI (North)[1]	NM	TX
Design Temperature Range (°C)	-40 to 40	-40 to 40	-50 to 40	-30 to 40	-30 to 40
Design Ice Loading[2] (inches, radial loading)	1 in	1 in	1 in	1 in	1 in
Elevation above mean sea level (feet/meters)	Min. design criteria is 5,900 ft (1800 m) Use 11,000 ft (3353 m) elev. at sites >8,500 ft (2591 m)	<3300 ft (1006 m)	<3300 ft (1006 m)	>=3700 ft (1128 m)	>=3700 ft (1128 m)

[1] The division between MN/WI north and south is roughly defined as the east-west line running between St. Cloud, MN and Eau Claire, WI.

[2] For issues related to structural design, including regional seismic zones, refer to the Civil/Structural Design Criteria.

Table 2

The existence of any unusual environmental conditions should be considered at each substation site. These conditions may include corrosive fumes or vapors, explosive mixtures of dust or gases, steam, magnesium chloride spray, and salt spray.

2.7.1. Snow Accumulation

For substation installations in regions where very high snow depths and severe wind drifting of snow may inhibit substation entry/exit or equipment access, a determination must be made, based on factors such as frequency of deep-snow events, critical maintenance areas, and work practices whether extra design considerations are required. Consulting local operations and maintenance personnel to provide guidance on local snow accumulations is recommended. Typical industry practices include elevating bus heights, junction boxes, and switch operators, as well as installing a Dutch pedestrian gate adjacent to the main gate. Additional warning signs may also be installed.

2.8. Governmental/Regulatory Requirements

2.8.1. SF6

Sulfur Hexafluoride (SF6) is an effective gaseous dielectric widely used in electric transmission equipment. SF6 is used in gas-insulated switchgear and bus and is the industry-preferred dielectric and interrupting medium for transmission circuit breakers. SF6 is also a potent and long-lived greenhouse gas.

Xcel Energy policy is to minimize SF6 emissions through recycling and avoidance of leakage. SF6 pressure in equipment is normally monitored via a pressure switch. Equipment to be purchased should be evaluated for its track record with respect to SF6 leaks and for the quantity of SF6 it requires. Besides its environmental effects, circuit breakers with SF6 leaks have higher maintenance costs, and, if undetected, could cause system contingencies.

The use of SF6 insulated equipment should be avoided if good non-SF6 alternatives, such as vacuum insulated equipment, are available.

2.8.2. PCBs

Polychlorinated Biphenyls (PCBs) are man-made chemical compounds with excellent flame retardant and insulating properties. PCBs also pose numerous health risks for humans and wildlife and are not biodegradable. Although PCBs were banned in the U.S. in 1977, they were often added to the oil used in electric equipment from the 1920s until the 1970s. New equipment and mineral oil does not contain PCBs, but equipment containing PCB fluid is still in operation in many substations.

Xcel Energy guidelines and EPA regulations define how oil-filled equipment is to be labeled, handled, documented, and disposed. According to Xcel Energy guidelines, equipment containing oil with PCB concentrations less than 45 ppm is classified as non-contaminated. Equipment containing oil with PCB concentrations between 45 and 450 ppm is defined as “PCB Contaminated.” Equipment containing oil with PCB concentrations of 450 ppm or greater is defined as “PCB Equipment” and stringent regulations govern its use. These Xcel Energy-defined thresholds are more stringent than the EPA figures of 50 and 500 ppm to allow for inaccuracies in the test. For projects involving PCB equipment, current information on policies for handling PCBs should be obtained from the Environmental Services department.

2.8.3. Oil Containment

EPA regulations address requirements for oil Spill Prevention Control and Countermeasure Plans (SPCC Plans) and Facility Response Plans (FRPs). The goal of the SPCC rule is to prevent oil discharges from reaching navigable waters and to ensure effective responses to oil discharges. The rule also requires that proactive measures be used in response to oil discharges.

For projects at new or existing substations, a site-evaluation should be conducted to determine the potential environmental consequences of oil discharges and to evaluate the need for oil containment. Current information on Xcel Energy SPCC policies should be obtained from the Environmental Services department. Criteria for oil spill containment are given in the civil/structural design criteria XEL-STD-Criteria for Eng & Design of Civil & Structural Performance

NOTE: Care should be taken when designing oil containment for equipment that is located adjacent to other equipment needing a containment system for fire safety concerns and common system designs.

Containment facilities can include oil-containment berms, pits, curbs, or similar facilities. Containment can be designed for specific individual equipment or as a whole-site oil control. Engineering should work with Environmental Services department to determine the level of oil containment that will be required for each site. Civil and Electrical Engineering should also work together to determine the best type of oil containment for the site as what may be obvious to one group, may not be feasible or ideal for the other. IEEE 979 and IEEE 980 may also be useful references.

2.8.4. Asbestos

"Asbestos" is a term used to describe six naturally occurring fibrous minerals: chrysotile, amosite, crocidolite, tremolite, anthophylitte, and actinolite. Of these, the forms that were most commonly used are chrysotile (white asbestos), amosite (brown asbestos), and crocidolite (blue asbestos). Asbestos is strong, insulates well, and resists fire and corrosion and for these reasons, it has been used in hundreds of products. Asbestos is used in many forms, including raw form, yarn, cloth, felt, tape, wick packing, paper, millboard, and cement.

Asbestos became popular in the United States in the early 1900s. Its period of greatest use was from the 1940s to the 1970s. In the 1960s, evidence began to emerge of lung cancer, asbestosis, and other health risks associated with the inhalation of asbestos. The use of asbestos is not banned, but it is seldom used by American industry because of health and liability concerns. There is an international market for asbestos, however, and imported materials may still contain asbestos. Laboratory tests are the only way to conclusively identify asbestos.

Asbestos products are not being used with any new installation work, but it may exist in existing substations. Some of the common uses of asbestos are thermal pipe and boiler insulation, fireproofing, soundproofing, floor coverings, ceiling tiles, roofing materials, and transite pipe, transite conduit, and sheeting. For substation projects, some places to look for asbestos include: fireproofing and insulation for buildings, cables and pipes, electrical cloth and tape (e.g. tape wrapped around feeder cables), electrical equipment enclosure panels and partitions, and floor tiles.

Regulations govern asbestos removal and demolition for renovation projects that involve asbestos. Asbestos abatement must be performed in existing facilities if the asbestos will be disturbed as part of the project.

2.8.5. Mercury

Mercury is used in thermometers, barometers, diffusion pumps, and many other devices. It is used as a liquid contact for mercury switches, and it is used in mercury cell batteries and other electrical apparatus. Gaseous mercury is used in mercury-vapor lamps and advertising signs. Mercury is also used in some industrial processes. Exposure to mercury or its compounds can cause severe health problems. Mercury is an environmental pollutant in areas where industrial or agricultural waste can reach waterways. Numerous federal and state regulations govern mercury and its release into the environment. The use of equipment containing mercury in substations is to be avoided. Examples of where mercury may be found in substations include mercury switches and some Buchholz relays from European manufacturers. Mercury will be removed from substations where practical.

2.8.6. Noise

Normal substation operation produces continuous audible noise, impulse audible noise, and radio frequency noise. Of these, continuous audible noise is the most noticeable and is the most likely to be subject to government regulation. All new and expanded substations will be designed to comply with the sound level requirements for the jurisdictions in which the facility is located. Colorado Title 25, Article 12, is an example of local noise ordinances. This may be accomplished via specifications for the operating equipment (primarily transformers), additional setback distances, enclosures, barriers, or a combination thereof. Complaints raised about existing substations should be handled on a case-by-case basis. When a local permitting authority calls for more extensive treatment than required by state authority, reimbursement will be sought from the permitting authority for the added costs. Refer to IEEE 1127 for additional information with regard to design of substations for acceptance by the community.

2.8.7. Aesthetics

A permitting authority may place aesthetic constraints on new or expanded substation development. In these cases, these requirements will be followed within reason (as determined by Substation Engineering, Siting and Land Rights, and the Community Relations departments). When a permitting authority requires more extensive treatment than considered reasonable, reimbursement will be sought from the permitting authority for the costs to install the extra aesthetic treatment.

2.8.8. Electric and Magnetic Fields

Electric and magnetic fields decrease rapidly with distance, and are typically minimal at the fence lines of a substation. Although there are regulations regarding the strength of electric fields in public areas, these typically do not present design constraints on transmission substations. There are currently no design constraints on substations due to electric and magnetic fields.

Strong magnetic fields can occur with air-core reactors. This must be taken into consideration in the design for the installation of this type of equipment, such as with the spacing, structures, internal fencing, grounding, and foundations. The strength of the magnetic field around a reactor should be coordinated with the manufacturer to ensure that the magnetic fields do not cause problems for adjacent equipment or impose a danger to personnel in the vicinity of the reactors.

2.9. System Modeling and Analysis

The standard tool for calculating fault currents is CAPE (Computer Aided Protection Engineering).

The standard tool for carrying out transient analysis studies is Alternative Transients Program / Electromagnetic Transients Program (ATP/EMTP). It is recommended that transient analysis studies be performed when large capacitor banks or shunt reactors are to be installed. In addition, transient analysis studies may also be appropriate when major expansions are planned to the system or when interconnections to another utility are required.

3 Project Criteria

Multiple voltages listed in the tables below, indicated by asterisks, are legacy systems existing today. Those are generally not considered standard voltages for future installations.

3.1. Transmission System Voltages

Standard Transmission System Voltages

Nominal Voltage (kV)	NSP Region Standard	PSCo Region Standard	SPS Region Standard
34.5	Yes	No	No*
46	No	No*	No
69	Yes	Yes	Yes
88	No*	No	No
115	Yes	Yes	Yes
138	No	Yes	No
161	Yes	No	No
230	Yes	Yes	Yes
345	Yes	Yes	Yes
500	Yes	No	No

Table 3

3.2. Distribution System Voltages

Standard Distribution System Voltages

Nominal Voltage (kV)	NSP Region Standard	PSCo Region Standard	SPS Region Standard
2.4	No*	No	Yes
4.16	No*	Yes	Yes
7.2	No	No	Yes
12.0	No	No	Yes
12.5	Yes	Yes	Yes
13.2	No	Yes	Yes
13.8	Yes	Yes	Yes
22.9	No	No	Yes
23.9	Yes	No	No
24.9	No*	Yes	No*
34.5	Yes	No	Yes

Table 4

3.2.1. Regional Variations

In the PSC region, the distribution system uses a 13.2kV standard voltage instead of 13.8kV. One reason for this is insulation coordination. As noted elsewhere in this document, BIL must be derated at higher altitudes. When the insulation of 14.4kV-rated electrical equipment is derated for the elevations in the PSC region, it is not adequate for use on a 13.8kV operating voltage.

3.3. Electric Phase Rotation and Phase-Angle Relationships

All transmission voltages in the system are in phase electrically within an interconnected grid. In the United States, there are three main power grids or interconnections (Eastern, Western, and Texas/ERCOT), and these grids are not currently synchronous. Xcel Energy has transmission facilities in both the Eastern and Western Interconnects. PSCo is in the Western Interconnect. SPS, NSPM, and NSPW are in the Eastern Interconnect.

The phase-angle relationship between transmission and distribution voltages varies throughout the system, and must be verified for each location. In the Denver and northern front range portions of the PSC region, the distribution voltage typically leads the transmission voltage by 30°. Standard transformers (i.e. primary leads the secondary by 30°) are used, but they are connected in the substation such that the secondary leads the primary.

Care must be taken to make sure that the phase-angle relationship between all facilities affected by a project is known and is accounted for in the project design.

4 Outdoor Electrical

4.1. Transmission Substation Physical Arrangement

4.1.1. Outdoor Open-Type Air-Insulated Bus-and-Switch Arrangement

The Xcel Energy standard transmission substation structure is the conventional outdoor open-type air-insulated bus-and-switch arrangement. Standard structure design is low profile. Box structure designs exist in many substations and this type of design may be continued when modifying these substations or when required by space limitations or other constraints.

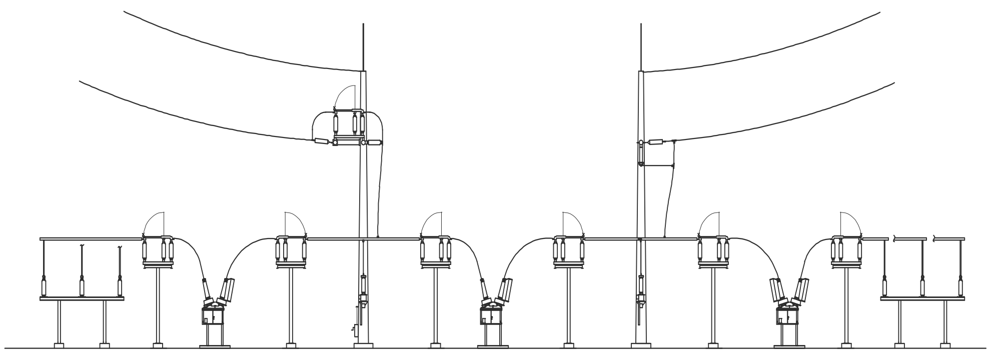


Figure 6: Example of Low Profile Substation

Steel is the standard material for all substation structures. Wood pole designs are discouraged for new installations because wood is less reliable, has a shorter life, requires more maintenance than steel, and may be less rigid causing switches to come out of adjustment. Wood structures typically have a lower installed cost than steel, however, and should be considered for temporary facilities. Refer to XEL-STD-Criteria for Eng & Design of Civil & Structural Performance and XEL-STD-EMS-J.08-001-OUTDOOR HIGH-VOLTAGE AIR

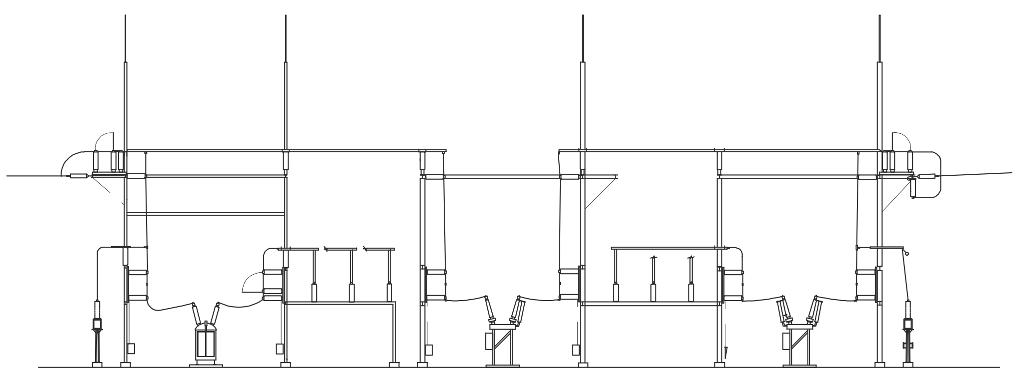


Figure 7: Example of a Box Structure Substation

SWITCHES AND OPERATING MECHANISMS for more details.

4.1.2. Gas-Insulated Substation

The SF6 gas-insulated substation is an alternative that may be considered in special cases. In the gas-insulated substation, all of the components and bus work are enclosed in SF6-filled compartments. The use of gas, instead of air, as the insulating medium allows the spacing and clearances to be significantly reduced, so that the substation requires a much smaller footprint. Additionally, the substation can be housed inside a building, which is generally considered an aesthetic improvement over visible bus work and equipment. The gas-insulated substation also provides protection from environmental factors such as pollution, salt, and snow.

The SF6 gas-insulated substation is not an Xcel Energy standard, and should only be considered where required by technical or permitting limitations.

4.2. Distribution Substation Physical Arrangement

The two Xcel Energy standard physical arrangements for distribution substations are metalclad switchgear and outdoor open-type air-insulated bus-and-switch arrangements. Xcel Energy typical configurations are described in the sections below. The type of structure to be used in a given substation is defined in the distribution planning philosophy document (XEL-STD-B.01-001-PHASE I DESIGN.pdf and XEL-STD-B.01-002-PHASE II DESIGN design documents). The selection will be based on factors including initial and ultimate substation loading, system voltage, switching configuration and requirements, and substation location. Refer to the distribution planning criteria for more information on distribution substation configurations.

4.2.1. Outdoor Open-Type Air-Insulated Bus-and-Switch Arrangement

Xcel Energy standard distribution substation arrangements include the conventional, outdoor, open-type, air-insulated, bus-and-switch arrangement. The standard structure design is box structure. In open-air type designs, the switches, circuit breakers, and bus connections are open and visible, making them easier to monitor and repair than switchgear configurations. Open-air designs can be configured for overhead or underground terminations. Adding additional feeder bays to a box structure lineup is a straightforward process. Therefore, it is standard practice to construct the feeder bays as they are needed.

Steel is the standard material for substation structures. Wood pole designs are discouraged for new installations because wood is less reliable, has a shorter life, and requires more maintenance than steel. Wood structures typically have a lower installed cost than steel, however, and should only be considered for temporary facilities. Refer to the sections below, as well as the civil/structural design criteria for more details.

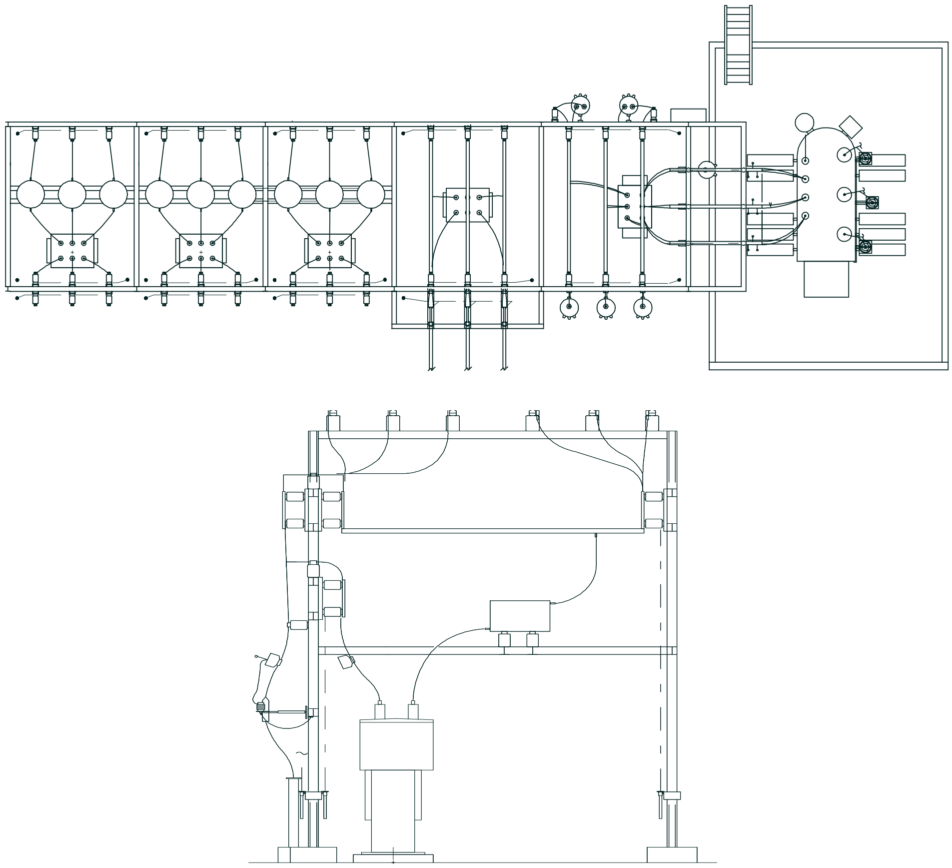


**Figure 8: Example of an NSP, Standard, Open-Type Air-Insulated Bus-and-Switch Arrangement.
Top picture is Plan View of Transformer and Distribution Bus Section
Bottom picture is Section View of Feeder Bay.**

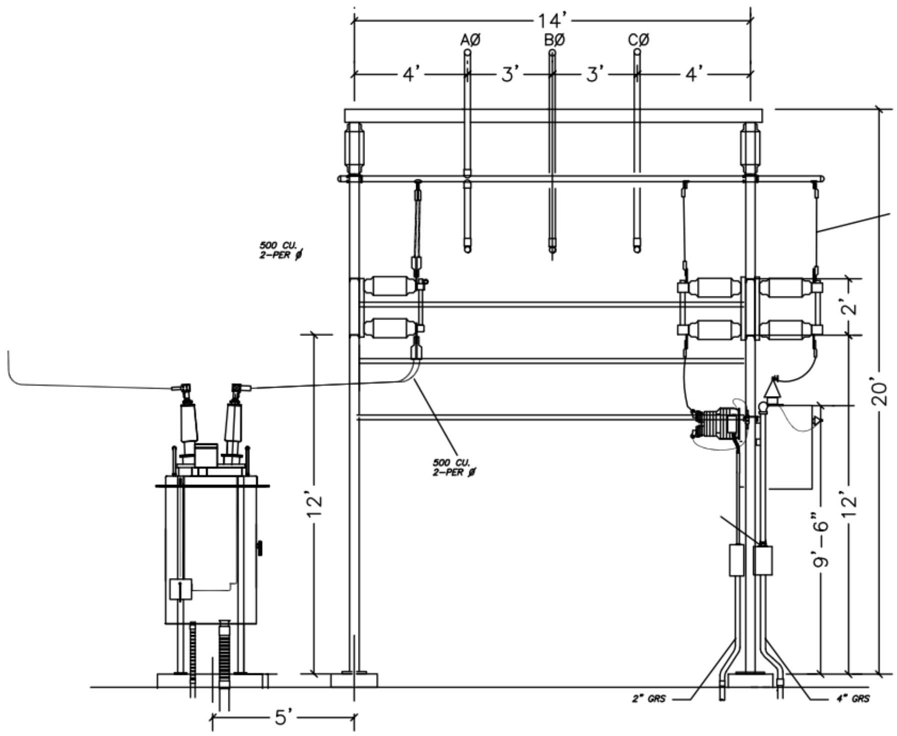


Figure 9: Example of an PSCo, Standard, Open-Type Air-Insulated Bus-and-Switch Arrangement.

4.2.2. Main and Transfer Bus

The main bus/transfer bus (MTB) design is used mainly for open-air distribution substations with a maximum firm capacity of 45 MVA and an ultimate installation of two 28 MVA transformers, bus regulators, (or individual feeder regulators) and transformer load-break switches. Regulators are not needed when the transformers are provided with a Load Tap Changer, and transformer circuit breakers can then be installed in the space provided for bus regulators. The MTB substation configuration has been used in the past for 69kV transmission substations in the NSP regions, and for 230kV and below in the PSC and SPS regions. The standard MTB configuration includes two sections but can include up to three. Each section has provisions for a main bus, transfer bus, and three feeders. Each feeder is complete with circuit breakers and switches. A load interrupter switch or circuit breaker can be installed between main bus sections. Feeder exits can be either underground or overhead and can be bifurcated if required. When feeder reactors are required, they should be located between the main bus and the circuit breaker to limit the fault current the breaker will see, as well as the downstream feeder equipment. Feeder regulators are normally installed outside the bay for easier access. For underground distribution, an additional structure may be needed to support the overhead to underground transition points (pot heads) for some designs.

If the substation is in its first stage of development and only one feeder is installed, the transfer bus may be left out and a fused by-pass installed. The Xcel Energy standard MTB configuration is shown in Figure 10 and Figure 11, and Figure 12.

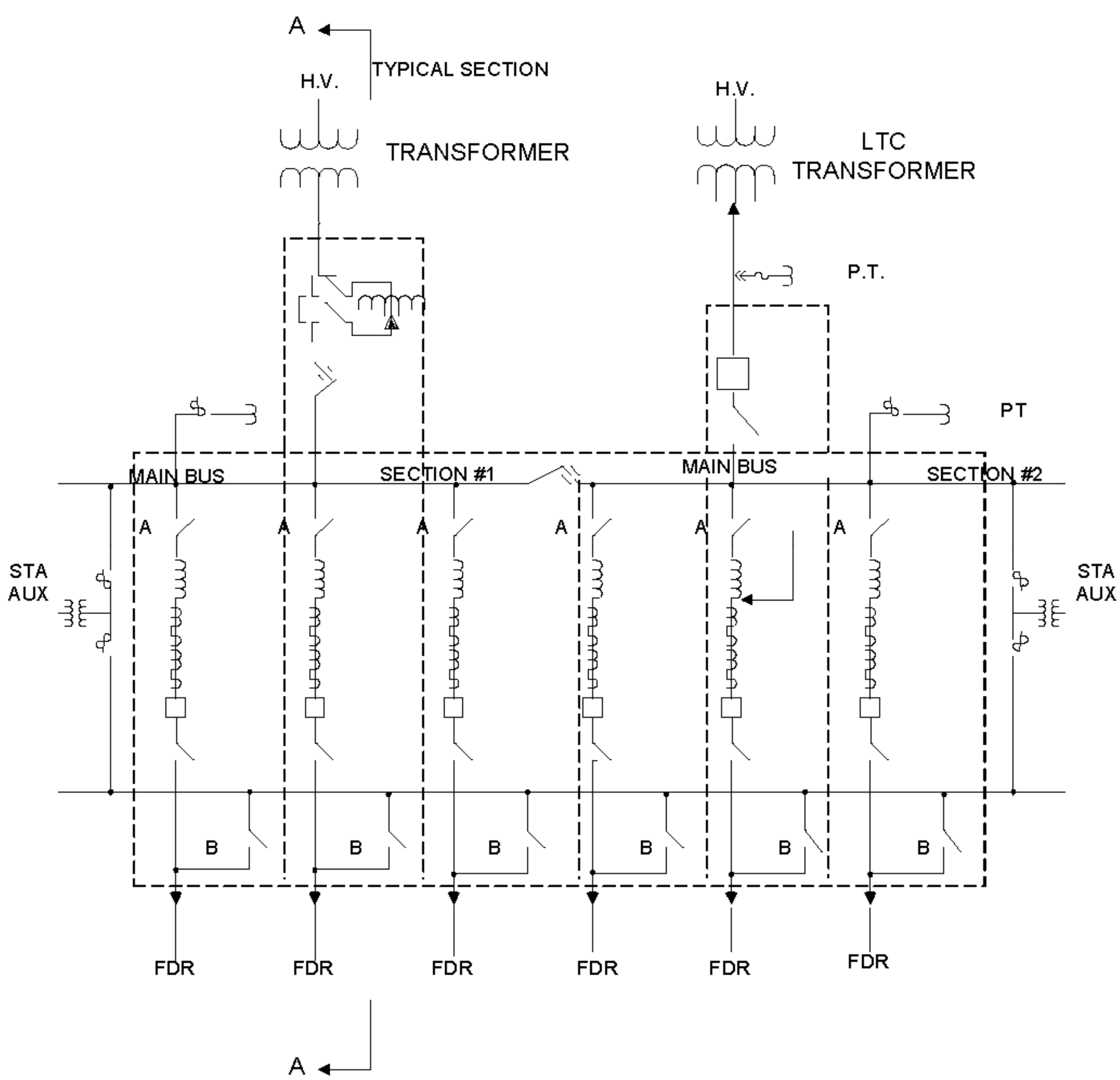


Figure 10: Standard NSP MTB Scheme

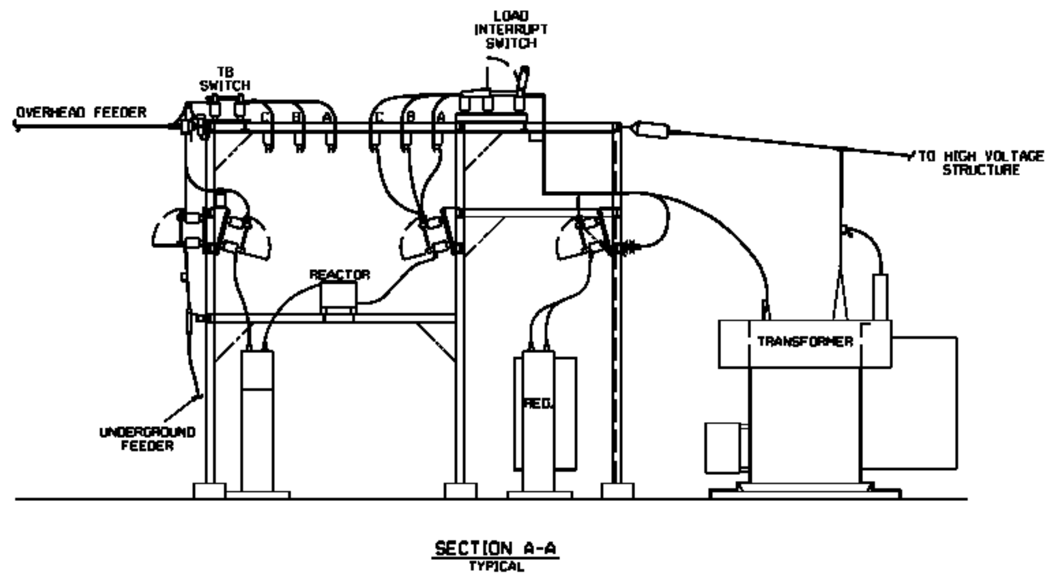


Figure 11: Example of an NSP MTB Scheme

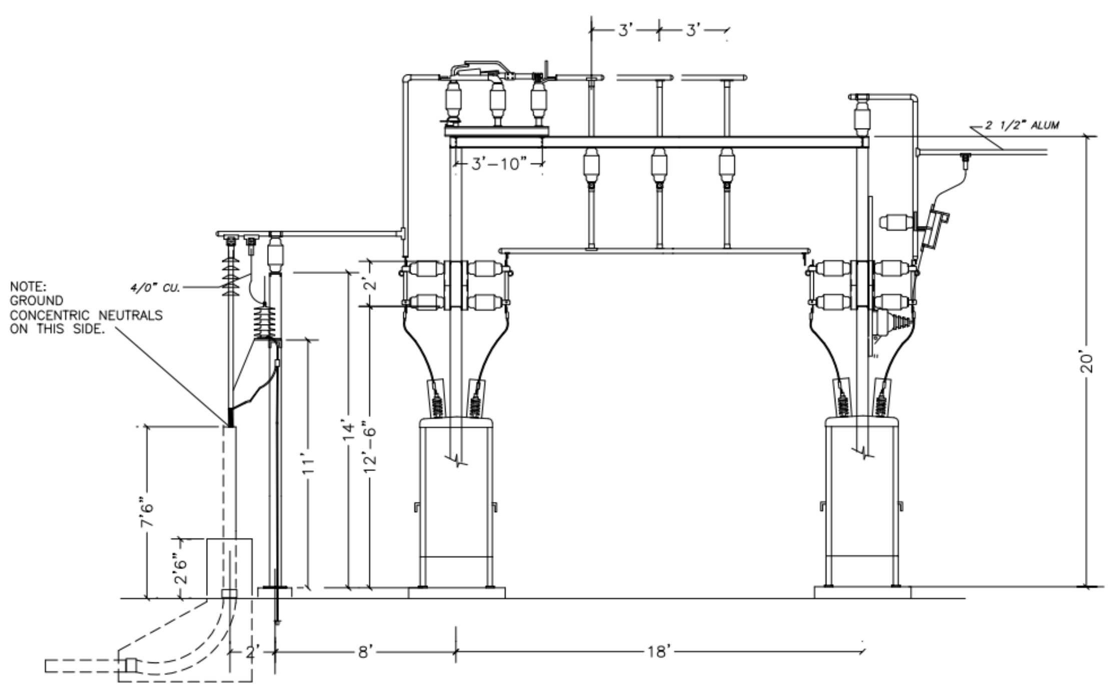


Figure 12: Example of a PSCo MTB Scheme

4.2.3. Tandem Bus Scheme (TB)

The tandem bus scheme design consists of two buses, Main and Tandem, with the same capacity. The main bus can be taken out of service and the entire load switched to the tandem bus. A transfer bus could be used instead of the tandem bus, therefore eliminating the TA switches, but is normally limited to the capacity of the feeder breaker that is serving the bus.

The TB configuration is used for distribution substations 50 MVA and larger with a maximum capacity of 200 MVA. The ultimate installation would include three 70 MVA transformers, transformer circuit breakers, and two bus tie breakers. The use of a TB configuration may also be applied to distribution substations with less than 50 MVA transformers when future capacity increases may be planned or reasonably expected.

There can be up to three bus sections with this design. Each section has provisions for a main bus, tandem bus, and up to 9 feeders. Each feeder may include a circuit breaker, reactors, and switches. Bus-tie breakers and associated switches are arranged to provide maximum flexibility of bus connections. The Xcel Energy standard TB configuration is shown in Figure 13 and Figure 14.

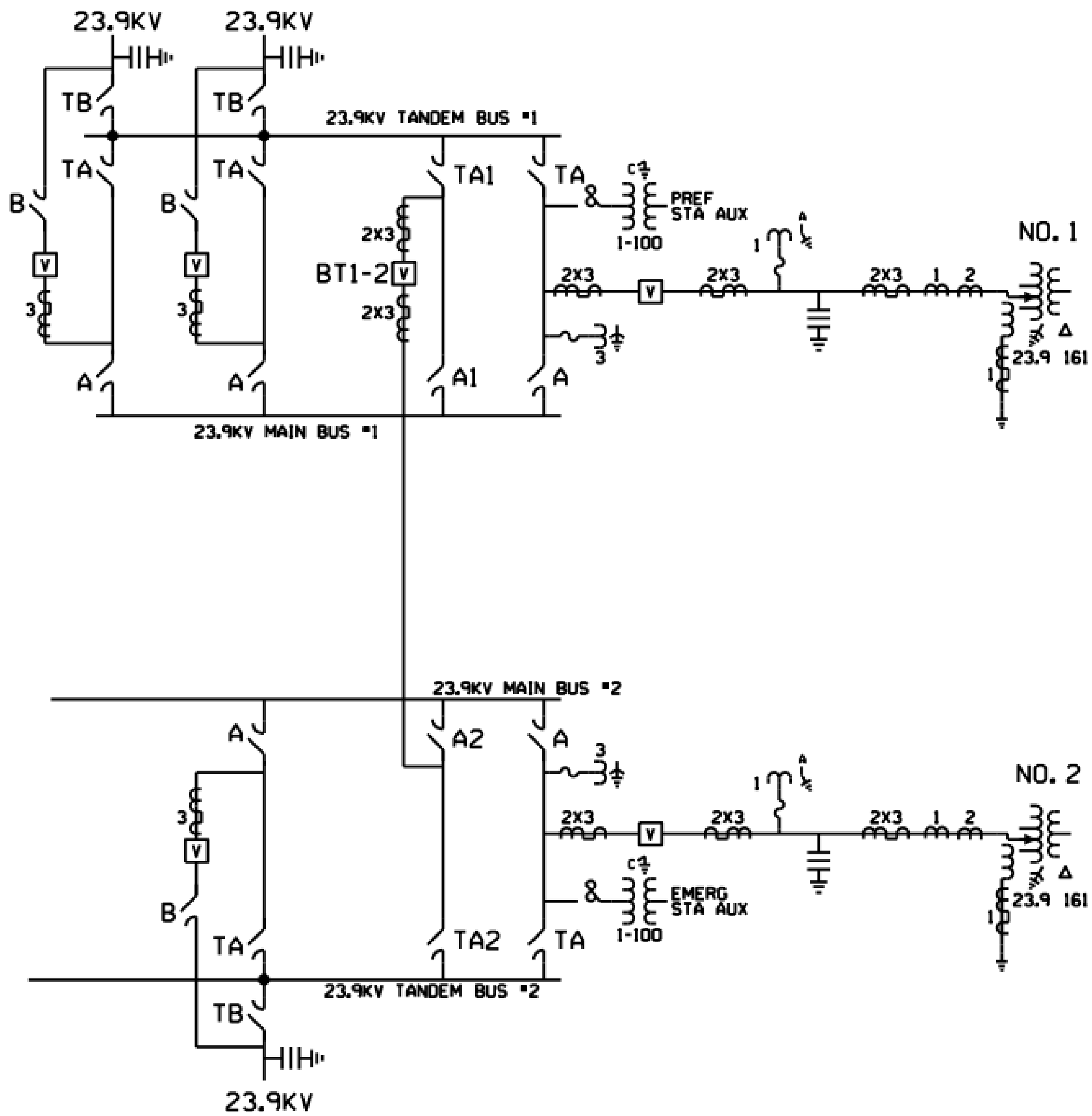


Figure 13: TB Scheme

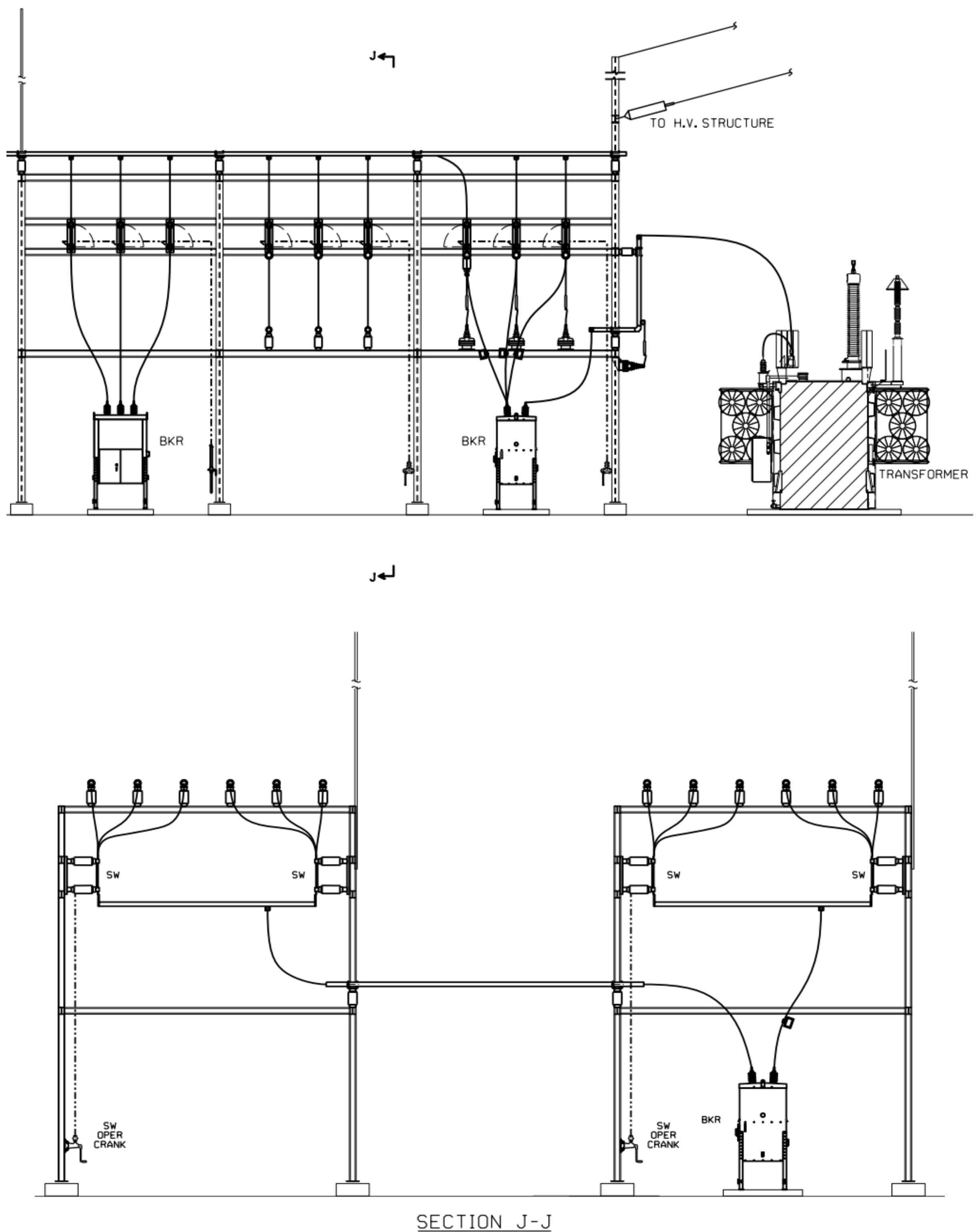


Figure 14: TB Scheme

4.2.4. Metal Clad Switchgear

Metal clad switchgear is one of Xcel Energy's standard physical configurations for distribution substations. Metal clad switchgear is housed in an equipment enclosure, complete with circuit breakers, disconnects, and control and relaying. Switchgear designs have a lower profile than open-type bus and switch arrangements, and have some advantages in the areas of space requirements and aesthetics. Being enclosed, switchgear should experience less outages caused by animals. Switchgear can be used with underground feeder entrances only. Adding additional cubicles to existing switchgear lineups may present difficulties. Therefore, when installing switchgear, it is standard practice to install the ultimate switchgear lineup at the initial construction.

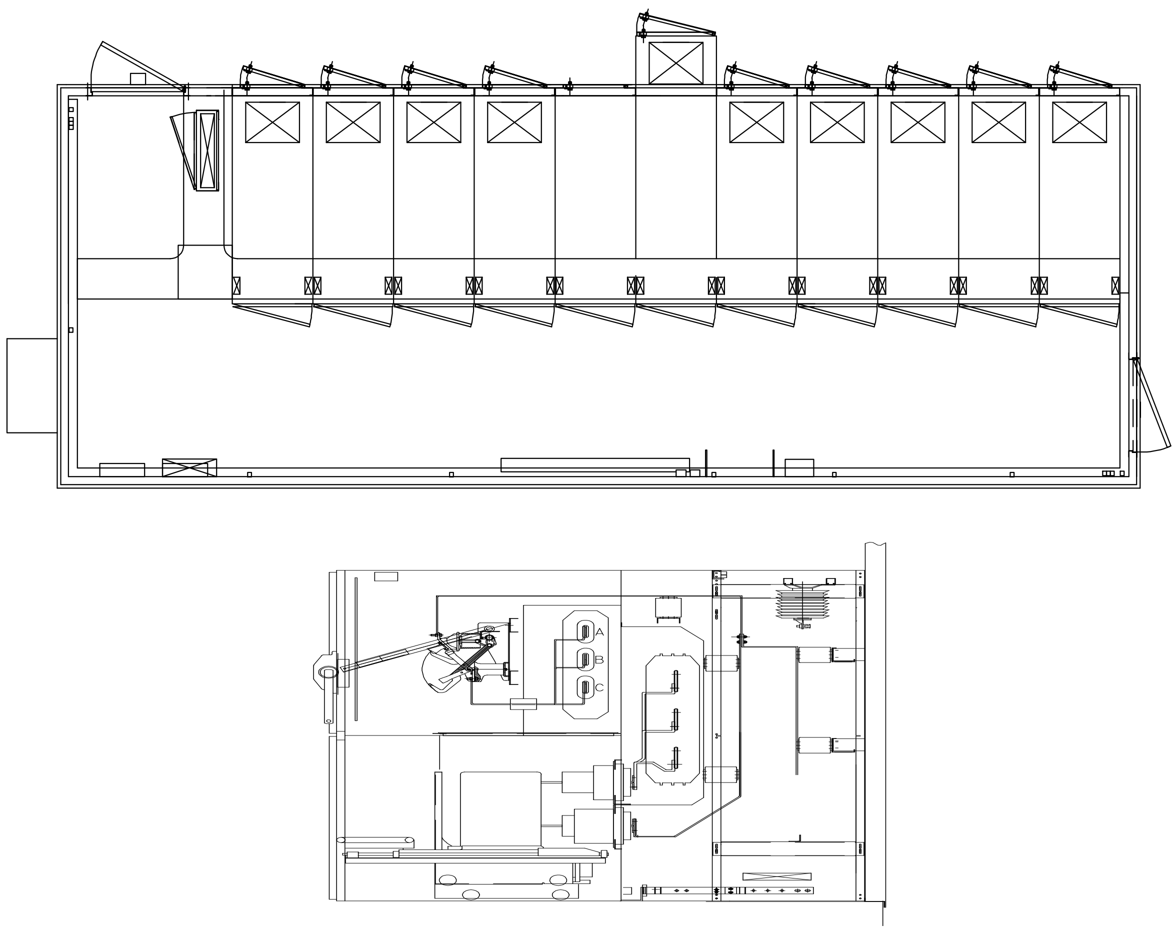


Figure 15: Example of a Metal Clad Switchgear
Top picture is Plan View of Equipment Enclosure and Switchgear Lineup
Bottom picture is Section View of Feeder Cubicle

4.3. Phase Sequence, Bus Arrangement, and Marking

At PSCo and NSP, the standard bus arrangement in substations has “B” phase in the center. The phase sequence required for the transformers may fix the location of “A” and “C” phases. When the transformers or other constraints do not determine the bus arrangement, the preferred bus layout is A-B-C from south to north, west to east, and top to bottom. These standards do not apply to SPS, which uses a “1-2-3” phase designation system.

Variation of the bus arrangement within a substation should be avoided. Variation may be necessary, however, in certain cases, such as substations with three different voltages or where similar three-phase transformers are located with their high voltage sides in opposite directions. Phase markings on equipment and structures consists of capital letters A-B-C, and should be clearly shown on the substation plan drawings.

4.4. Electric Clearances and Spacing

Electric clearance and spacing standards have been established by Xcel Energy for use in substation designs. These clearances meet or exceed NESC minimum requirements. For more information, refer to electrical clearance standards: NSP-STD-ED 4.02.02.01 for NSP, and PSC-STD-Substation Clearance for SPS and PSCo. All substation arrangements will be designed to allow safe maintenance and repair of adjacent equipment.

4.5. Insulation Coordination and Protection

Substation designs must provide for insulation coordination and protection. The first step in insulation coordination is to determine voltage stresses. System transient analysis studies can be performed to determine the amplitude, wave shape, and duration of system voltage stresses. The results will include temporary overvoltages, switching surges, lightning strikes, and longitudinal overvoltages. The results will vary from one substation to the next. Voltage stresses can be reduced by surge arresters and other protective devices, lightning protection (shielding) for substations and lines, grounding designs, air gaps, and other means.

The second step in insulation coordination is to select equipment insulation strength and design protective device/surge arrester applications to protect against expected failure conditions. Transient analysis studies will also aid in determining where surge arresters should be located.

NOTE: All line terminations and transformers (high and low side) should have surge arrestors, regardless of voltage or breaker type. If there are spark gaps on an existing site, they should be replaced at the next project opportunity.

Each OpCo of Xcel Energy has established Standard Basic Lightning Impulse Insulation Level (BIL) ratings and surge arrester ratings. These ratings may not be appropriate for all substations, however, and substation engineering must verify the correct insulation coordination for each substation project.

At elevations above 3000 ft., BIL ratings should not need to be increased, except at 34.5kV, when lightning arresters are also installed. This assumes that the arrester lead length has minimal affect on the protective voltages. Methods for calculating the effect of the arrester lead lengths are available and may be considered for individual projects. At locations where BIL ratings have already been increased due to altitude, future ratings should match.

In the Denver area, there are some “compact” 230kV substations that use 650kV BIL insulation. These are former 115kV substations that have been upgraded to 230kV. There was not sufficient space to build them to the 900kV BIL standard. This “compact” design is not a standard Xcel Energy practice, and should not be repeated except under special circumstances.

4.5.1. Transmission Insulation Coordination

Transmission Substation Standard BILs and Surge Arrester Ratings

Voltage (kV)	BIL (kV)[1]	MCOV(kV)[2]	Duty-Cycle (kV)
13.2	150	8.4	10
13.8[3][4]	150	8.4	10
34.5[3][4][5]	200	22	27
46	250		
69	350	48	60
88	450	57	72
115	550	76	96
138	650	84	108
161	750	106	132
230	900	152	192
345	1300	230	288
500	1550	335	420

(1)The standard BIL refers to external equipment and bus work BIL ratings. Transformers and other equipment sometimes use lower or higher internal BIL levels.

(2)This is the Maximum Continuous Operating Voltage for Metal Oxide Surge Arrester Applications. The standard surge arrester rating may not be correct for all locations. Engineering must verify the rating to use for each substation.

(3)Where surge arresters are installed for transformer delta tertiary windings rated for 13.8kV or 13.2kV, the surge arresters shall be rated for 15.3kV MCOV and 18kV duty-cycle. Where surge arresters are installed for transformer delta tertiary windings rated for 34.5kV, the surge arresters shall be rated for 39kV MCOV and 48kV duty-cycle.

(4) Due to overvoltage during $3I_0$ faults, arresters used on network feeders must have a nominal voltage rating of greater than phase-to-phase voltage (13.8kV)

(5)At elevations of 10,000 ft. and above, a 250kV BIL rating should be assumed.

Table 5

4.5.2. Distribution Insulation Coordination

Distribution Substation Standard BILs and Surge Arrester Ratings

Voltage (kV)	BIL (kV) (1)	MCOV (kV) (2)	Duty-Cycle
2.4	60	2.55	3
4.16	75	2.55	3
7.2	95	8.4	10
12.5	110	8.4	10
13.2(3)(4)	110	8.4	10
13.8(3)	110	8.4	10
22.9	150	15.3	18
23.9	150	15.3	18
34.5(3)	200	22	27
46	250		

(1)The standard BIL refers to external equipment and bus work BIL ratings. Transformers and other equipment sometimes used reduced internal BIL levels.

(2)This is the Maximum Continuous Operating Voltage for Metal Oxide Surge Arrester Applications. The standard surge arrester rating may not be correct for all locations. Engineering must verify the rating to use for each substation.

(3)Where surge arresters are installed for transformer delta tertiary windings rated for 13.8kV or 13.2kV, the surge arresters shall be rated for 15.3kV MCOV and 18kV duty-cycle. Where surge arresters are installed for transformer delta tertiary windings rated for 34.5kV, the surge arresters shall be rated for 39kV MCOV and 48kV duty-cycle.

(4) Due to overvoltage during $3I_0$ faults, arresters used on network feeders must have a nominal voltage rating of greater than phase-to-phase voltage (13.8kV)

Table 6

4.5.3. Regional or Other Variations

By industry standard, insulation ratings are valid for elevations up to 3300 ft (1000 m). At altitudes higher than 3300 ft (1000 m), the rated dielectric strength of equipment and materials is decreased. This is because, at higher elevations, the density and pressure of air is lower and the insulating properties of air are decreased. Altitude correction factors can be found in various industry equipment standards. (One reference is IEEE Std C37.30 IEEE Standard Requirements for High-Voltage Air Switches.) In the SPS region, designs are typically based on >= 3700 ft elevation. In the PSC region, designs are typically based on a 5900 ft elevation.

The standard surge arrester rating may not be applicable to all locations. System parameters such as grounding, line lengths, and normal operating voltage range may require that surge arresters with different ratings be used. Special consideration should be given, or transient analysis studies performed, for surge arrester ratings and applications for EHV systems.

There may be existing substations that deviate from the table above. Such deviations from the table are not necessarily a basis for future designs except as noted. Deviations from standard designs, layouts, or equipment insulation specifications or large additions to the system (e.g. EHV lines, new generation, large capacitor banks) may require transient analysis studies. The output of these studies will aid in the selection of appropriate BIL ratings for a given application.

4.6. Ampacity of Equipment

4.6.1. Standard Ampere Ratings

An important part of the substation design is deciding the ampere ratings of the bus work and equipment. As with the rest of the design, future substation upgrades should be taken into account. System Planning should provide information regarding power flows into the substation for various system transmission line configurations and contingencies and for various future scenarios.

The substation bus conductors should, at a minimum, be sized based on the ampacity requirements of the substation (as provided by Planning). Once the ampacity requirements are determined, switches and circuit breakers will be sized to meet or exceed these ratings when required. In some cases, the determining factor in sizing the bus conductors will be structural and mechanical requirements. For any case, the substation bus conductor and equipment should not limit the capacity of connected transmission line facilities. Exceptions can be approved by Transmission Planning and Operations based on transmission and distribution line load levels.

Table 7 shows the design criteria variables to be used for determining the maximum ampacity ratings of the substation rigid and stranded bus conductors for new designs. Standard ampacity ratings for new rigid bus conductors shall be determined based on the calculation methods provided in IEEE 605-2008, and ampacity ratings for stranded conductors shall be determined using the calculation methods provided IEEE 738-2006.

Design Criteria for Substation Bus Conductor Ampacity Ratings

	NSP	**PSC**	**PSC ≥8500 ft**	**SPS**
Summer Ambient Temp. (Deg. C)	40	40	35	40
Day of the Year	June 21 (172nd day)	June 21 (172nd day)	June 21 (172nd day)	June 21 (172nd day)
Temp. Rise (Deg. C)	45	45	50	45
Bus Temp. (Deg. C)	85	85	85	85
Emissivity Outdoors (*e*)	0.5	0.5	0.5	0.5
Emissivity Indoors (e)	0.35	0.35	0.35	0.35
Absorptivity (*a*)	0.5	0.5	0.5	0.5
Degrees N. Latitude	43	40	40	35
Time of Day	Noon	Noon	Noon	Noon
Atmospheric Conditions	Clear	Clear	Clear	Clear
Elevation	1,100 ft (336 m)	5,900 ft (1800m)	11,500 ft (3506 m)	>=3,700 ft (1128 m)
Wind Speed (ft/sec)	2	2	2	2
Wind Direction	90	90	90	90
Line Orientation	E/W (90˚)	E/W (90˚)	E/W (90˚)	E/W (90˚)

Note 1: For indoor calculations, solar heat gain should not be applied.

Note 2: When wind speeds are zero, forced convection heat loss rate should not be applied.

Table 7

The ratings and criteria provided in the XEL-EXT-Facility Ratings Methodology, Bus Conductor Ampacity Facility Ratings Analysis are not to be used for determining conductor ampacities in new, upgraded or expanded substation designs. The criteria below shall be followed for design purposes.

4.6.2. Regional or Other Variations

At altitudes higher than 3300 ft, the rated continuous current of equipment and materials is decreased. Altitude correction factors can be found in various industry equipment standards. (One reference is IEEE Std C37.30 IEEE Standard Requirements for High-Voltage Air Switches.)

4.7. Transmission Bus Conductor Standard Ampere Ratings

Table 8 gives guideline minimum bus conductor ampacities for transmission substations. It is strongly recommended to use "Heavily Loaded Substations" ratings, except when designing taps to radial loads. Bus conductor ratings should not be rated below incoming transmission line loads. Exceptions to these minimums can be justified in certain cases, such as for small tapped substations. Higher ampacities will often be required, depending on the project requirements.

Transmission Substation Bus Conductor Guideline Minimum Ampacity Ratings

Nominal Voltage (kV)	Application	Lightly Loaded Substations (A)	Heavily Loaded Substations (A)
69	Transm. Transformer Termination	1200	2000
69	Line Termination	1200	2000
69	Main Bus	1200	2000
115 and above	Transm. Transformer Termination	1200	2500
115 and above	Line Termination	2000	2500
115 and above	BHB (Row and Bus) or RB	2000	2500

Table 8

4.8. Distribution Bus Conductor Standard Ampere Ratings

The distribution substation standard ampacity ratings for bus and feeders are given by the distribution planning philosophy documents (see XEL-STD-B.01-001-PHASE I DESIGN.pdf).

4.9. Short-Circuit Considerations

Short circuit calculations are conservative to account for future system additions such as nearby generation or an increase in system transmission lines. These changes can have a significant impact on available fault currents. Initially designing for higher fault currents will minimize the impact of higher fault currents in future designs.

Both phase and ground fault current values will be obtained for calculations. When selecting the design short-circuit value, the designer should take into consideration future surrounding system growth, if possible. All substations should be designed using the future five-year short-circuit value plus 20% or the In Service Date value plus 20%, whichever is higher. In areas with very low expected ground fault values, (less than 10kA) use 200% of the expected value for ground grid design, as shown in the table below. Generally, phase values are used for equipment and structure designs. Information for certain transmission and distribution equipment is described in Sections 4.9.1 and 4.9.2. Design values for Substation Grounding, Sec 4.11, will always be based on ground faults. In all cases, the maximum design value will not exceed 63kA due to breaker sizing.

Phase or Ground Fault Value (from Planning or CAPE)	**Design Value**	**Minimum Value**
<=10kA	200%	5kA
>10 kA	120%	20kA

NOTE: Fault current values should be checked against the design value every time an element is added to the substation which could increase the fault value such as a line or transformer. Also, the design fault values shall be listed on all substation one-line or circuit diagrams.

The phase and ground short-circuit design ratings, once selected, will be applied to all aspects of the substation design, including equipment ratings and bus design. While the available short-circuit current varies from station to station, some Xcel Energy standard equipment ratings have been defined.

4.9.1. Short-Circuit Considerations for Transmission Substations

For transmission substations, Xcel Energy standard circuit breakers' short-circuit ratings are: 40kA for 69kV, 115kV, and 230kV, and 63kA for 345kV. Xcel Energy standard circuit-switcher short-circuit ratings are: 40kA at 115kV and 20kA at 230kV. These values are based on Xcel-wide approved equipment selections and interruption capability requirements.

4.9.2. Short-Circuit Considerations for Distribution Substations

The distribution substation standard short-circuit ratings are listed in the distribution planning philosophy document (see XEL-STD-B.01-001-PHASE I DESIGN.pdf).

4.10. Rigid Bus Dampening

Bus vibration is caused by low steady winds, less than 15 mph, blowing across a bus span at approximately right angles. Under certain low velocity wind conditions, eddies will break off alternately from the top and bottom surfaces of the bus causing the bus to vibrate in a vertical plane. The bus will vibrate at its natural frequency, provided that this frequency is within the range that can be triggered by the wind. In general, longer bus spans will vibrate.

In the past, scrap cable was installed inside tubular bus to prevent vibration. Today, external dampers are preferred because they are more economical and easier to install than scrap cable. For additional information, see NSP-STD-ED 6.01.05-Bus Vibration Dampers For Rigid Bus.pdf and PSC-STD-7170-Substation Rigid BUS.pdf.

4.11. Substation Grounding

All substations shall include a grounding system designed in accordance with IEEE 80 guidelines to protect people inside and outside the facility by limiting step and touch potentials during faults and switching. The grounding system also: limits ground potential rise, protects system components, allows relays to identify faults, and provides a safe return path for neutral currents. Future fault currents in high growth areas may exceed existing system levels, and designs need to accommodate for higher fault levels than calculated during design. Procedures for modeling and calculating expected fault current values are described in Section 4.9. Once selected, the design value used for ground grid design shall be noted on the grounding drawing.

Soil resistivity affects the ability of a grounding system to dissipate fault current into the soil. Both ground grid resistance and voltage gradients within the substation increase with soil resistivity. Soil resistivity tests should be performed for new substations and during major expansions.

The standard substation grounding system is a partial grid with a driven rod bed. All substation ground grid and equipment grounding conductors shall be a minimum 4/0 copper cable. The ground grid shall extend 3ft outside the substation fence and beyond the swing of any gates. The fence shall be connected to the ground grid at regular intervals not to exceed 50ft. A surface layer of crushed rock will be used as a high resistivity surface to reduce step and touch potentials. Ground wells may be utilized when required. Refer to standard "XEL-STD-EDS-G.08-001-SUBSTATION GROUNDING for more information.

4.12. Lightning Shielding

All substation electric equipment, electric bus, and support structures should be shielded from direct lightning strikes. Shield masts and shield wires are the preferred methods of lightning shielding within substations. In some cases, it may not be economical to completely protect every piece of equipment. Any equipment left out of the protection areas shall be noted and reviewed by subject matter experts.

Two widely used methods for designing substation lightning shielding are i) "fixed angle zone of protection" or "traditional cone" and ii) "electro-geometric model" or "rolling sphere method" (RSM). The rolling sphere method is based on detailed scientific and mathematical analysis, is generally more conservative, and can lead to more costly shielding designs than the empirically based cone system. Xcel has chosen fixed angle and RSM as the preferred methods for design. The fixed angle method is to be utilized for substation applications with insulation levels less than 550 kV BIL, which corresponds to voltage under 115 kV and the RSM for 550 kV BIL (115 kV) and above. Refer to IEEE 998 for substation applications, IEEE 1243 for transmission line applications and IEEE 1410 for distribution applications.

In order to prevent significant outages for fallen shield wires or for modification to shield wires during construction, care should be taken to avoid crossing shield wires above multiple sections of bus or above multiple pieces of equipment.

4.13. Corona

Measures to limit corona on conductors and other energized parts shall be included in the designs for substations that operate at 345kV and above. In some cases, for example at higher altitudes or when there is excessive noise, corona mitigation may also be necessary at 230kV. Corona is limited primarily through use of larger diameter or bundled conductors and connectors or by devices that approximate smooth, spherical surfaces. Special hardware (e.g. bolt shields, corona rings, spherical balls) is used on switches, buses, and attachments, while conductors are polished smooth and free of any scratches or burrs. For additional information, see IEEE 605.

4.14. Outdoor Cabling and Raceway Systems

The design of cable and raceway systems varies from station to station. Below-grade (underground) cable in substation yards will be installed in conduits, in duct banks, in concrete cable trench, or direct buried. Above-grade cable in substation yards is installed in conduit, wire way, or cable tray.

High-voltage power and control/instrument cables (1000V, 600V respectively) should be installed in duct banks, other protective cableways, or conduits within the substation yard, unless it is not practical due to other design constraints. High-voltage power cables shall be segregated from all other cables. Refer to IEEE 525 for additional information.

5 Safety and Security

5.1. Personal Protective Grounds

All substation equipment and busses must have provisions for attaching personal protective grounding cables. Each device (transformers, circuit breakers, CCVTs, etc.) requiring regular access by maintenance personnel must have specific grounding points on each of the high-voltage leads attached to the device or have space to install clamps directly onto conductors. Only approved ground attachment devices are to be used. The ground attachment points must be adequate for the maximum available fault current (see Sec 4.11) in the substation. Any deficiencies should be corrected as they are discovered.

Testing of personal grounding cables and connection points has shown that there are no approved personal grounding provisions that are capable of safely grounding equipment at fault levels exceeding 50kA. At locations where the fault level may exceed 50kA, steps must be taken to reduce the available fault to a maximum of 50kA before the work site may be safely grounded. In locations where the fault levels are known to be at or above 47.5kA, the project engineer shall consult System Protection Engineering for fault studies to determine the fault levels at the substation, and whether switching to lower the available fault current is required.

The fault current used for design shall also be listed on all substation one-line or circuit diagrams (see Sec. 4.9) and should be updated on a yearly basis. Special provisions for grounding must also be included in metalclad switchgear. Refer to IEEE 1246 for additional information.

5.2. Wildlife Protection

5.2.1. Transmission Substations

Due to the relatively large clearance distances involved, transmission substations rarely experience flashovers due to animals and do not require the use of wildlife protection devices on energized equipment and bus structures. Transformer tertiary bushings may require wildlife protection. Animals may cause other types of damage and safety concerns in substations and basic measures to prevent or deter animal entry are to be taken. The standard substation fence design includes barriers to animals entering the substation (e.g. closely-spaced chain link, metal strip near the top).

5.2.2. Distribution Substations

Distribution substations have many design features intended to provide protection from wildlife.

Refer to the XEL-STD-Guideline for Wildlife Protection and XEL-STD-Guideline for Application of Wildlife Protection.pdf for additional information regarding wildlife protection considerations. IEEE 1264 may also be a useful reference.

5.3. Fencing

Substations are completely enclosed to provide a protective barrier for public safety and security for facilities. The standard enclosure is a galvanized, chain link fence, although a wall or the exterior wall of a building may be used to provide the barrier in some cases. A decorative wall or building may be installed in some locations if required by codes, regulations, or permits.

The fence or other type of barrier shall meet or exceed NESC requirements. The fence should also be in accordance with Xcel Energy Security guidelines (XEL-STD-Guideline for Substation Physical and Cyber Security). The standard fence is galvanized chain-link consisting of seven feet of fabric topped with one-foot of barbed wire. According to Xcel Energy security guidelines, a ten-foot minimum exterior clear zone free from trees, shrubs, structures, and equipment is recommended when property lines permit.

If there is no line-of-sight visibility between the main substation gate and the entrance off the public roadway, then a security gate will be installed at the driveway entrance off the public road. A security gate provides increased security at substation that may have an unusually long driveway, foliage, or other features that could provide cover to trespassers.

The substation fence will generally not be placed directly on the property line. The substation ground grid normally extends three feet outside the fence as part of the ground grid design. The ground grid should be within the property line and covered with the yard surface aggregate. It is recommended that the fence be located twenty (20) feet inside the property line, but where it is not possible, a minimum of five (5) feet inside the property line is required to accommodate typical grounding practices. All external fences adjacent to the substation security fence will be electrically isolated from the substation fence and ground grid. See standard XEL-STD-EDS-G.08-001-SUBSTATION GROUNDING for additional detail.

5.4. Substation Access Control

All exterior gates and doors shall be locked for security. Within the substation, equipment enclosure entrances shall also be locked. Gates may have a dual-padlock system if workers from other utilities or companies require access.

5.5. Substation Lighting

Substation yards and electrical equipment enclosures shall be illuminated in accordance with the National Electric Safety Code. Outdoor yard lighting for substation equipment shall provide an average of 2 foot-candles for safe operation/maintenance of equipment and for security. Remote areas of the substation yard shall have an average of 0.2 foot-candles.

The Xcel Energy standard is that unoccupied substations not be illuminated at night. Only a small percentage of substations are illuminated at night for various reasons specific to the substation. For instance, local codes or regulations may require lighting, or lighting may be necessary to improve security at a particular site.

5.6. Fire Protection

Special attention should be given to the location of large transformers in substations. Transformer fires can result in large amounts of flaming oil spread through the substation. This can lead to damage of nearby equipment. It is important that adequate equipment separation be provided so that damage to other substation equipment is kept to a minimum in the event of a transformer fire.

The substation grading should be prepared so that spilled oil flows away from buildings or other large transformers and cannot easily access underground cable trenches. Substations with remote oil containment may also offer a form of fire protection.

The edge of the oil containment or anticipated spill area of large transformers should be separated from the surface of other transformers or control buildings by the distances shown in Table 9 below. Table 9 distances are from IEEE 979-2012.

Separation Distances

Mineral Oil Volume (gal.)	Distance (ft.)
500 to 5000	25
>5000	50

Table 9

Protective firewalls or barriers should be considered whenever these clearances cannot be achieved. In rare cases, fire hydrants or sprinkler systems may also be beneficial as part of the fire protection system. IEEE 979-2012 mentions additional methods of fire suppression when a firewall is not feasible. These methods are not addressed in this document. However, a study of these methods will be conducted for possible inclusion in future revisions.

In general, electrical equipment enclosures have two exits on opposite sides or corners and the doors have panic hardware. Panic (emergency egress) hardware will be included on all new enclosures and as the opportunity occurs, will be added to existing enclosures that do not presently have panic hardware. Fire extinguishers are provided at each exit of the equipment enclosure. Some GIS equipment enclosures may require fire suppression systems. If a fire extinguisher is missing, contact an O&M manager. Refer to XEL-STD-Specification for Procurement of Fire Extinguishers, and IEEE 979-2012 for additional information related to fire protection.

5.7. Signs and Nameplates

A sign listing the substation name, 911 address, and GPS coordinates, should be posted in 3 ½-inch lettering on the substation fence. The sign should be located such that, during an emergency, a passerby or exiting employee can easily read it. "NO TRESSPASSING" and "HAZARD WARNING" signs shall also be posted at 50 to 100-foot intervals on each side of the substation fence. Xcel's Public Safety Awareness Programs publish in Spanish any time more than 10% of the population speak Spanish as a primary language according to census data. In Colorado, Texas, and New Mexico, over 10% of the population speak Spanish as a primary language. With this data, the requirement is such that all external substation HAZARD signage will be in both English and Spanish at all installations so there is only one material requirement and not two different sign types in the catalog.

Within the substation, all power equipment and switches will be labeled. Warnings signs will also be posted for battery systems, buried cable, and areas of limited clearance. Examples of these signs are located in Appendix A. Substation signs shall meet or exceed the requirements of the National Electric Safety Code. See standard "XEL-STD-Guideline for Substation Physical and Cyber Security" for additional information.

6 Major Equipment

6.1. Transmission Transformers

6.1.1. Number and Size of Transformers

System Planning and Asset Management determine the number and size of transformers required for a substation. Transformers are manufactured to specification and there are no industry-preferred or standard MVA ratings. However, Xcel Energy does use several standard transformer size ratings for specifying and purchasing transformers. Having a limited number of standard sizes in the system simplifies transformer replacements and relocations. See XEL-STD-Criteria for Power Transformer Loading for more information.

Standard Transmission Transformer Ratings

Operating Region	Top MVA Rating[1]
NSP	47, 70, 112, 120, 187, 336, 448, 672
PSC	100, 150, 280, 560
SPS	84, 250, 448, 560

[1] based on operation at 65°C winding temperature rise

Table 10

6.1.2. Transformer Connections

The standard winding configuration for transmission transformers is a grounded-wye-connected autotransformer. A delta-connected tertiary winding is typically included as it provides a path for circulating third harmonic currents. The delta tertiary also allows the transformer to be a zero sequence source. The tertiary will be specified at a distribution voltage level (unless it is a buried tertiary) and will often be used to supply station auxiliary power or VAR control devices.

6.2. Distribution Transformers

6.2.1. Number and Size of Transformers

System Planning and Asset Management determine the number and size of transformers required for a substation. Transformers are manufactured to specification and there are no industry-preferred or standard MVA ratings. However, Xcel Energy does use several standard transformer size ratings for specifying and purchasing transformers. Having a limited number of standard sizes in the system simplifies transformer replacements and relocations.

A discussion of transformers to be used in distribution substations is provided in the distribution planning philosophy document (XEL-STD-B.01-001-PHASE I DESIGN.pdf and XEL-STD-B.01-002-PHASE II DESIGN). The standard sizes are given in the table below.

Standard Distribution Transformer Ratings

Distribution System Voltage	Top MVA Rating[(1)]
2.4	Undefined
4.16	Undefined
7.2	Undefined
12.5	7, 14, 28, 50
13.2	7, 14, 28, 50
13.8	7, 14, 28, 50, 70
22.9	7, 14, 28
23.9	7, 14, 28, 50, 90.5
34.5	12, 28, 50, 70
46	Undefined

[(1)]based on 65°C winding temperature rise

Table 11

6.2.2. Transformer Connections

The standard distribution transformer connection for new substations is delta-connected primary, grounded-wye-connected secondary. The high side leads the low side by 30°.

Other transformer connections have been, and still are, used in the different Xcel Energy operating regions.

6.3. Distribution Voltage Regulation

Voltage regulation on the distribution system will be provided by Voltage Regulators or by Load Tap Changer-equipped (LTC) transformers. These devices operate in a similar fashion. The distribution voltage is compared to a desired set point, and the regulator or LTC adjusts the voltage in discrete steps based upon the taps in the winding. LTC transformers regulate the voltage on the distribution bus. Regulators or capacitor banks can be applied to regulate the voltage on just one feeder or to regulate an entire bus.

6.4. Circuit Breakers

The proper selection and application of circuit breakers is critical in substation design. The Xcel Energy standard transmission circuit breaker design for 72.5kV to 362kV is dead-tank, SF6, with bushing CTs. Live-tank circuit breakers are also available and may be used in certain cases. (The dead-tank circuit breaker design has a grounded tank, whereas the live-tank circuit breaker design has interrupters that are at line voltage and are on insulated columns.) Synchronous-closing circuit breakers may be used on larger capacitor bank and reactor installations – the application is determined on a case-by-case basis. The Xcel Energy minimum continuous current rating for 72.5kV circuit breakers is 2000A. The Xcel Energy minimum continuous current rating for circuit breakers rated 121kV and higher is 3000A. See XEL-STD-EMS-J.04-007-OUTDOOR HIGH-VOLTAGE AC CIRCUIT BREAKERS.

6.5. Reclosers

Reclosers are specialized circuit breakers for use at distribution voltages. Reclosers have limited ratings designed specifically for distribution duty. They contain a complete three-phase and ground-overcurrent protection package. The protection for reclosers can be either relayed or series-trip. Relayed reclosers can be used where there is DC control voltage available.

Series-trip reclosers do not require a separate DC or AC control voltage to operate. These types of reclosers have been typically installed in rural substations or locations where there is no DC control voltage.

6.6. Metal Clad Switchgear

Metal clad switchgear (MCSG) consists of an outdoor metal enclosure which houses medium voltage bus and several physically separated areas known as cubicles or units. The MCSG also contains an aisle for personnel to access the cubicles. Within each cubicle resides a circuit breaker and connections for medium voltage cable or bus to exit the structure for connection with feeders, transformers, capacitor banks, and other switchgear. Relays for the control and communication of the MCSG reside on the door of each cubicle. Switchgear also typically will include an I/O Remote Terminal Unit (RTU), which will communicate to the substation master RTU. Metal clad switchgear is generally built by a manufacturer and installed as a single unit. See Section 4.2.4 above and XEL-STD-EMS-J.06-001 Metalclad Switchgear Assembly for more detail on switchgear components and ratings.

6.7. Disconnect Switches

Disconnect switches are used primarily for isolation of equipment. Care must be taken to properly apply disconnect switches, especially where the switch may be called on to interrupt current, such as loop or line charging currents. Typically, the switchblade is arranged to open towards the equipment it is protecting, and away from the energized bus. This allows the switch to be fully isolated and de-energized while in the open position.

The standard substation disconnect switch is a three-pole, outdoor, high-voltage, non-enclosed, group-operated air switch. The minimum continuous current rating of a switch will not limit the transmission power flow path. Hook-stick type switches are not used for transmission substations above 69kV. Grounding switches may be used for underground transmission lines or when required for maintenance at other locations. Manual operators are standard, unless motor-operators are needed for automatic or remote operation. Swing-handle operators are standard for smaller manually operated switches, while worm-gear operators are used for larger switches that require more force to open. Specifically, worm-gear operators are standard for manually-operated switches rated 115kV and above or 2000A or greater. See XEL-STD-EMS-J.08-001-OUTDOOR HIGH-VOLTAGE AIR SWITCHES AND OPERATING MECHANISMS for more information.

6.8. Capacitors

For detailed engineering and design information including vertical clearances for all voltage levels, see XEL-STD-Eng & Design of Capacitor Banks.

6.8.1. Shunt Capacitors

Shunt capacitor banks are often used for VAR support, voltage control, and to increase system capacity. The standard configuration for shunt capacitor banks is fuseless, grounded-wye. The number and size of capacitor banks will be determined by System Planning and Asset Management.

6.8.2. Shunt Capacitors for Transmission Substations

Stack construction with factory-assembled capacitor racks is used at all transmission voltages. An ultimate MVAR rating is normally specified such that additional capacitor cans may be added in the future to increase the MVAR rating without replacing the entire bank.

For new installations where there is not a station battery and the capacitor bank breaker/switching device has a capacitive trip device, the breaker is not used primarily for capacitor bank fault protection. In these installations, the capacitor bank will be protected with fuses. The breaker will then act as a capacitor bank switch for voltage control and during unbalanced conditions.

For additional information about capacitor bank design and controls see: XEL-STD-Eng & Design of Capacitor Banks

Current-limiting reactors may be required to limit inrush and outrush currents of the capacitor banks. If not reduced to an acceptable level, these currents may damage the capacitor bank switching devices or nearby circuit breakers.

6.8.3. Shunt Capacitors for Distribution Substations

Capacitor banks for distribution systems are sometimes installed in substations on either the bus or on feeders. This is discussed further in the distribution planning philosophy document (XEL-STD-B.01-001-PHASE I DESIGN.pdf and XEL-STD-B.01-002-PHASE II DESIGN).

6.8.4. Series Capacitors

Series capacitor banks are used on long transmission lines to increase line loadability. They have been applied in a few cases on long 345kV and 500kV lines.

6.9. Reactors

The Xcel Energy standard design for reactors is dry-type, air-core. Calculations should be performed to determine the reactor size. A transients study may also be required to confirm the necessity and size.

6.9.1. Shunt Reactors

Shunt reactors are used to provide VAR control and to limit voltage rise during light loading conditions. One standard application is to connect shunt reactors to transmission transformer tertiaries. This is due to the possibility of high tertiary fault currents from higher-capacity transformers. Tertiary reactors may be used in place of line reactors when allowed by the characteristics of the line. A study is required to determine the necessity and applicability of a shunt reactor on a line. A circuit breaker will be used for reactor switching and the preferred location is between the transformer and the reactor. The breaker must be sized for the available fault current. No switching will take place on the neutral side of tertiary reactors. See XEL-STD-Eng & Design of Capacitor Banks for more information.

6.9.2. Series Reactors

Series reactors may be used where current limiting is required or to limit transients caused from capacitor bank switching. One common application is in the circuits of shunt capacitor banks. When two or more shunt capacitor banks are installed in a substation, reactors will usually be required. Series reactors are also frequently used to limit fault current levels on distribution feeders.

6.10. Wave Trap Installations

For new installations, wave traps are to be supported by a pedestal or similar support and are not to be suspended. For special cases such as replacing an existing suspended wave trap, the engineer shall prepare an estimate of the cost to replace the suspended design. The Director of Engineering must approve all decisions to continue with a suspended design for a wave trap. If a suspended option for a wave trap is approved by the Director of Engineering, the Substation Design Manager shall approve the design in writing. The design shall also be sealed by a PE when the prints are issued due to the inherent risk of suspending wave traps. (Each of these is a custom design and only a current PE approval is valid.) See XEL-STD-Specification for Procurement of Line Traps for more information.

6.11. System Restoration

6.11.1. Black Start Emergency Generators

Several key transmission substations include a diesel generator designed to automatically start-up and carry the required station auxiliary load for up to 36 hours in the event of a system blackout. This should provide sufficient time to restart major generation and piece the grid back together under worst-case scenarios. Distribution substations do not typically have emergency generators.

7 Electric Equipment Enclosures

7.1. AC Auxiliary System

Every substation includes an AC auxiliary supply system for lighting, heating, maintenance, and other electrical loads. Additionally, each substation that has primary and secondary protective relays and a battery system should have two AC auxiliary sources. An automatic transfer switch will be included to switch between the two sources (preferred and emergency).

The sources for auxiliary power are usually transformer tertiary windings or distribution busses. If these sources are not available or are not economically feasible, auxiliary power may be obtained from the local distribution company, an emergency generator, or a voltage transformer connected to a transmission bus. No distribution load from the tertiary windings shall be outside of the substation yard.

The Xcel Energy standard AC auxiliary system rating is 120/240V single-phase, and this is used with auxiliary equipment rated up to 100kVA. However, for substations that would require auxiliary equipment rated higher than 100kVA with a 120/240 single-phase system, a three-phase auxiliary system is used. Three-phase auxiliary systems have been rated 120/240V in all three regions and 120/208V in the PSC region. See PSC-STD-E40.1–Alternating Current Station Service Design and NSP-STD-ED 4.04.01-AC System Requirements for more information.

7.2. DC Auxiliary System

Each substation that has protective relaying includes at least one DC system (including storage battery and charger). DC is the primary power source for relay and control power. Nearly all new substations utilize a 125VDC battery system. Other voltages, such as 12VDC or 48VDC, may be used when it is economically practical to do so. Today's equipment includes sufficiently

DC System A	DC System B
Protection System 1	Protection System 2
Pilot Comm System 1	Pilot Comm System 2
DTT System 1	DTT System 2
Breaker Trip Coil 1	Breaker Trip Coil 2
Motor Operator 1 (Switch)	Motor Operator 2 (Switch)
	Breaker Failure
Metering & Transducers	
Local Alarm System (Annunciator/HMI/LCU)	RTU
	Telephone Protection

Table 12

Note: Motor operated switches will be placed on the same DC source as the initiating device hardened power supplies so that electronics and trip coils can share the same DC supply without adverse effects. However, for all new installations above 100 kV, the DC circuits to the trip coils shall be separate circuits, in separate cables and routed in separate conduits, or separate cables if cables are direct buried, and with different circuit breakers on the panel as shown in Table 12. The DC panels should be configured to accommodate separate batteries in the future. Consideration should be given to adding a second DC source to existing stations based on criticality and reliability. Use Table 12

Note: Motor operated switches will be placed on the same DC source as the initiating device as the design for segregation in the event of a redundant battery design unless the existing configuration/wiring prevents the standard configuration from being implemented. For considerations regarding battery-monitoring systems, see the XEL-STD-Guideline for Engineering & Design of AC-DC Systems – Battery Monitoring Systems.

Refer to XEL-STD-DC-M.05-001 Design Criteria for Substation DC Auxiliary System for battery and charger sizing criteria.

Appendix A Warning Sign Examples

Figure 16 - Example of a 12” x 14” ‘Hazardous Voltage’ Bilingual Sign

Figure 17 - Example of a 10" x 14" 'No Smoking' Sign

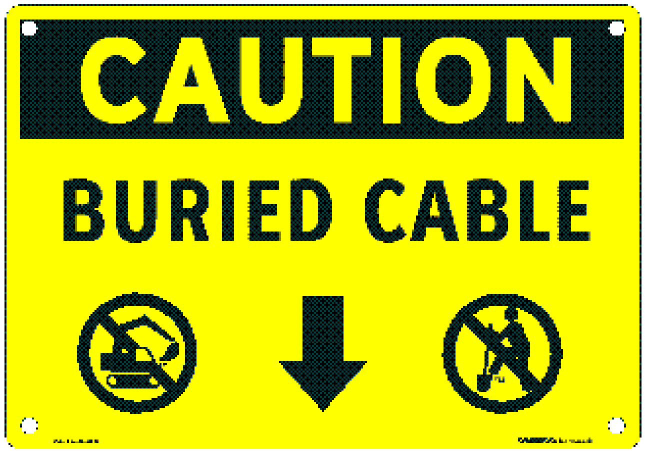


Figure 18 - Example of a 10" x 7" 'Buried Cable' Sign

Figure 19 - Example of a 10" x 12” 'Limited Clearances' Sign

Appendix B Reference Documents

B.1. Capital Asset Accounting – Procedure Guidelines, Asset Separation – Funtionalization of Substations

B.2. Colorado Title 25, Article 12, Noise Abatement

B.3. EDS-G.02-001, Substation Clearances – 345kV and Below

B.4. XEL-STD-Guideline for Wildlife Protection

B.5. IEEE 1127-1998, Guide for the Design, Construction, and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility

B.6. IEEE 1243-1997, Guide for Improving the Lightning Performance of Transmission Lines

B.7. IEEE 1246-2002, Guide for Temporary Protective Grounding Systems Used in Substations

B.8. IEEE 1264-2014, Guide for Animal Deterrents for Electric Power Supply Substations

B.9. IEEE 1410-2004, Guide for Improving Lightning Performance of Electric Power Overhead Distribution Lines

B.10. IEEE 525-2007, Guide for the Design and Installation of Cable Systems in Substations

B.11. IEEE 605-2008, Guide for Bus Design in Air Insulated Substations

B.12. IEEE 738-2006, Standard for Calculating the Current-Temperature of Bare Overhead Conductors

B.13. IEEE 80-2000, Guide for Safety in AC Substation Grounding

B.14. IEEE 979-2012, Guide for Substation Fire Protection

B.15. IEEE 980-2013, Guide for Containment and Control of Oil Spills in Substations

B.16. IEEE 998-2012 – Guide for Direct Lightning Stroke Shielding of Substations

B.17. IEEE C2-2012 - The National Electric Safety Code

B.18. IEEE Std C37.30 IEEE Standard Requirements for High-Voltage Air Switches

B.19. NFPA 70 – 2014 - National Electrical Code

B.20. NSP-STD-ED 4.02.02.01, Outdoor Electrical and Working Clearances

B.21. NSP-STD-ED 4.04.01-AC System Requirements

B.22. NSP-STD-ED 6.01.05, Bus Vibration Dampers for Rigid Bus

B.23. PSC-STD-7170, Substation Rigid Bus

B.24. PSC-STD-E40.1, Alternating Current Station Service Design

B.25. XEL-EXT-Facility Ratings Methodology Comparison for Rigid Bus Ampacity.pdf

B.26. XEL-STD-B.01-002, Substation Integration Design Phase 2

B.27. XEL-STD-Criteria for Eng & Design of Civil & Structural Performance

B.28. XEL-STD-Criteria for Power Transformer Loading

B.29. XEL-STD-Criteria for Eng & Design of Civil & Structural Performance

B.30. XEL-STD-DC-M.05-001, Design Criteria for Substation DC Auxiliary System

B.31. XEL-STD-EDS-G.08-001, Substation Grounding

B.32. XEL-STD-EMS-J.04-007-OUTDOOR HIGH-VOLTAGE AC CIRCUIT BREAKERS

B.33. XEL-STD-EMS-J.06-001, Metalclad Switchgear Assembly

B.34. XEL-STD-EMS-J.08-001-OUTDOOR HIGH-VOLTAGE AIR SWITCHES AND OPERATING MECHANISMS

B.35. XEL-STD-Eng & Design of Capacitor Banks

B.36. XEL-STD-Guideline for Application of Wildlife Protection

B.37. XEL-STD-Guideline for Engineering & Design of AC-DC Systems – Battery Monitoring Systems

B.38. XEL-STD-Guideline for Substation Physical and Cyber Security

B.39. XEL-STD-Guideline for Wildlife Protection

B.40. XEL-STD-Specification for Procurement of Line Traps

B.41. XEL-STD-Specification for Procurement of Fire Extinguishers

B.42. XEL-STD-B.01-001-PHASE I DESIGN.pdf

Outdoor Substation Direct Stroke Lightning Protection

Review of various lightning protection design practices - ROLLING SPHERE

1.0 Several techniques of protecting substations from direct lightning strokes have been used in the past. They can be classified basically into the following three categories.

1.01 The technique described in references [1], [2] and [7] is based on scale model tests developed in the 1940's to investigate the protective value of ground wires and vertical masts for transmission lines and substations. This is independent of the voltage level of the energized equipment and depends on the geometric relationship between the shield, the equipment, and the earth. Insulation level, surge impedance, stroke current "Magnitude, and probability of lightning occurrence in the area are not considered directly. These model tests were based on the following assumptions:

i) All lightning strokes propagate vertically downward.
ii) The station is in flat terrain.
iii) Thunderstorm cloud base is at 1000 ft. above ground.
iv) Earth resistivity is relatively low.

1.02 The second method, referred to as "Fixed Angle Zone of Protection" described in reference (8), is also based on the geometric relationship between "the shield, the equipment, and the ground. This method, in effect, is an extension of the previous technique. All equipment within a zone described by a fixed angle from the shield is said to be protected. The angle used for an independent shield is typically 45 degree from the vertical. The angle used for the area between two shields is typically 45 degree or 60 degree from vertical. Again, the normal operating voltage level, insulation level, surge impedance, stroke current magnitude, and probability of lightning occurrence in the area are not directly considered.

1.03 With the advent of high voltage and extra high voltage substations and switching stations, a new method called the "Electro-Geometric Model" has been developed to design shielding. This method is an extension of methods in use for transmission line protection. This model, used in this standard, takes into account the negative polarity impulse critical flashover voltage of insulation (ICFO) and surge impedance (Z) to determine the "Critical Striking Distance" (R_{sc}) which is to be used in the shielding design. This method does not directly consider isokeraunic level.

This method of protection is based on the following premises:

i) The length of the final jump of a lightning flash, called the "Critical Striking Distance", is related to the magnitude of current produced by the stroke.
ii) An impending stroke can begin its final jump from any point above the earth, and will strike the closer of two effectively grounded points within its striking distance.
iii The magnitude of current, which can be driven into an electrical system without causing a flashover of insulation, is dependent upon the surge impedance and the

insulation level. Therefore, for a given insulation level and-surge impedance, lightning strokes below a given current level (and therefore with less than a given striking distance) can be allowed to strike energized equipment.

Physical understanding of the Electro-Geometric Model may be aided by Visualizing a "Rolling Sphere" with radius equal to the critical striking distance (R_{sc}). If the sphere cannot be made to touch any energized equipment .due to interference of shields, then all strokes of magnitudes greater than that 'Corresponding to R_{sc} will always have a shorter path to the earth or a shield than to the energized equipment, and adequate shielding has been achieved. If 'the sphere can be made to contact any energized equipment, a stroke of great enough magnitude, with its final jump originating at the center of the sphere, will have a shorter path to the energized equipment than to the earth or a shield, and adequate shielding has not been achieved.

Therefore, it remains only to ensure that shield masts, wires, or structures etc., are placed such that all strokes with striking distance above the critical value will have a shorter path to the shielding feature than to equipment which is to be protected.

It is very important, however, to remember that the radius of the rolling sphere changes with the voltage level and it is very small at distribution voltage levels. At distribution voltage levels (e.g., 13.8kV), shielding base strictly upon R_{sc} may be extensive and costly, due to small values of R_{sc}. A fixed minimum useful radius is recommended for these voltage levels.

All that remains for a specific application is to determine the critical striking distance and to create a shield network and evaluate its adequacy.

2.0 Step-By-Step-Procedures And Design Flow-Chart

1) Study the general arrangement drawings and locate the take-off structures, high structures for bus supports, main equipment and other important points of interest.

2) Divide the total substation into areas by voltage level.

3) For large substations or switching stations, subdivide the voltage level areas into smaller areas of interest (e.g., 345 kV capacitor areas; 345/230 kV transformers, etc.).

4) Consider alternate positions of movable equipment (i.e., vertical-break disconnecting switches).

5) List the assumptions, (i.e., height of the shielding masts; typical sag for the shield wires, etc.).

6) Determine the critical striking distance for each voltage level in the station using Figs. 7 & 8.

7) Evaluate shielding provided by the existing substation structures. Find the unprotected areas.

8) Make several preliminary designs in order to provide adequate protection at minimum cost. Methods available to correct for inadequate shielding include

   i) Addition of masts on the top of existing steel structures.

   ii) Stringing shield wires between existing steel structures.

   iii) Addition of freestanding shield masts, possibly with shield wires attached.

   iv) Relocation of smaller equipment to an area which is already shielded.

   Methods (i) and (ii) are less costly than method (iii). In general, methods (i) and (ii) will achieve adequate shielding in most stations with standard layouts. Use of freestanding masts may be required for stations of low-profile design or where some equipment is rather remote from the main portion of the station.

9) At lower voltages (below 115kV), shielding based on Rsc may not be practical, since Rsc is small and excessive cost may be involved. minimum useful value of 60 ft. is recommended for Rsc.

10) Once the shielding design for each sub-area has been performed and evaluated for adequacy, check that the entire substation has been adequately shielded.

11) The flow chart (Figure 6) summarizes the step-by-step procedure.

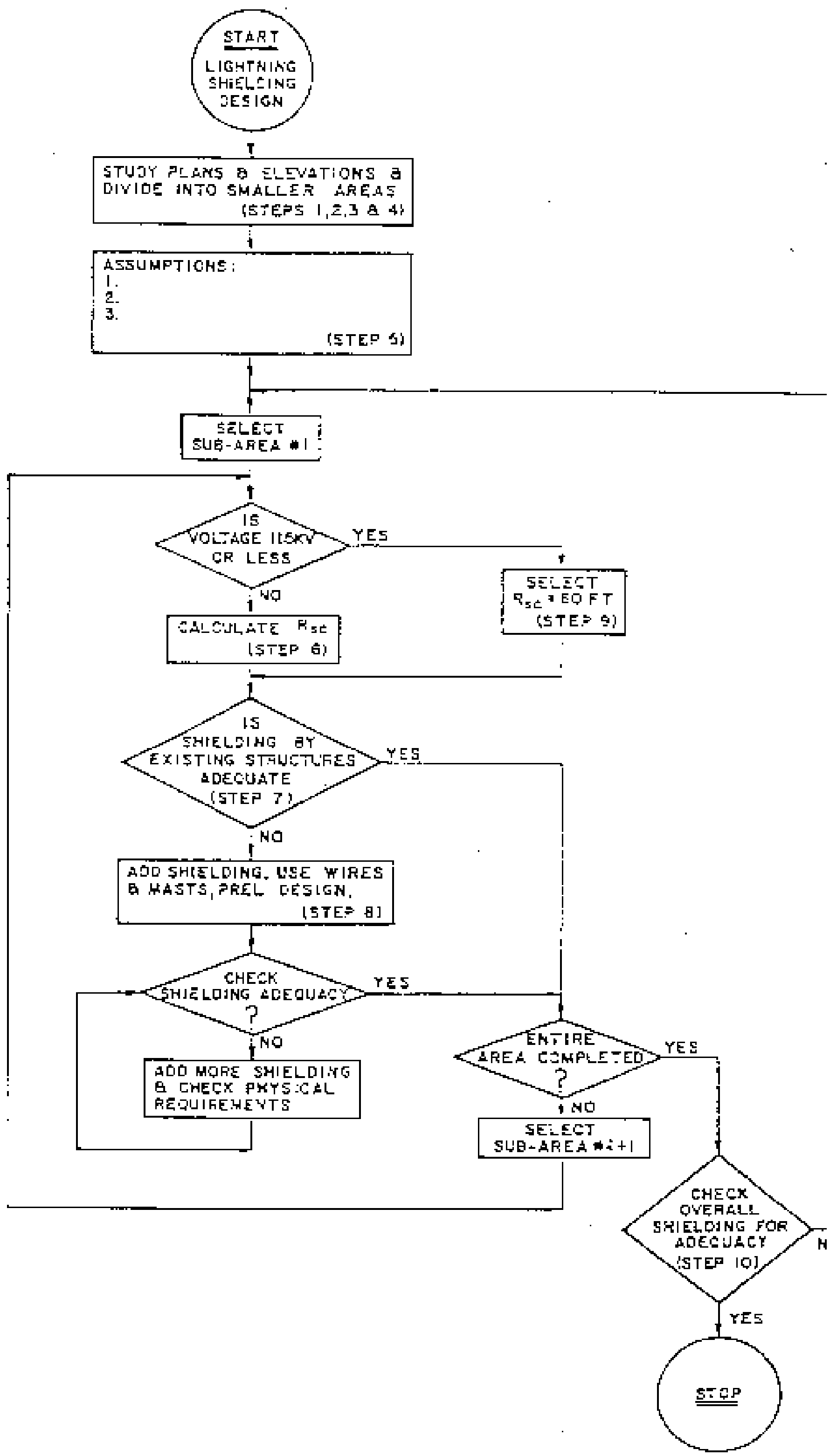


FIG 6 FLOW CHART

OUTDOOR SUBSTATION DIRECT STROKE LIGHTNING PROTECTION

3.0 Definitions

R_{sc} - Critical-striking distance based on insulation level & surge impedance, in ft. (Radius of the Rolling Sphere.)

I_c - Critical lightning current in kA.

Z - Surge impedance of bus work in Ohms.

ICFO - Negative polarity impulse critical flashover level of insulation in kV.

H_{av} - Average height of bus phase conductor above ground in ft. For string bus, use attachment height minus 2/3 of the maximum sag.

r - Outside radius of bus phase conductor in ft. for single conductor. Use the geometric mean radius for bundled conductor.

BIL - Basic impulse level in kV

$_{Ioc}$ - Critical prospective lightning current to zero resistance earth in kA. = 1.1 x I_c

a - Distance between two shield wires in ft.

b - Super-elevation in ft.

h - Equipment height in ft.

hs - Height of the mast or the shield wire in ft.

x' - Distance from a mast to a protected object in ft.

x - Distance between masts in ft.

q' - Horizontal distance between the mast & the center of the Rolling Sphere in ft. (for R_{sc} greater than h_s)

4.0 Selected References

[1] McCann, G.D., "Lightning Protection of Hazardous Structures", Electrical Engineering, December, 1942, pp. 591-597.

[2] "Transmission and Distribution Reference Book", Westinghouse Electric Corporation, East Pittsburgh, 1964, pp. 630-632.

[3] "Transmission Line Reference Book : 345 kV and Above", Chapter 12, General Electric Company, Electric Power Research Institute (Sponsor), 1975, pp. 545-597.

[4] "Bibliography of Publications Pertaining to Lightning Protection", IEEE Transmission Substation Subcommittee of the IEEE Substations Committee, IEEE Transactions on Power Apparatus and Systems, Vol. PAS-94, No. 4, July/August 1975, pp. 1241-1247.

[5] Linck, E., "Shielding of Modern Substations Against Direct Lightning Strokes", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-94, No. 5, September/October 1975, pp. 1674-1679.

[6] Mousa, A.M., "Shielding of High-Voltage Substations", IEEE Transactions on Power Apparatus and Systems,- Vol. PAS-95, No. 4, July/August 1976, pp. 1303-1310.

[7] "Surge Protection in Power Systems", Chapter 6, IEEE Tutorial Course Text 79EHO144-6-PVR, 1978, pp. /6-83.

[8] "Design Guide for Rural Substation", Chapter VI, Rural Electrification Administration, U.S. Dept. of Agriculture, June, 1978, pp. 35-37.

[9] Lee, R.H., "Lightning Protection of Buildings", IEEE Transactions on Industry Applications, Vol. IA-15, No. 3, May/June-1979, pp. 236-240.

[10] Changery, H.J., "National Thunderstorm Frequencies for the Contiguous United States", Report No. NUREG/CR-22.t2, National Oceanic and Atmospheric Administration, Ashville, North Carolina, November 1981.

[11] MacGorman, D.R., et al, "Lightning Strike Density for the-Contiguous United States from Thunderstorm Duration Record", Report No. NUREG/CR-3/89, National Oceanic and Atmospheric Administration, Norman, Oklahoma, May 1984.

APPENDIX 1: Critical Striking Distance (R_{sc}) For Transmission Voltage Levels

Critical Striking distance (the radius of the rolling sphere) can be calculated from the following equation derived from reference [6], equation number from the reference is shown in parenthesis following the equation.

$$R_{sc} = 47.2 \times \left(\frac{ICFO}{Z}\right)^{2/3} \text{ ft.}$$

$$\text{where, } Z = 60 \ln\left(\frac{2H_{av}}{r}\right) \text{ ohms} \qquad (2)$$

The critical lightning current (I_c) or the maximum stroke current that would not cause flashover to the phase conductor neglecting reflections from the substation equipment and bus structures is given by

$$I_c = \frac{ICFO}{\frac{Z}{2}} \qquad (1)$$

Critical prospective lightning current (I_{oc}) to zero resistance to earth is

$$I_{oc} = 1.1\, I_c \qquad (3)$$

where 1.1 is an uncertainty factor.

The effective striking distance, R_{sc}, in meters (or ft.) is related to I_{oc}, in kA, by the equation

$$R_{sc} = 8.5\,(I_{oc})^{2/3} \text{ meters} \qquad (4)$$

$$R_{sc} = 8.5\left(1.1 \times 2 \times \frac{ICFO}{Z}\right)^{2/3} \text{ meters}$$

$$R_{sc} = 14.38\left(\frac{ICFO}{Z}\right)^{2/3} \text{ meters}$$

$$\text{or} \quad R_{sc} = 47.2\left(\frac{ICFO}{Z}\right)^{2/3} \text{ ft}$$

The constant 8.5 and the exponent $^2/_3$ used in the above equation were calculated and refined from the empirical relations and statistical data [6].

Based on equations (2) and (4), two sets of curves have been drawn. Figure 7 shows the calculation of Surge Impedance (Z) as a function of radius (r) and average height of bus phase conductor (H_{av}). The range of Z is between 250 ohms and 400 ohms for most practical cases. Figure 8 shows the calculation of Critical Striking Distance (R_{sc}) versus Surge Impedance and ICFO.

The value of the negative polarity impulse critical flashover level of insulation (ICFO) is always greater than the basic impulse level (BIL). If the value of ICFO is not known, the BIL value may be used instead. This will produce a conservative design.

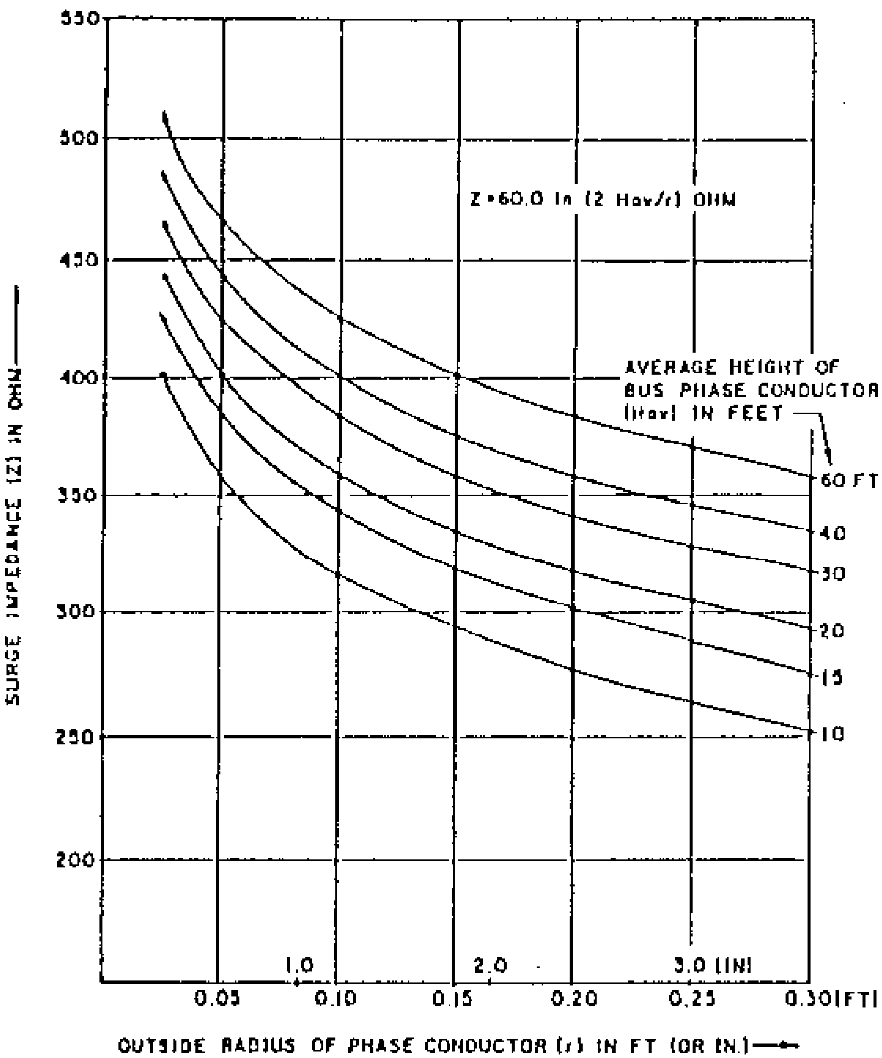


FIG 7 CALCULATION OF SURGE IMPEDANCE

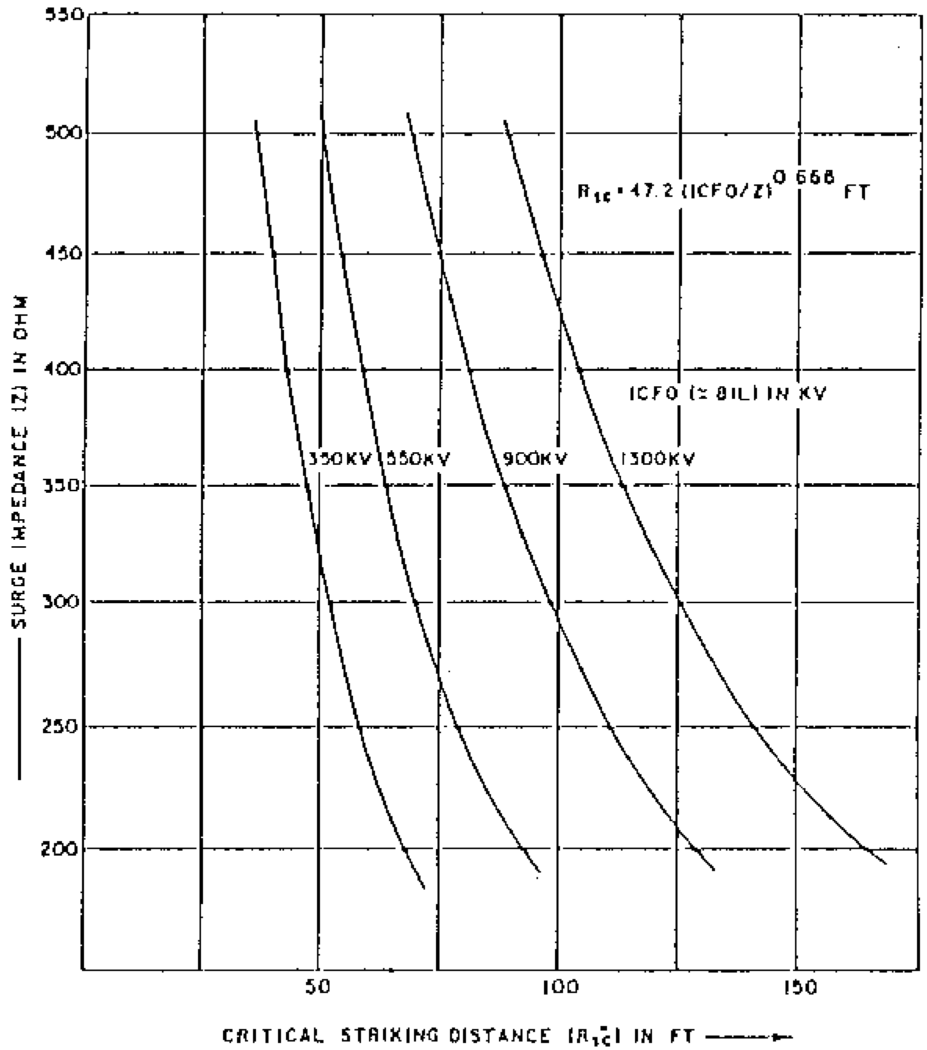


FIG 8 CALCULATION OF CRITICAL STRIKING DISTANCE

OUTDOOR SUBSTATION DIRECT STROKE LIGHTNING PROTECTION

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE **10/27/98**		**1**	**SHEET 8 of 14**	**ED 4.01.03.01**

APPENDIX 2: Critical Striking Distance for Subtransmission and Distribution-;Voltage Levels

Special attention must be given while designing direct stroke shielding for subtransmission and distribution voltage levels (below 115 kV). Shielding based on R_{sc} calculated from the insulation level (ICFO) may not be practical, since R_{sc} is small and excessive cost may be involved. This is evident from the following calculations.

69 kV system	H_{av}	=	17.5 ft.
	r	=	0.75 in. (1.5 in. tube)
	ICFO	=	350 kV (BIL)
	Z	=	379.7 ohms
	I_{oc}	=	2.03 k-A
	R_{sc}	=	44.7 ft.
15 kV system	H_{av}	=	15.0 ft.
	r	=	0.75 in. (1.5 in. tube)
	ICFO	=	110 kV (BIL)
	Z	=	370.4 ohms
	I_{oc}	=	0.653 kA
	R_{sc}	=	21.0 ft.

The critical current magnitudes involved based on BIL and Z are small for these voltages. All the statistical information available indicates that less than 1% of all lightning strokes have a current magnitude of 5 kA or less, and less than 0.1% of all strokes have current magnitudes of less than 2 kA.

A fixed minimum useful critical striking distance (R_{sc}) of 60 ft. is recommended for 115 kV and below in light of the following considerations. This will provide shielding from direct strokes with current magnitudes above 3.2 kA.

i) The total area of the substation occupied by lower voltage equipment is usually small. This, combined with the statistics showing that less than 1% of all lightning strokes has current magnitudes less than 5 kA, indicates that the probability of the lower voltage equipment actually being struck by lightning which penetrates the shielding is small.

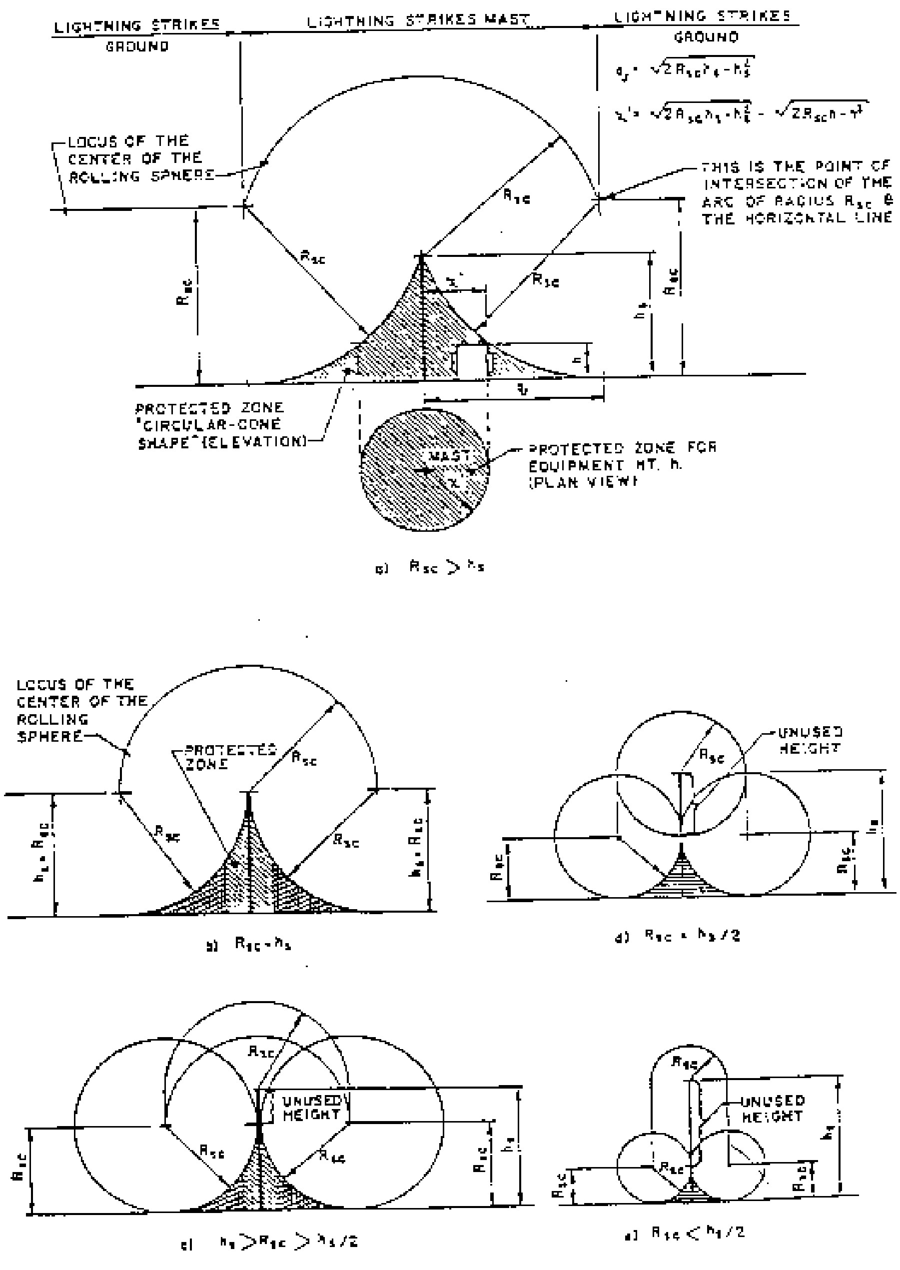
ii) The lower voltage equipment is usually not very tall.

iii) The lower voltage equipment is usually connected to a transformer which will normally have arresters connected to it. The arrester will provide protection against flashover for the area in most cases.

iv) The consequences (equipment damage, system stability, etc.) of a flashover in a lower voltage section of the station are normally not as severe as those for a flashover of transmission level equipment.

APPENDIX 3: Protected Zone for A Single Mast of Height(h_s)

The following sketches (Figure 9) illustrate graphically the zone of protection provided by a single mast of height h_s for various values of the radius of the rolling sphere. The single mast provides a "Circular Cone-Like" shaped protected zone.



PROTECTED ZONE FOR A SINGLE MAST OF HEIGHT
Figure 9

APPENDIX 4: Protected Zone for A Single Wire of Height (h_s)

The following sketches (Figure 10) illustrate graphically the zone of protection provided by a single wire of height h_s for various values of the radius of the rolling sphere (R_{sc}). The single wire provides a "Circular Tent like" shaped protected zone.

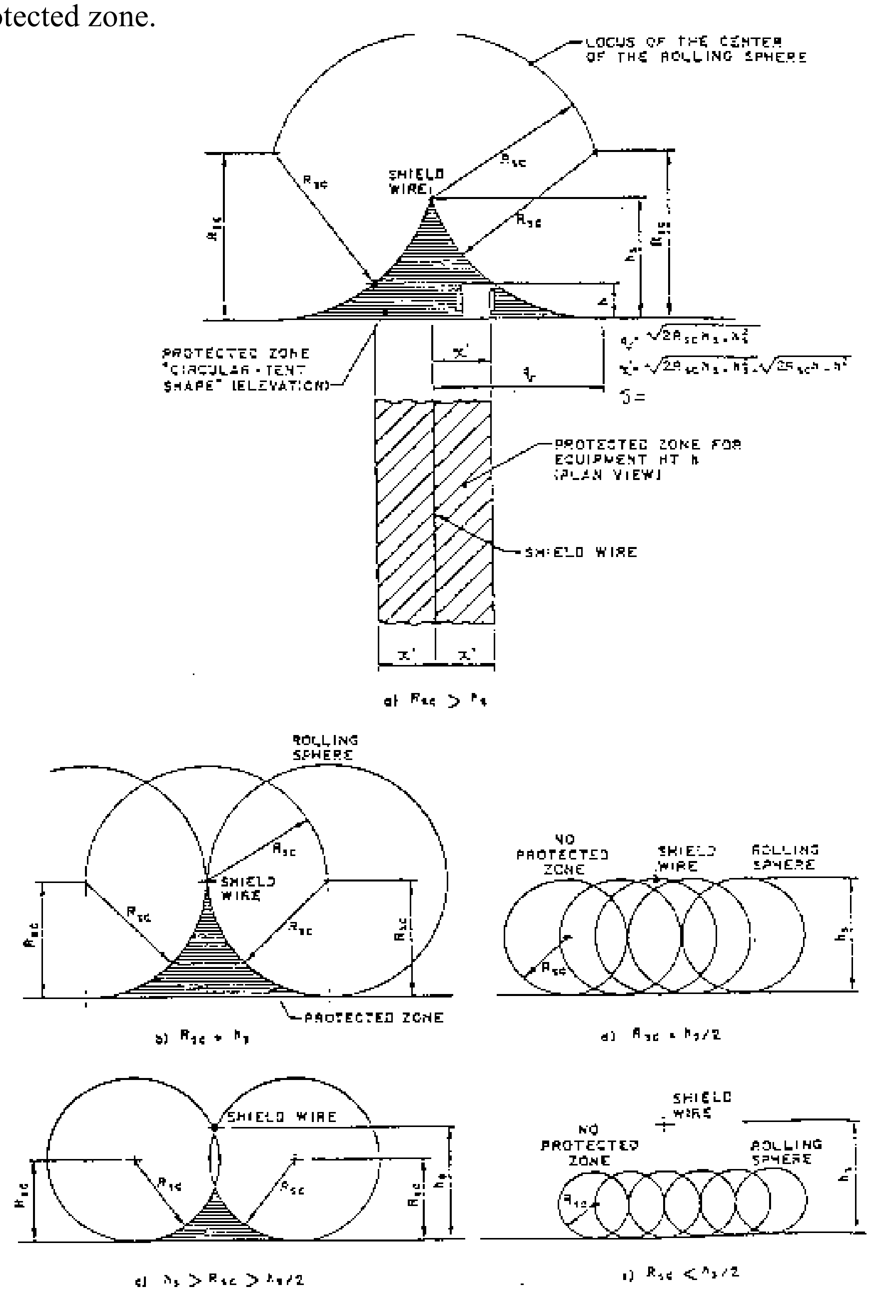


FIG 10 PROTECTED ZONE FOR A SINGLE SHIELD WIRE OF

PROTECTED ZONE FOR A SINGLE SHIELD WIRE OF HEIGHT (h_s) FOR A GIVEN R_{sc}
Figure 10

APPENDIX 5: Protected Zone for A Pair of Parallel Shield Lines

Parallel shield wires will provide a protected zone as shown in Figure 11. If it is desired to provide shielding such that equipment of height “h” is shielded anywhere between the two wires, the low point of the protected zone is set equal to “h”.

Since the Rolling Sphere "rests" on the wires, the distance between the shield height and the low point of the protected zone depends only on R_{sc} and “s”, the spacing between the shield wires. This distance between the shield height and the low point of the protected zone is defined as the “super-elevation”, “b”, of the shield wires over the low point of the protected zone.

To set the low point of the protected zone equal to “h”, the super-elevation “b” is set equal to the height of the shield wires minus the height of the protected equipment:

$$b = h_s - h$$

Then the proper spacing of the shield wires, “I_s” must be determined for that value of “b”, either graphically or from the equation:

$$s = 2\sqrt{(2 \times b \times R_{sc}) - b \times b}$$

This equation is valid for “s” less than $2R_{sc}$.

If the diameter of the Rolling Sphere is less than the spacing of wires, the two wires no longer interact and should be checked individually. It is recommended that “s” be less than $1.33R_{sc}$. This will typically be achieved if the spacing is made to be approximate the bay width at 230 kV and above.

If the spacing “s” is already fixed, the required super-elevation “b” can .be determined graphically or from the equation:

$$b = R_{sc}\left(1-\left(1-\sqrt{\frac{0.5s}{Rsc}}\right)\right)$$

This equation is valid for “s” less than $2R_{sc}$.

The above discussion applies only to the area between the shield wires. For the areas outside the last shield wire, refer to the method for a single shield wire.

Appendix 5

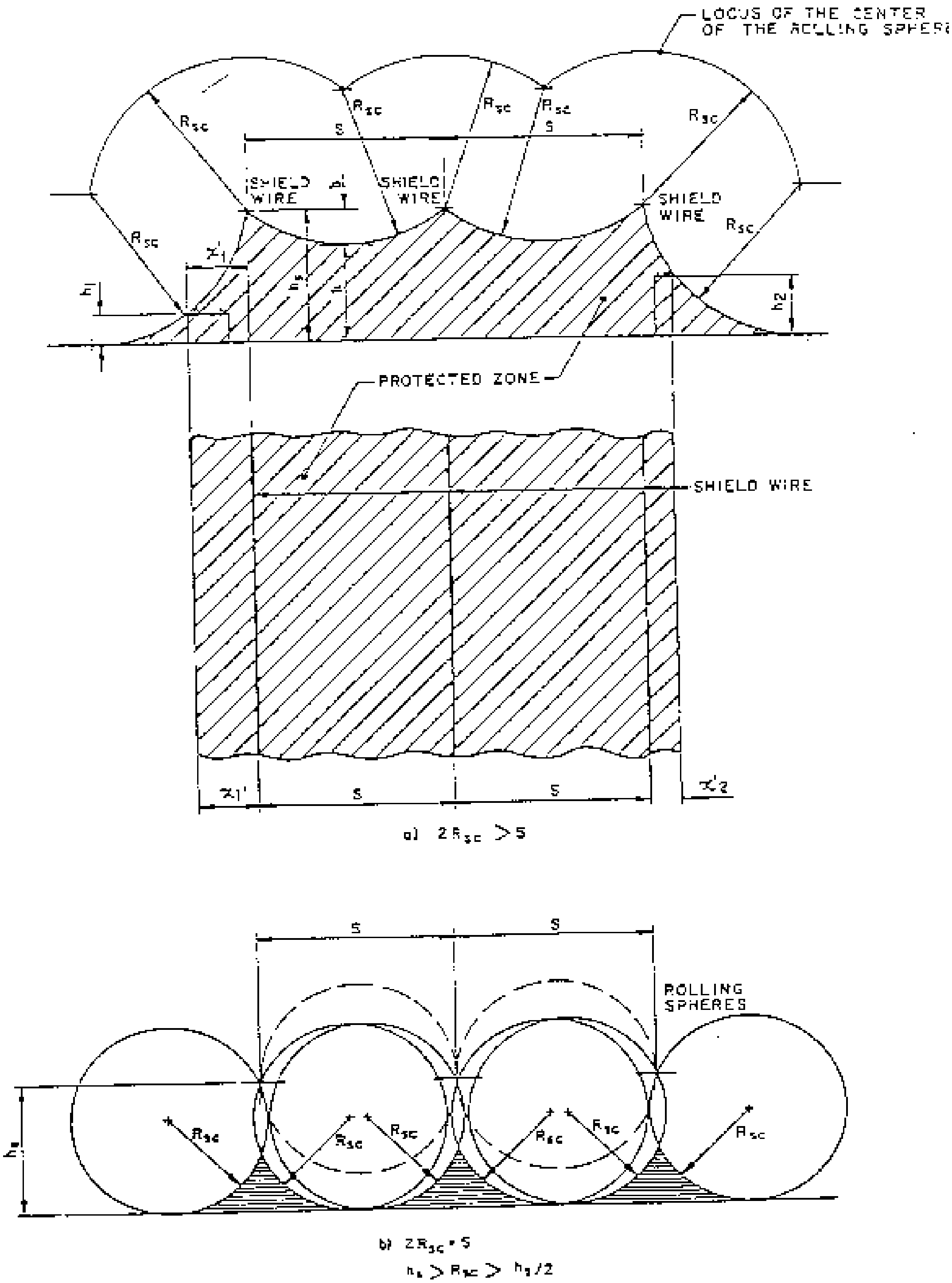


FIG 11 PROTECTED ZONE FOR TWO OR MORE PARALLEL SHIELD WIRES

OUTDOOR SUBSTATION DIRECT STROKE LIGHTNING PROTECTION

Rolling Sphere Example:

$$R_{sc} = 47.2\left(\frac{ICFO}{Z}\right)^{2/3} \text{ ft}$$

$$\text{where } Z = 60\ln\left(\frac{2H_{av}}{r}\right)\ \Omega$$

Using *ICFO* = 550 BIL, 5" BUS and 27' avg. bus height in area concerned,

$$Z = 60\ln\left(\frac{2\times 27'}{0.208'}\right)$$

$$Z = 333\ \Omega$$

$$R_{sc} = 47.2\left(\frac{550}{333}\right)^{2/3} \text{ ft}$$

$$R_{sc} = 47.2\times 1.40 = 66' \text{ for } 115 \text{ kV}$$

R_{sc} of 60' should be used for the distribution area.

For the static wire,

$$S = 2\sqrt{(2(50'-27')\times 66') - (50'-27')^2} = 100\text{ft spacing}$$

where, h_s = 50' (height of shield wires, and
h = 27' (height of protected equipment).

For the shield poles,

$$S = 2\sqrt{(2(60'-27')\times 66') - (60'-27')^2} = 114.3\text{ ft spacing}$$

where, hs = 60' (height of shield pole, and
h = 27' (height of protected equipment).

1. Phase Marking

1.1. The preferred arrangement and phase sequence marking of buses in three phase assembled switchgear shall be A - B - C from front to back, top to bottom, or left to right, as viewed from the circuit breaker operating mechanism side. This is in accordance with NEMA standard publication no. SG2-3-1950 standards for power switchgear assemblies.

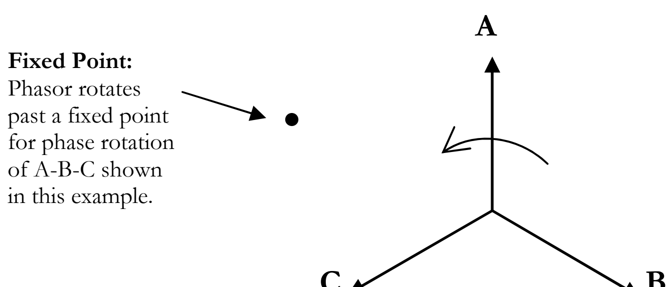
1.2. The arrangement of other buses, such as those in outdoor substations, shall always have the "B" phase in the center. When a transformer(s) is present or planned, it will determine the location of "A" and "C" phases. H1 and X1 will be connected to A-phase. If this is not easily done, then further discussion with the project engineer will be required. When the phase sequence of a transformer(s) does not determine the arrangement, the buses shall be A - B - C from south to north, west to east, and top to bottom.

It is also preferred that the phase sequencing in the N-S and E-W directions match from one voltage area of the substation to another. To do so, may require an exception to the phase match preference indicated in the paragraph above An exception to the phase match preference could be caused due to multiple voltages within the substation. See Figure 2 for two examples of these types of situations.

Caution should be taken when three-phase transformers are located with the high voltage sides in opposite directions. This may require difficult phase swapping to keep the A-phase on the H1 and X1 bushings. If all options for phase-swapping have been exhausted, further discussion will be required before proceeding.

1.3. Circuit breakers should normally be oriented so that bushings 1 and 2 are on A-phase. There may be occasions where this in not practical.

1.4. Except for the transformer phase sequence, section 1.2 above does not apply to EHV installations (345 kV and above). Bus phasing shall be arranged to match the line phasing.



Phase Rotation
FIGURE 1

2. Interconnected Companies – Phase Rotations

Phasing information for interconnected companies should always be verified with the specific company for each specific line or location.

3. Marking Phases in Stations

3.1. Phase markings will consist of a capital letter A - B - C.

3.2. Method of marking

Phase designations will usually be marked with stencils. Plastic, engraved symbols and stamped, metallic symbols may also be used.

3.3. Frequency of phase markings

Phases should be marked in a sufficient number of places so the phase relation of all equipment can be readily identified. However, a phase marking should not be applied to each piece of equipment.

3.4. Location of phase markings

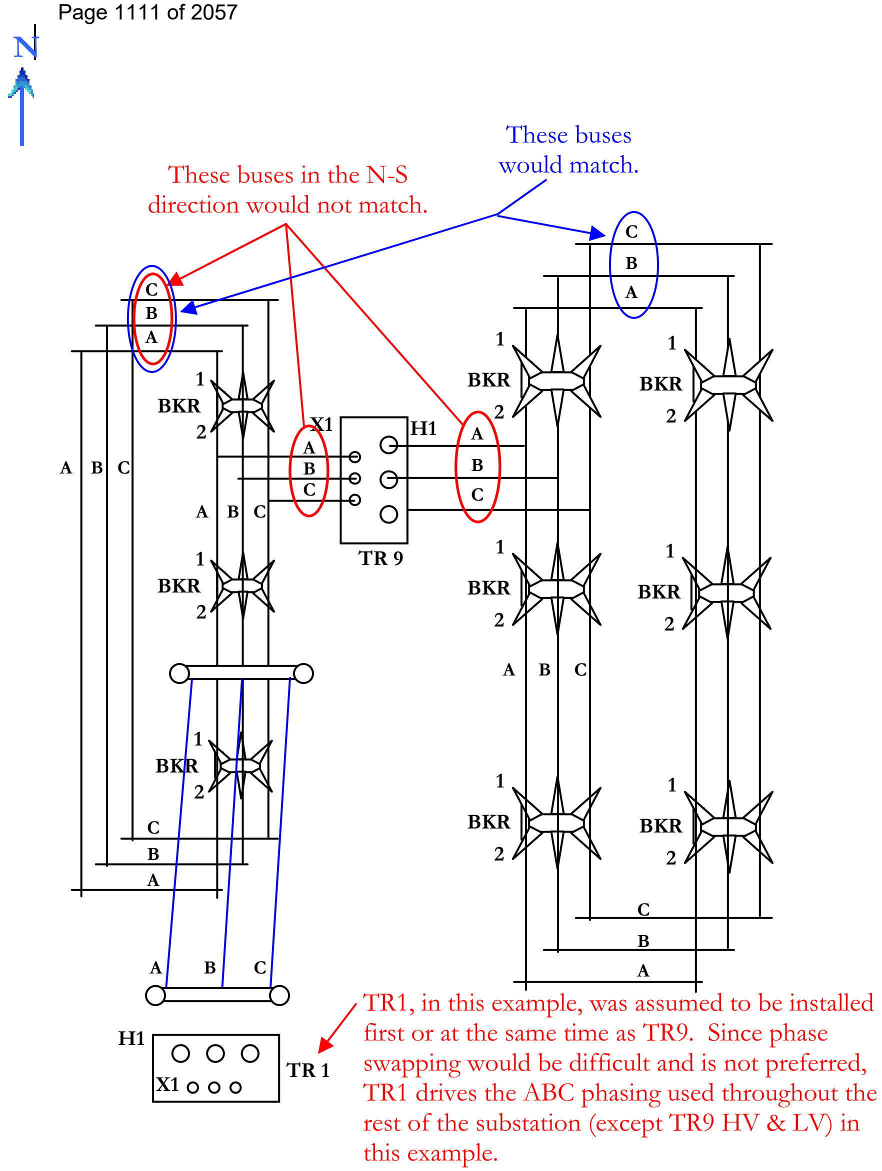
3.4.1. On the larger outdoor substations, the phases should normally be marked on circuit breakers, near all bushings of a three-phase transformer, and wherever else it appears desirable. On the smaller substations, the phases should normally be marked on a steel or wood structure - in preference to marking single-phase transformers or other equipment which may be replaced at relatively frequent intervals.

3.4.2. On indoor stations, the buses should be identified, but if practicable, the markings should be on a de-energized part of the installation. The phases should also -be marked near outgoing line terminations and wherever else it appears desirable.

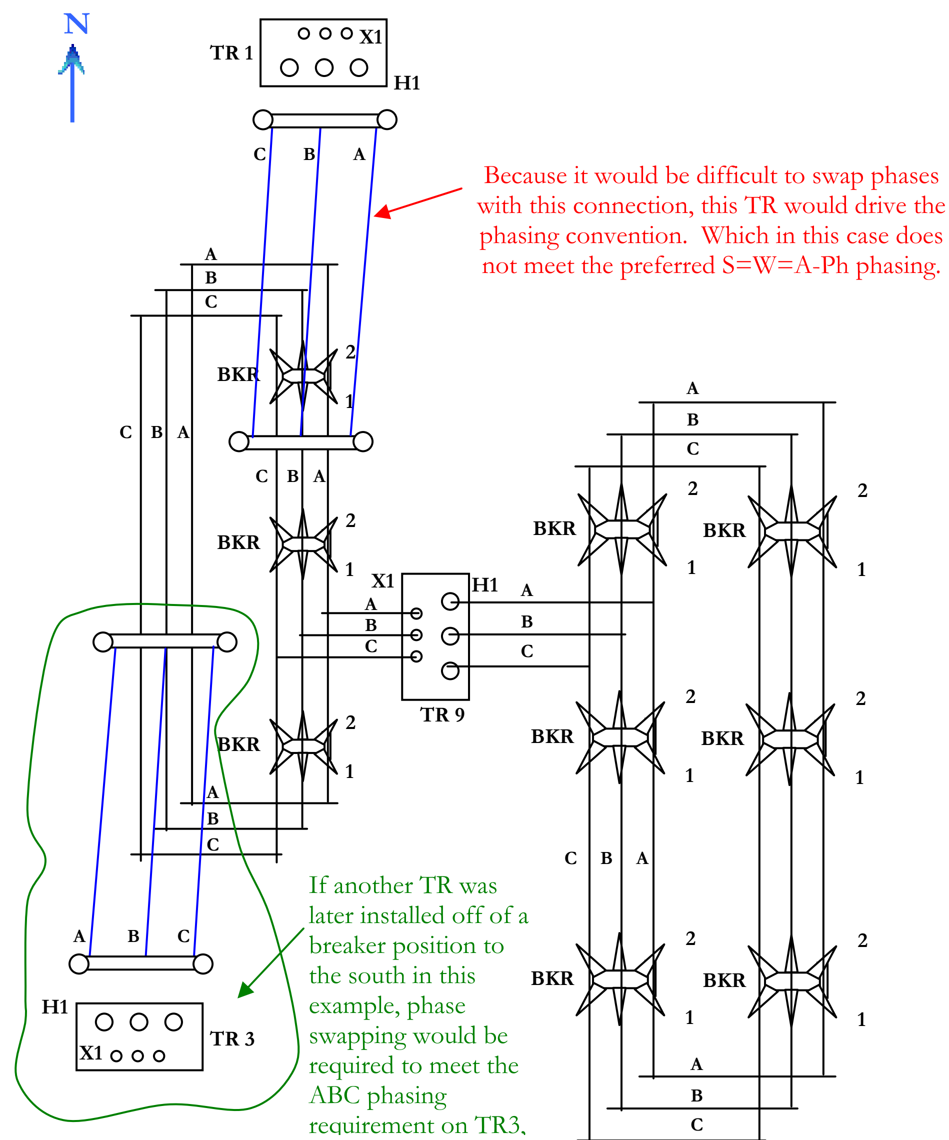
3.4.3. Where relays, protective devices, or meters are associated with a particular phase, they should be identified with phase markings. The nameplates used for relays will include device number and phase identification when appropriate.

3.4.4. Phase markings should never be located on removable doors, circuit breaker oil tanks, etc. where the phase markings may be interchanged.

3.4.5. Whenever practical, phase markings should not be located on or near the energized parts of equipment.



Example 1
Situation where for the most part S = W = A-Ph for all but the buses connecting TR 9.



Example 2
Situation where all TR Phasing and buses match, but it is not the preferred S = W = A-Ph phasing

FIGURE 2

Instruction for Marking Phases in Stations

Xcel Energy - North	Date: 11/11/2011	Approved: SJM/JMT	Rev. 2	**Substation Engineering & Design Standards**	
				Sheet 3 of 3	**ED 4.01.05.01**

SUBSTATION TUBULAR BUS CRITERIA

TABLE OF CONTENTS

1. Introduction

This standard provides allowable tubular bus spans for typical Xcel Energy substation configurations and analyzes these typical bus layouts. Results from this analysis are in the form of tables that can be used to layout a substation. If the desired layout does not meet all aspects of the criteria, detailed analysis of the electrical and structural requirements will be necessary.

In the process of developing the standard, it was apparent that too many tables would be produced due to the number of variables. The tables provided at the end of this document are not meant to satisfy all anticipated Xcel Energy substation layouts, but will meet the needs of a majority of typical layouts.

2. Scope

This standard covers outdoor distribution and transmission substations which meet all criteria as defined in this standard. If a substation does not meet **all** criteria, calculations must be performed to determine an acceptable bus span length.

The following tables can be found at the end of this standard.

The criteria that are set forth in this document are agreed upon by civil and electrical entities and are to be strictly followed. Therefore, if a bus span is to be used or analyzed and the criteria fall outside the scope of this document, engineers shall determine the electrical and structural requirements of the configuration.

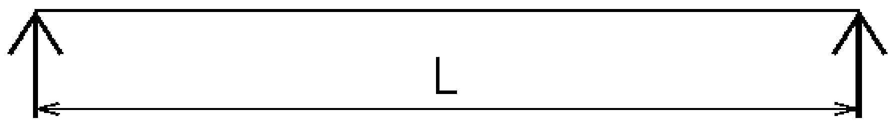
3. Definition of Terms

3.1. Span

Span is the allowable length of bus that can be supported by either a switch, a bus support or an A-frame tap. In the case of the bus supports and A-frame taps, the span is measured to the center-line of the supporting member. When switches are involved the span is measured from the middle of the switch pad.

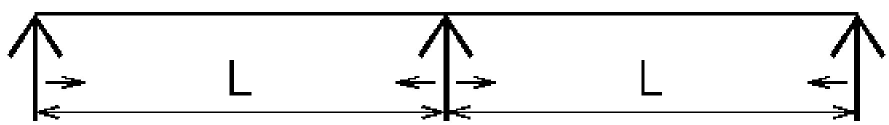
3.1.1. Single Span

A single span is a length of bus with two supports, one at each end.



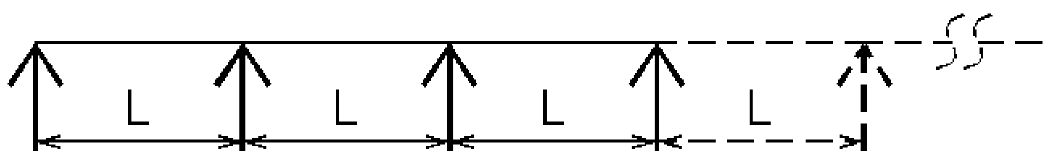
3.1.2. Double Span

A double span is a continuous length of bus with three supports. The spans can either be equal or unequal. If unequal spans are considered, the center support may be moved up to 20% of L along the bus in either direction and an end support may freely move towards the center support.



3.1.3. Multiple Span

A multiple span is a continuous length of bus with four or more supports. There is one support at each end and intermediate supports that divide the bus into three or more equal spans. If unequal spans are considered, the center and end supports may be moved as long as no single span is more than the allowable maximum span L.



4. Support Conditions

The support conditions of a bus span are either pinned or fixed connections to a supporting element.

4.1.1. Pinned Connection

In a pinned connection, moment is not transferred to the supporting member. In the case of a bus fitting over a bus support, the span is continuous and is considered a pinned connection even though it may be tack welded.

Examples: bus fittings over bus supports, expansion fittings on switches, A-frames

4.1.2. Fixed Connection

In a fixed connection, moment is transferred to the supporting member. In this standard, a fixed connection at the switch pad only transfers moment from vertical loads only.

Example: bus bolted directly to switch pad

4.2. Overbus and Underbus

Overbus and underbus loads are tap points from bus spanning perpendicular to a particular bus span. The placement of this point-load in the span varies with each configuration. The values in the tables represent overbus placed at mid-span.

Note: The placement of overbus in a span which has a fixed switch fitting should not be used; this **wi**ll always result in over-stressing the switch pad.

4.3. Bus Support

A bus support is assumed as a station post insulator for the purpose of this standard.

5. Design Criteria

5.1. Electrical Criteria

5.1.1. Voltage Classes

The following voltage classes (kV) were considered for this standard:

12.5/13.8
23
34.5
69
115
161
230
345

5.1.2. Fault Current

A maximum fault current value was determined for each voltage class considered in this standard. The maximum fault current selected for distribution voltages is based on typical transformer impedances and sizes utilized in most Xcel Energy distribution substations. The maximum fault current selected for transmission voltages (69 kV and above) is based on reasonably expected fault currents in Xcel Energy's system. Listed below are the selected fault currents for each voltage class:

Voltage Class (kV)	Basis for Selection	Selected Maximum Fault Current (kA)
12.5/13.8	3 - 28 MVA @ 7.5% 3 - 47 MVA @ 10.5% 2 - 70 MVA @ 10.5%	30
23	2 - 70 MVA @ 10.5%	20
34.5	2 - 70 MVA @ 7.5%	20
69	2 - 115/69 kV - 70 MVA @ 4%	20
115	Metro Area Loop Metro Area Loop Non-Metro Loop	63 40 23
161	Non-Metro Loop Eau Claire Substation (plus growth)	30 23
230	Metro Area Loop Non-Metro Loop Non-Metro Loop	40 30 23
345	Metro Area Loop Non-Metro Loop Non-Metro Loop	40 30 23

5.1.3. Phase Spacing

Phase spacing was taken from Xcel Energy standards ED 4.02.02.02 and ED 4.02.02.03 based upon current Xcel Energy standard substation design. The following table lists the minimum phase spacing used in this standard. Larger phase spacing may be used.

Voltage Class (kV)	Phase Spacing (feet)	
	w/o switches	w/ switches
12.5/13.8	3'-0"	4'-0"
23	3'-6"	5'-0"
34.5	3'-6"	6'-0"
69	5'-0"	8'-0"
115	8'-0"	10'-0"
161	9'-0"	14'-0"
230	16’-0”	16’-0”
345	16’-0”	16’-0”

5.2. Bus Type & Material

All tubular bus is formed using 6063-T6 aluminum alloy that has an allowable stress limit of 25,000 psi for bending. This standard is valid for the following aluminum tubular bus types at the selected voltage classes:

Voltage Class (kV)	Bus Type
12.5/13.8	3 1/2" & 5" Sch. 40
23	3 1/2" & 5" Sch. 40
34.5	3 1/2" & 5" Sch. 40
69	3 1/2" & 5" Sch. 40
115	3 1/2", 5", & 6" Sch. 40
161	3 1/2", 5", & 6" Sch. 40
230	3 1/2", 5", & 6" Sch. 40
345	3 1/2", 5", & 6" Sch. 40

5.3. Loading Conditions

All bus calculations were done with three loading conditions:

Load Case #1: 40 mph wind, short circuit load and 1/2" radial ice (influences load on fixed connection at switches)

Load Case #2: 90 mph wind, short circuit load and no ice (influences horizontal load on switches and bus supports)

Load Case #3: Self weight of the bus (used for normal deflections)

5.4. Equations

5.4.1. Wind Equations: The horizontal force on the bus due to wind (Ref. 3 and 5)

Load Case 1:

$$\mathrm{Wind}_{40mph} := (4psf)\cdot\frac{\mathrm{Bus}_{OD} + 2\cdot I}{12}$$

Load Case 2:

$$\mathrm{Wind}_{90mph} := 0.00256k_z\cdot G_{RF}\cdot V^2\cdot\frac{\mathrm{Bus}_{OD}}{12}$$

Where:

Wind_{mph} = Wind load, lb/ft
V = Wind velocity, 90 mph
Bus_{OD} = Outer diameter of bus, inches
I = Radial ice thickness, ½ inches
k_z = Velocity pressure exposure coefficient, 0.92 for bus under 33 ft in elevation.
GRF = Gust response factor, 1.0

5.4.2. **Short Circuit Equation:** The horizontal force on the bus due to short circuitforce (IEEE Std 605-1998, Ref. 2):

$$F_{sc} := \frac{5.4\,\Gamma\cdot\left(D_f\cdot\sqrt{2}\cdot I_{sc}\right)^2}{10^7\cdot D}$$

Where:

F_{sc} = Short circuit load on bus, lb/ft
I_{sc} = Fault current, amps
D = Bus phase spacing, inches
D_f = Decrement factor, 1.6
□ = constant based on fault type, 1.0

5.4.3. **Ice Load Equation:** The vertical load on the bus due to ice load (Ref. 1):

$$W_{ice} := \left(\gamma_{ice}\right)\cdot\left(\frac{\pi}{4}\right)\cdot\left[\left(\frac{Bus_{OD} + 1\cdot in}{12}\right)^2 - \left(\frac{Bus_{OD}}{12}\right)^2\right]$$

Where:

W_{ice} = Weight of ice on bus, lb/ft
γ_{ice} = Weight of ice, 57 lb/ft^3
Bus_{OD} = Outer diameter of bus, inches

5.5. Switch Pad Moment Capacity

The allowable switch pad moment capacity for all types of switches at all voltage classes being considered in this standard is assumed to be a minimum of 4000 in-lb due to vertical loads only. This capacity affects bus span when there is a fixed connection to a switch pad. A value of 4000 in-lb was decided to be the minimum acceptable pad moment strength and the maximum design moment capacity by Xcel Energy and switch manufacturers.

5.6. Horizontal Load Capacities of Switches

The following table lists the allowable horizontal loads at the switch pad allowed in this standard:

Voltage Class (kV)	Allowable Horizontal Switch Load (lbs.)
12.5/13.8	1,039
23	805
34.5	657
69	423
115	1,050
161	939
230	672
345	477

The controlling horizontal load capacities of the switches listed in the table were provided by USCO Power Equipment Corporation switches and are a function of the weakest component of the switch (insulator, bearing, etc.). These are not operational loads and are higher than ANSI C37.32 allowable terminal pad loads.

5.7. Horizontal Load Capacities of Insulators (Cantilever Strength)

The following table lists the ultimate horizontal loads applied at the top of the insulator allowed in this standard:

Voltage Class (kV)	Ultimate Horizontal Standard Strength Insulator Load (lbs.)	Ultimate Horizontal High Strength Insulator Load (lbs.)	Ultimate Horizontal Extra High Strength Insulator Load (lbs.)
12.5/13.8	2,000	Not Used	Not Used
23	2,000	Not Used	Not Used
34.5	2,000	Not Used	Not Used
69	1,500	Not Used	Not Used
115	1,700	2,600	4,500
161	1,200	1,850	Not Used
230	950	1,450	Not Used
345	1,000	1,450	2,000

Notes:

Overload factors for ultimate design are as follows: 2.5 for wind, 1.0 for short circuit.

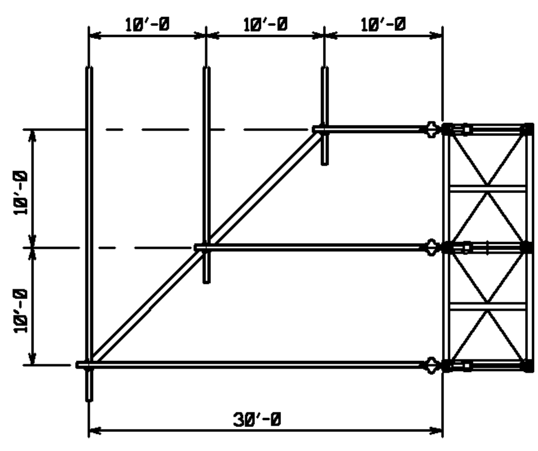
The bolt hole size and pattern changes for 115kV extra high strength insulators and for 345kV high strength insulators. To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.

5.8. Overbus/Underbus Loads

The loads applied at an overbus/underbus tap point are treated as vertical point-loads on the span. It is assumed that the combined effects of short circuit loads acting simultaneously on the overbus and underbus are a less critical case for bus design and are not considered in this standard. The loads that were used for design are summarized in the following table:

Voltage Class (kV)	Bus Size	Overbus Span (ft.)	Overbus/Underbus Point-Load w/ No-Ice (lbs.)
12.5/13.8, 23, 34.5, 69, 115	3 1/2"	30	85
12.5/13.8, 23, 34.5, 69, 115	5"	30	125
115	6"	30	140
161	3 1/2"	40	105
161	5"	40	145
161	6"	40	175
230, 345	3 1/2"	40	160
230, 345	5"	40	200
230, 345	6"	40	230

The amount of weight that the vertical point-load induces is dependent on the voltage class and span arrangements. The overbus arrangement is an A-frame tapping up to a bus spanning perpendicular to the main bus. This perpendicular bus is assumed to span to either a switch or a bus support. Half of the overbus span plus the weight of the A-frame makes up the vertical point-load on the main bus span. For example*, in the case of 115kV with standard ten foot phase spacing, the overbus span would be 30 feet of bus: two ten foot phase spacing plus one more phase spacing to the next support. Also, for the 115kV class, there would be approximately 18 feet of two and a half inch bus in the A-frame. This brings the total vertical point-load to roughly 125 lb. For load cases with ice, the vertical point-load is doubled. The loads at 161kV, 230kV, and 345kV are greater because of larger phase spacing.



*115 kV Example

5.9. Bus Deflection

The vertical deflection of the bus was defined to be an aesthetic issue in bus span design. Deflection criteria for rigid bus shall be L/200, where L is the length of span between supports, with the exception of bus in a simple span with overbus where the deflection will be limited to L/150. Deflections should be considered on bus without ice. Ice loads are considered temporary and should not be included.

6. Calculations

6.1. Single Span Calculations

Calculations must be performed if the substation bus configuration does not meet all of the criteria in this standard. The following equations should be used (All equations are general structural equations, Ref. 4):

6.1.1. Single Span without Overbus

6.1.1.1. Fixed-Pinned End Conditions

a) Moment at Switch with Fixed Fitting:

$$M := \frac{3 \cdot W_{ice} \cdot L^2}{2}$$

Where:

M	=	Moment at switch with fixed fitting, in-lb.
W_{ice}	=	Uniform vertical load on bus including 1/2" ice and self weight, lb/ft
L	=	Span, ft.

b) Maximum Horizontal Load:

$$H := \frac{1}{2} \cdot \left(Wind_{90} + F_{sc}\right) \cdot L$$

Where:

H	=	Horizontal reaction at the switch, lb
$Wind_{90}$	=	90 mph wind load on the bus, lb/ft
F_{sc}	=	Fault current load on the bus, lb/ft
L	=	Span, ft.

c) Maximum Vertical Load (at Fixed End):

$$V := \frac{5 \cdot W_{ice} \cdot L}{8}$$

Where:

V = Vertical reaction at the switch, lb
W_{ice} = Uniform vertical load on bus including 1/2" ice and self weight, lb/ft
L = Span, ft.

d) Normal Deflection:

$$\Delta := 9.34 \frac{W_{no\_ice} \cdot L^4}{E \cdot I}$$

Where:

Δ = Deflection of bus, inches
W_{no_ice} = Self weight of bus, lb/ft
L = Span, ft.
E = Modulus of elasticity of bus, 10,000,000 psi
I = Moment of inertia of bus, in^4

e) Fiber Stress Moment: Use the greater of the following two equations:

Load Case 1:

$$M := 12 \sqrt{\left(W_{ice} \cdot \frac{L^2}{8}\right)^2 + \left[\frac{\left(Wind_{40mph} + F_{sc}\right) \cdot L^2}{8}\right]^2}$$

Load Case 2:

$$M := 12 \sqrt{\left(W_{no\_ice} \cdot \frac{L^2}{8}\right)^2 + \left[\frac{\left(Wind_{90mph} + F_{sc}\right) \cdot L^2}{8}\right]^2}$$

The maximum moment can then be used to determine the stress in the bus:

$$\sigma := \frac{M}{S}$$

Where:

M	=	Maximum moment in bus, in-lb
W_{ice}	=	Uniform vertical load on bus including 1/2" ice and self weight, lb/ft
W_{no_ice}	=	Self weight of bus, lb/ft
L	=	Span, ft.
$Wind_{mph}$	=	Wind load, lb/ft
F_{sc}	=	Fault current load on the bus, lb/ft
σ	=	Stress in the bus, lb/in^2
S	=	Section modulus of the bus, in^3

6.1.1.2. Pinned-Pinned End Conditions

a) Maximum Horizontal Load Either End:

$$H := \frac{1}{2} \cdot \left(Wind_{90} + F_{sc} \right) \cdot L$$

Where:

H	=	Horizontal reaction at either end, lb
$Wind_{90}$	=	90 mph wind load on the bus, lb/ft
F_{sc}	=	Fault current load on the bus, lb/ft
L	=	Span, ft.

b) Maximum Vertical Load:

$$V := \frac{W_{ice} \cdot L}{2}$$

Where:

V	=	Vertical reaction at either end, lb
W_{ice}	=	Uniform vertical load on bus including 1/2" ice and self weight, lb/ft
L	=	Span, ft.

c) Normal Deflection:

$$\Delta := 22.5 \cdot \left(\frac{W_{no\_ice} \cdot L^4}{E \cdot I} \right)$$

Where:

Δ	=	Deflection of bus, inches
W_{no_ice}	=	Self weight of bus, lb/ft
L	=	Span, ft.
E	=	Modulus of elasticity of bus, 10,000,000 psi
I	=	Moment of inertia of bus, in^4

d) Fiber Stress Moment: Use the greater of the following two equations:

Load Case 1:

$$M := 12 \sqrt{\left(W_{ice} \cdot \frac{L^2}{8} \right)^2 + \left[\frac{\left(Wind_{40mph} + F_{sc} \right) \cdot L^2}{8} \right]^2}$$

Load Case 2:

$$M := 12 \sqrt{\left(W_{no\_ice} \cdot \frac{L^2}{8} \right)^2 + \left[\frac{\left(Wind_{90mph} + F_{sc} \right) \cdot L^2}{8} \right]^2}$$

The maximum moment can then be used to determine the stress in the bus:

$$\sigma := \frac{M}{S}$$

Where:

M	=	Maximum moment in bus, in-lb
W_{ice}	=	Uniform vertical load on bus including 1/2” ice and self weight, lb/ft
W_{no_ice}	=	Self weight of bus, lb/ft
L	=	Span, ft.
$Wind_{mph}$	=	Wind load, lb/ft
F_{sc}	=	Fault current load on the bus, lb/ft
σ	=	Stress in the bus, lb/in^2
S	=	Section modulus of the bus, in^3

6.1.2. Single Span with Overbus

6.1.2.1. Pinned-Fixed End Conditions

This calculation always results in the moment at the switch exceeding the 4000 in-lb switch pad capacity. Therefore, an expansion fitting must be used at the switch.

6.1.2.2. Pinned-Pinned End Conditions

a) Maximum Horizontal Load Either End:

$$H := \frac{1}{2}\cdot\left(Wind_{90} + F_{sc}\right)\cdot L$$

Where:

H = Horizontal reaction at either end, lb
$Wind_{90}$ = 90 mph wind load on the bus, lb/ft
F_{sc} = Fault current load on the bus, lb/ft
L = Span, ft.

b) Maximum Vertical Load:

$$V := \frac{W_{ice}\cdot L}{2} + \frac{P_{ice}}{2}$$

Where:

V = Vertical reaction at either end, lb
W_{ice} = Uniform vertical load on bus including 1/2" ice and self weight, lb/ft
P_{ice} = Overbus load with ice, lb.
L = Span, ft.

c) Normal Deflection:

$$\Delta := 22.5\cdot\left(\frac{W_{no\_ice}\cdot L^4}{E\cdot I}\right) + \frac{P_{no\_ice}\cdot L^3}{48\cdot E\cdot I}$$

Where:

Δ = Deflection of bus, inches
W_{no_ice} = Self weight of bus, lb/ft
L = Span, ft.
P_{no_ice} = Overbus load without ice, lb.
E = Modulus of elasticity of bus, 10,000,000 psi
I = Moment of inertia of bus, in^4

d) Fiber Stress Moment: Use the greater of the following two equations:

Load Case 1:

$$M := 12\sqrt{\left(W_{ice}\cdot\frac{L^2}{8} + P_{ice}\cdot\frac{L}{4}\right)^2 + \left[\frac{\left(Wind_{40mph} + F_{sc}\right)\cdot L^2}{8}\right]^2}$$

Load Case 2:

$$M := 12\sqrt{\left(W_{no\_ice}\cdot\frac{L^2}{8} + P_{no\_ice}\cdot\frac{L}{4}\right)^2 + \left[\frac{\left(Wind_{90mph} + F_{sc}\right)\cdot L^2}{8}\right]^2}$$

Where:

M	=	Maximum moment in bus, in-lb
W_{ice}	=	Uniform vertical load on bus including 1/2" ice and self weight, lb/ft
W_{no_ice}	=	Self weight of bus, lb/ft
P_{ice}	=	Overbus load with ice, lb.
P_{no_ice}	=	Overbus load without ice, lb.
L	=	Span, ft.
$Wind_{mph}$	=	Wind load, lb/ft
F_{sc}	=	Fault current load on the bus, lb/ft

6.2. Double or Multiple Span Calculations

The equations for double and multiple spans are not easily written. The procedure for determining span reactions, deflections and moments should be done using a structural analysis program.

7. Explanation of Bus Span Tables

The tables present maximum spans that meet allowable design considerations that have been presented in this document. The spans were analyzed by modeling the supports, end conditions and members. Loads were applied to a model to determine the structural capacity. Normal deflections, stress and support reactions were checked against allowable values.

8. Assumptions and Recommended Practices

The lessons learned in the process of establishing this standard are numerous and complex. The following are some lessons that played roles in the forming of this standard.

1) <u>Switch as a Structural Component</u>

A switch is made up of several independent structural components including the pad, the insulators, the base, and the blade and jaw. It is not possible to accurately model the switch as a single structural component.

2) Switch Pad Capacity

This can be simply stated as " the stronger the pad the longer the span". Different switch manufactures have structurally stronger pads than others. A value of 4000 in-lb was decided to be the minimum acceptable pad moment strength and the maximum design moment capacity.

3) Expansion Fittings

The typical expansion fitting will relieve the switch pad of moment. The expansion fitting can be structurally installed with the fins orientated vertically or horizontally. However, for clearance purposes, Xcel Energy practice is to install the fins horizontal. Pullout of the bus from the expansion fitting was determined not to be an issue provided it is installed properly. On single span switch to switch configurations (both switches having expansion fittings), there should be a 1.25" gap between the casting face and the bus end. Other configurations should follow the manufacturer recommendations for installation.

4) Bus Deflection

The vertical deflection of the bus was determined not to be of paramount importance. The aesthetics of the bus deflection does not have to limit the span of the bus. However, for this standard, the deflection criteria for rigid bus shall be L/200, where L is the length of span between supports, with the exception of bus in a simple span with overbus where the deflection will be limited to L/150.

5) Breaker and Transformer Bushing Connections

When connecting directly to a breaker or transformer bushing, it is recommended to use a flexible jumper rather than a rigid bus connection. This standard does not include rigid bus connections to breaker or transformer bushings.

9. References

(1) Beer, F.P. and Johnston, E.R., "Mechanics of Materials", 2nd Edition, 1991.

(2) "IEEE Guide for Design of Substation Rigid-Bus Structures", ANSI / IEEE Standard 605-1998.

(3) "Civil/Structural Performance Criteria" Xcel Energy DC-F, 02/21/03.

(4) West, H.H., "Analysis of Structures", 2nd Edition, 1989.

(5) "National Electric Safety Code" IEEE C2-2002.

10. Maximum Rigid Bus Span Length Tables

The tables that follow are the applications that were analyzed for this standard.

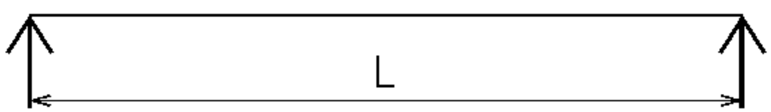
Note: The existence of IEEE 605-2008 is acknowledged. IEEE 605-2008 is a more recent standard than what is utilized in this standard. The incorporation of IEEE 605-2008 for this standard is presently in review; it may be incorporated into future versions of this standard.

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
12.5/13.8	30	3'-0	3.5”	Standard	21'-0	0.12	LF1	23'-0	0.41	LF3	23'-0	0.41	LF3
12.5/13.8	30	3'-0	5”	Standard	17'-0	0.03	LF1	26’-6	0.37	LF2	34’-0	0.99	LF3
12.5/13.8	30	4'-0	3.5”	Standard	21'-0	0.12	LF1	26'-0	0.67	LF3	26'-0	0.67	LF3
12.5/13.8	30	4'-0	5”	Standard	17'-0	0.03	LF1	34’-0	0.99	LF2	38’-6	1.63	LF3
23	20	4'-0	3.5”	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
23	20	4'-0	5”	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
23	20	5'-0	3.5”	Standard	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
23	20	5'-0	5”	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
34.5	20	4'-0	3.5”	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
34.5	20	4'-0	5”	Standard	17'-0	0.03	LF1	41'-0	2.10	LF2	43'-0	2.54	LF4
34.5	20	6'-0	3.5”	Standard	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
34.5	20	6'-0	5”	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
69	20	5'-0	3.5”	Standard	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
69	20	5'-0	5”	Standard	17'-0	0.03	LF1	31’-0	0.69	LF2	43'-0	2.54	LF4
69	20	8'-0	3.5”	Standard	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
69	20	8'-0	5”	Standard	17'-0	0.03	LF1	41'-0	2.10	LF2	43'-0	2.54	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	23	8'-0	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
115	23	8'-0	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
115	23	8'-0	6"	Standard	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
115	23	10'-0	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
115	23	10'-0	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
115	23	10'-0	6"	Standard	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
115	40	8'-0	3.5"	Standard	21'-0	0.12	LF1	27'-6	0.84	LF3	27'-6	0.84	LF3
115	40	8'-0	5"	Standard	17'-0	0.03	LF1	38'-0	1.55	LF2	40'-6	2.00	LF3
115	40	8'-0	6"	Standard	15'-6	0.01	LF1	37'-0	0.97	LF2	47'-0	2.53	LF5
115	40	10'-0	3.5"	Standard	21'-0	0.12	LF1	30'-0	1.19	LF3	30'-0	1.19	LF3
115	40	10'-0	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
115	40	10'-0	6"	Standard	15'-6	0.01	LF1	44'-0	1.95	LF2	48'-6	2.87	LF4
115	40	8'-0	3.5"	High	21'-0	0.12	LF1	27'-6	0.84	LF3	27'-6	0.84	LF3
115	40	8'-0	5"	High	17'-0	0.03	LF1	38'-0	1.55	LF2	40'-6	2.00	LF3
115	40	8'-0	6"	High	15'-6	0.01	LF1	37'-0	0.97	LF2	48'-6	2.87	LF4
115	40	10'-0	3.5"	High	21'-0	0.12	LF1	30'-0	1.19	LF3	30'-0	1.19	LF3
115	40	10'-0	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
115	40	10'-0	6"	High	15'-6	0.01	LF1	44'-0	1.95	LF2	48'-6	2.87	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	63	10	5"	Standard	17'-0	0.03	LF1	21'-0 *	0.14	LF2	30'-0	0.60	LF3
115	63	10	6"	Standard	15'-6	0.01	LF1	20'-6	0.09	LF2	29'-0	0.37	LF5
115	63	10	5"	Extra High	17'-0	0.01	LF1	21'-0 *	0.14	LF2	30'-0	0.60	LF3
115	63	10	6"	Extra High	15'-6	0.01	LF1	20'-6	0.09	LF2	37'-0	0.97	LF3

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

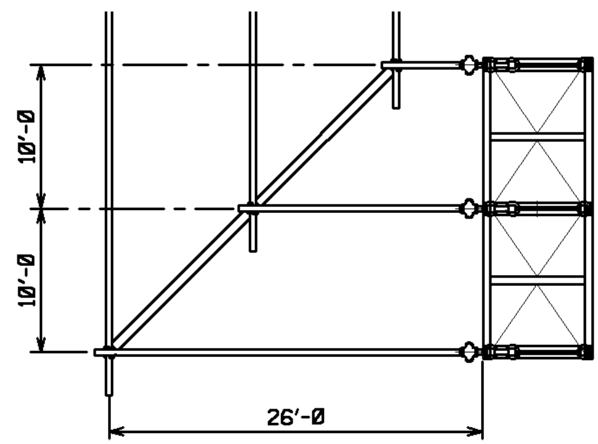
Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support

* In the case where the standard 115kV ring-bus layout is used, a 26'-0 span is acceptable from the switch pad to the 45 degree bus support for the longest of the three spans. This is possible due to the shorter adjacent spans contributing less short circuit load.

Note: The bolt hole size and pattern changes for 115kV extra high strength insulators.
To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.



* 115 kV Ring-Bus Layout

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
161	23	9'-0	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
161	23	9'-0	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	23	9'-0	6"	Standard	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
161	23	14'-0	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
161	23	14'-0	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	23	14'-0	6"	Standard	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
161	23	9'-0	3.5"	High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
161	23	9'-0	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	23	9'-0	6"	High	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
161	23	14'-0	3.5"	High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
161	23	14'-0	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	23	14'-0	6"	High	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
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Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
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Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

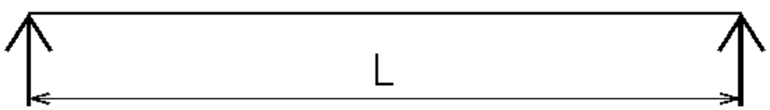
Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
161	30	9'-0	3.5"	Standard	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
161	30	9'-0	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	30	9'-0	6"	Standard	15'-6	0.01	LF1	48’-6	2.87	LF4	48’-6	2.87	LF4
161	30	14'-0	3.5"	Standard	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
161	30	14'-0	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	30	14'-0	6"	Standard	15'-6	0.01	LF1	48’-6	2.87	LF4	48’-6	2.87	LF4
161	30	9'-0	3.5"	High	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
161	30	9'-0	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	30	9'-0	6"	High	15'-6	0.01	LF1	48’-6	2.87	LF4	48’-6	2.87	LF4
161	30	14'-0	3.5"	High	21'-0	0.12	LF1	34’-0	1.96	LF4	34’-0	1.96	LF4
161	30	14'-0	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
161	30	14'-0	6"	High	15'-6	0.01	LF1	48’-6	2.87	LF4	48’-6	2.87	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

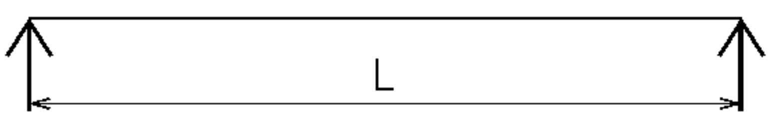
Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
230	23	16	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
230	23	16	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
230	23	16	6"	Standard	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
230	30	16	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
230	30	16	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
230	30	16	6"	Standard	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
230	40	16	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
230	40	16	5"	Standard	17'-0	0.03	LF1	42'-0	2.31	LF2	42'-0	2.31	LF5
230	40	16	6"	Standard	15'-6	0.01	LF1	38'-0	1.08	LF5	38'-0	1.08	LF5
230	23	16	3.5"	High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
230	23	16	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
230	23	16	6"	High	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
230	30	16	3.5"	High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
230	30	16	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
230	30	16	6"	High	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
230	40	16	3.5"	High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
230	40	16	5"	High	17'-0	0.03	LF1	42'-0	2.31	LF2	43'-0	2.54	LF4
230	40	16	6"	High	15'-6	0.01	LF1	40'-0	1.33	LF2	48'-6	2.87	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

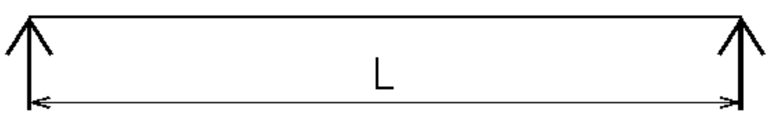
Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
345	23	16	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
345	23	16	6"	Standard	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
345	30	16	3.5"	Standard	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
345	30	16	5"	Standard	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
345	30	16	6"	Standard	15'-6	0.01	LF1	40'-6	1.40	LF2	48'-6	2.87	LF4
345	40	16	3.5"	Standard	21'-0	0.12	LF1	32'-0	1.54	LF2	34'-0	1.96	LF4
345	40	16	5"	Standard	17'-0	0.03	LF1	30'-0	0.60	LF2	43'-0	2.54	LF4
345	40	16	6"	Standard	15'-6	0.01	LF1	28'-0	0.32	LF2	40'-6	1.40	LF5
345	23	16	3.5"	High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
345	23	16	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
345	23	16	6"	High	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
345	30	16	3.5"	High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
345	30	16	5"	High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
345	30	16	6"	High	15'-6	0.01	LF1	40'-6	1.40	LF2	48'-6	2.87	LF4
345	40	16	3.5"	High	21'-0	0.12	LF1	32'-0	1.54	LF2	34'-0	1.96	LF4
345	40	16	5"	High	17'-0	0.03	LF1	30'-0	0.60	LF2	43'-0	2.54	LF4
345	40	16	6"	High	15'-6	0.01	LF1	28'-0	0.32	LF2	48'-6	2.87	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE I (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Extra High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
345	23	16	5"	Extra High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
345	23	16	6"	Extra High	15'-6	0.01	LF1	48'-6	2.87	LF4	48'-6	2.87	LF4
345	30	16	3.5"	Extra High	21'-0	0.12	LF1	34'-0	1.96	LF4	34'-0	1.96	LF4
345	30	16	5"	Extra High	17'-0	0.03	LF1	43'-0	2.54	LF4	43'-0	2.54	LF4
345	30	16	6"	Extra High	15'-6	0.01	LF1	40'-6	1.40	LF2	48'-6	2.87	LF4
345	40	16	3.5"	Extra High	21'-0	0.12	LF1	32'-0	1.54	LF2	34'-0	1.96	LF4
345	40	16	5"	Extra High	17'-0	0.03	LF1	30'-0	0.60	LF2	43'-0	2.54	LF4
345	40	16	6"	Extra High	15'-6	0.01	LF1	28'-0	0.32	LF2	48'-6	2.87	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

Application #1:

Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:

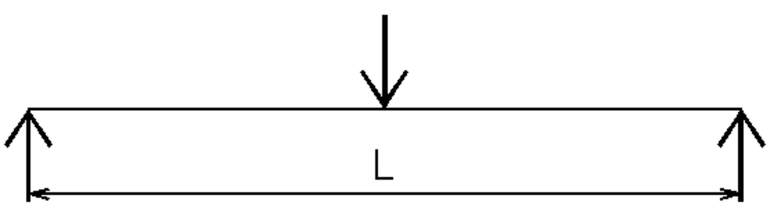
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE II

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
12.5/13.8	30	3'-0	3.5"	Standard	Do Not Use App #1		LF1	22’-6	1.11	LF3	22’-6	1.11	LF3
12.5/13.8	30	3'-0	5"	Standard	Do Not Use App #1		LF1	26'-6	0.92	LF2	33’-6	2.04	LF3
12.5/13.8	30	4'-0	3.5"	Standard	Do Not Use App #1		LF1	26'-0	1.80	LF3	26'-0	1.80	LF3
12.5/13.8	30	4'-0	5"	Standard	Do Not Use App #1		LF1	34'-0	2.17	LF2	37’-0	2.90	LF4
23	20	4'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
23	20	4'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
23	20	5'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
23	20	5'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
34.5	20	4'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
34.5	20	4'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
34.5	20	6'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
34.5	20	6'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
69	20	5'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
69	20	5'-0	5"	Standard	Do Not Use App #1		LF1	31'-0	1.57	LF2	37’-0	2.90	LF4
69	20	8'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
69	20	8'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/150
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

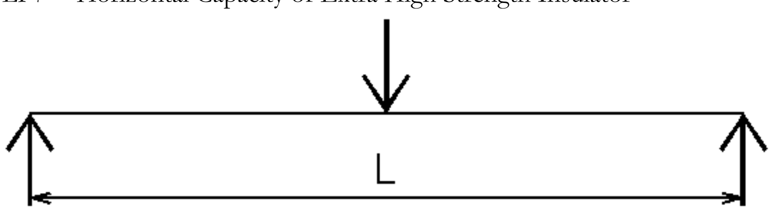
Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE II (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	23	8'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
115	23	8'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
115	23	8'-0	6"	Standard	Do Not Use App #1		LF1	44'-0	3.50	LF4	44'-0	3.50	LF4
115	23	10'-0	3.5"	Standard	Do Not Use App #1		LF1	27'-6	2.18	LF4	27'-6	2.18	LF4
115	23	10'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
115	23	10'-0	6"	Standard	Do Not Use App #1		LF1	44'-0	3.50	LF4	44'-0	3.50	LF4
115	40	8'-0	3.5"	Standard	Do Not Use App #1		LF1	27’-0	2.04	LF3	27’-0	2.04	LF3
115	40	8'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
115	40	8'-0	6"	Standard	Do Not Use App #1		LF1	37'-0	1.89	LF2	44'-0	3.50	LF4
115	40	10'-0	3.5"	Standard	Do Not Use App #1		LF1	27’-6	2.18	LF4	27’-6	2.18	LF4
115	40	10'-0	5"	Standard	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
115	40	10'-0	6"	Standard	Do Not Use App #1		LF1	44'-0	3.50	LF4	44'-0	3.50	LF4
115	40	8'-0	3.5"	High	Do Not Use App #1		LF1	27’-0	2.04	LF3	27’-0	2.04	LF3
115	40	8'-0	5"	High	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
115	40	8'-0	6"	High	Do Not Use App #1		LF1	37'-0	1.89	LF2	44'-0	3.50	LF4
115	40	10'-0	3.5"	High	Do Not Use App #1		LF1	27’-6	2.18	LF4	27’-6	2.18	LF4
115	40	10'-0	5"	High	Do Not Use App #1		LF1	37'-0	2.90	LF4	37'-0	2.90	LF4
115	40	10'-0	6"	High	Do Not Use App #1		LF1	44'-0	3.50	LF4	44'-0	3.50	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/150
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:

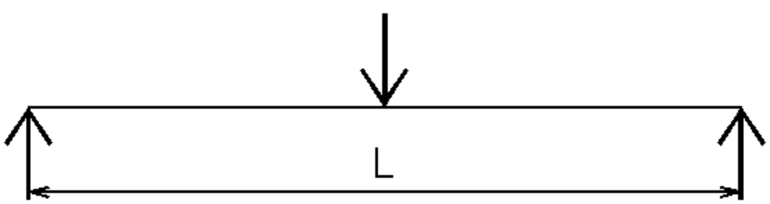
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE II (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	63	10	5"	Standard	Do Not Use App #1		LF1	21'-0	0.42	LF2	30'-0	1.41	LF3
115	63	10	6"	Standard	Do Not Use App #1		LF1	20'-6	0.25	LF2	29'-0	0.81	LF5
115	63	10	5"	Extra High	Do Not Use App #1		LF1	21'-0	0.42	LF2	30'-0	1.41	LF3
115	63	10	6"	Extra High	Do Not Use App #1		LF1	20'-6	0.25	LF2	37'-0	1.89	LF3
161	23	9'-0	3.5"	Standard	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	23	9'-0	5"	Standard	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	23	9'-0	6"	Standard	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4
161	23	14'-0	3.5"	Standard	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	23	14'-0	5"	Standard	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	23	14'-0	6"	Standard	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4
161	23	9'-0	3.5"	High	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	23	9'-0	5"	High	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	23	9'-0	6"	High	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4
161	23	14'-0	3.5"	High	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	23	14'-0	5"	High	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	23	14'-0	6"	High	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/150
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support

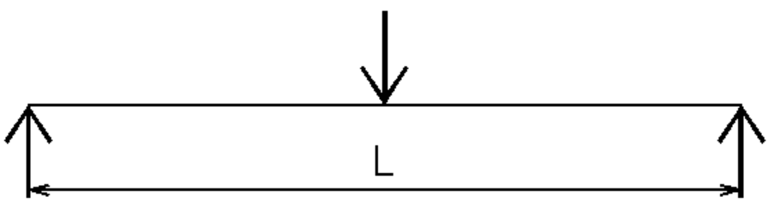
Note: The bolt hole size and pattern changes for 115kV extra high strength insulators. To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.

SINGLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE II (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
161	30	9'-0	3.5"	Standard	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	30	9'-0	5"	Standard	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	30	9'-0	6"	Standard	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4
161	30	14'-0	3.5"	Standard	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	30	14'-0	5"	Standard	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	30	14'-0	6"	Standard	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4
161	30	9'-0	3.5"	High	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	30	9'-0	5"	High	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	30	9'-0	6"	High	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4
161	30	14'-0	3.5"	High	Do Not Use App #1		LF1	26'-0	2.06	LF4	26'-0	2.06	LF4
161	30	14'-0	5"	High	Do Not Use App #1		LF1	36'-0	2.86	LF4	36'-0	2.86	LF4
161	30	14'-0	6"	High	Do Not Use App #1		LF1	42'-0	3.30	LF4	42'-0	3.30	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/150
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

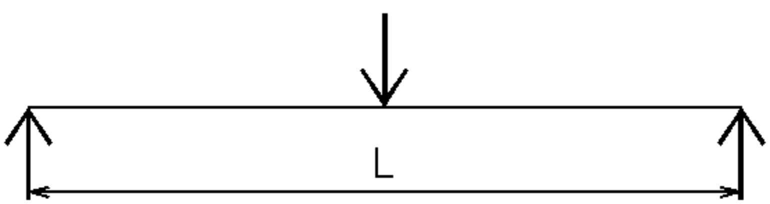
Application #3:
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE II (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
230	23	16	3.5"	Standard	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
230	23	16	5"	Standard	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
230	23	16	6"	Standard	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
230	30	16	3.5"	Standard	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
230	30	16	5"	Standard	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
230	30	16	6"	Standard	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
230	40	16	3.5"	Standard	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
230	40	16	5"	Standard	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
230	40	16	6"	Standard	Do Not Use App #1		LF1	38'-0	2.71	LF2	38'-8	2.80	LF5
230	23	16	3.5"	High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
230	23	16	5"	High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
230	23	16	6"	High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
230	30	16	3.5"	High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
230	30	16	5"	High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
230	30	16	6"	High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
230	40	16	3.5"	High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
230	40	16	5"	High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
230	40	16	6"	High	Do Not Use App #1		LF1	38'-0	2.71	LF2	40'-0	3.23	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/150
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:

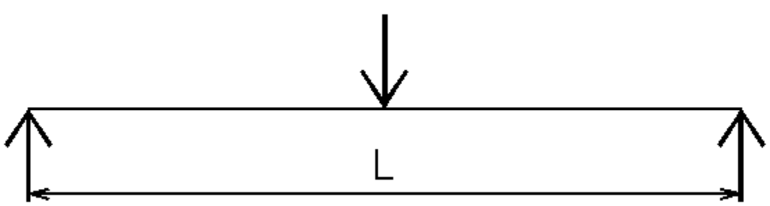
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE II (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Standard	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	23	16	5"	Standard	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	23	16	6"	Standard	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
345	30	16	3.5"	Standard	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	30	16	5"	Standard	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	30	16	6"	Standard	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
345	40	16	3.5"	Standard	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	40	16	5"	Standard	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	40	16	6"	Standard	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
345	23	16	3.5"	High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	23	16	5"	High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	23	16	6"	High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
345	30	16	3.5"	High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	30	16	5"	High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	30	16	6"	High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
345	40	16	3.5"	High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	40	16	5"	High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	40	16	6"	High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/150
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:

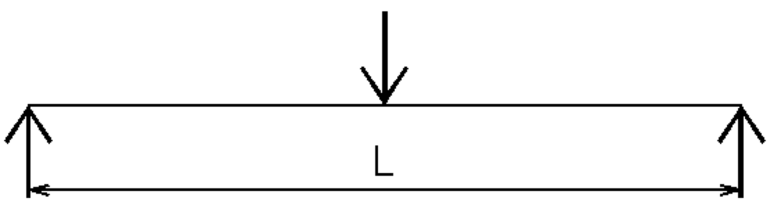
Bus Support to Bus Support

SINGLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE II (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
345	23	16	3.5"	Extra High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	23	16	5"	Extra High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	23	16	6"	Extra High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
345	30	16	3.5"	Extra High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	30	16	5"	Extra High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	30	16	6"	Extra High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4
345	40	16	3.5"	Extra High	Do Not Use App #1		LF1	22'-0	1.63	LF4	22'-0	1.63	LF4
345	40	16	5"	Extra High	Do Not Use App #1		LF1	33'-0	2.59	LF4	33'-0	2.59	LF4
345	40	16	6"	Extra High	Do Not Use App #1		LF1	40'-0	3.23	LF4	40'-0	3.23	LF4

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/150
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Switch Pad (expansion fitting at one end)
Switch Pad to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Switch Pad (expansion fitting at both ends)
Switch Pad to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support

DOUBLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE III

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	**Fault Current (kA)**	**Phase Spacing (ft)**	**Bus Type (in)**	**Insulator Strength**	**Maximum Span (L) (ft)**	**Expected Deflection (in)**	**Limiting Factor**	**Maximum Span (L) (ft)**	**Expected Deflection (in)**	**Limiting Factor**	**Maximum Span (L) (ft)**	**Expected Deflection (in)**	**Limiting Factor**
12.5/13.8	30	3'-0	3.5"	Standard	18'-6	0.09	LF5	18'-6	0.07	LF5	18'-6	0.07	LF5
12.5/13.8	30	3'-0	5"	Standard	17'-6	0.04	LF5	17'-6	0.03	LF5	17'-6	0.03	LF5
12.5/13.8	30	4'-0	3.5"	Standard	23'-6	0.22	LF5	23'-6	0.19	LF5	23'-6	0.19	LF5
12.5/13.8	30	4'-0	5"	Standard	21'-6	0.08	LF5	21'-6	0.07	LF5	21'-6	0.07	LF5
23	20	4'-0	3.5"	Standard	28'-0	0.45	LF1	36'-6	1.09	LF3	36'-6	1.09	LF3
23	20	4'-0	5"	Standard	23'-0	0.10	LF1	35'-6	0.50	LF5	35'-6	0.50	LF5
23	20	5'-0	3.5"	Standard	28'-0	0.45	LF1	40'-0	1.58	LF3	40'-0	1.58	LF3
23	20	5'-0	5"	Standard	23'-0	0.10	LF1	39'-6	0.76	LF5	39'-6	0.76	LF5
34.5	20	4'-0	3.5"	Standard	28'-0	0.45	LF1	36'-6	1.09	LF3	36'-6	1.09	LF3
34.5	20	4'-0	5"	Standard	23'-0	0.10	LF1	35'-6	0.50	LF5	35'-6	0.50	LF5
34.5	20	6'-0	3.5"	Standard	28'-0	0.45	LF1	42'-6	2.01	LF3	42'-6	2.01	LF3
34.5	20	6'-0	5"	Standard	23'-0	0.10	LF1	42'-6	1.02	LF5	42'-6	1.02	LF5
69	20	5'-0	3.5"	Standard	28'-0	0.45	LF1	35'-0	0.92	LF5	35'-0	0.92	LF5
69	20	5'-0	5"	Standard	23'-0	0.10	LF1	29'-6	0.24	LF5	29'-6	0.24	LF5
69	20	8'-0	3.5"	Standard	28'-0	0.45	LF1	44'-0	2.31	LF5	44'-0	2.31	LF5
69	20	8'-0	5"	Standard	23'-0	0.10	LF1	35'-0	0.47	LF5	35'-0	0.47	LF5

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE III (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	23	8'-0	3.5"	Standard	28'-0	0.45	LF1	42'-6	2.01	LF3	42'-6	2.01	LF3
115	23	8'-0	5"	Standard	23'-0	0.10	LF1	36’-0	0.52	LF5	36’-0	0.52	LF5
115	23	8'-0	6"	Standard	20'-6	0.05	LF1	32’-6	0.24	LF5	32’-6	0.24	LF5
115	23	10'-0	3.5"	Standard	28'-0	0.45	LF1	46'-0	2.76	LF4	46'-0	2.76	LF4
115	23	10'-0	5"	Standard	23'-0	0.10	LF1	39’-6	0.76	LF5	39’-6	0.76	LF5
115	23	10'-0	6"	Standard	20'-6	0.05	LF1	35'-0	0.33	LF5	35'-0	0.33	LF5
115	40	8'-0	3.5"	Standard	22'-0	0.17	LF5	22'-0	0.14	LF5	22'-0	0.14	LF5
115	40	8'-0	5"	Standard	20'-0	0.06	LF5	20'-0	0.05	LF5	20'-0	0.05	LF5
115	40	8'-0	6"	Standard	18’-6	0.03	LF5	18’-6	0.03	LF5	18’-6	0.03	LF5
115	40	10'-0	3.5"	Standard	25’-6	0.31	LF5	25’-6	0.26	LF5	25’-6	0.26	LF5
115	40	10'-0	5"	Standard	23'-0	0.10	LF1	23'-0	0.09	LF5	23'-0	0.09	LF5
115	40	10'-0	6"	Standard	20'-6	0.05	LF1	21’-6	0.05	LF5	21’-6	0.05	LF5
115	40	8'-0	3.5"	High	28'-0	0.45	LF1	27’-6	0.35	LF3	27’-6	0.35	LF3
115	40	8'-0	5"	High	23'-0	0.10	LF1	30’-6	0.27	LF6	30’-6	0.27	LF6
115	40	8'-0	6"	High	20’-6	0.05	LF1	28’-6	0.14	LF6	28’-6	0.14	LF6
115	40	10'-0	3.5"	High	28'-0	0.45	LF1	30’-0	0.50	LF3	30’-0	0.50	LF3
115	40	10'-0	5"	High	23'-0	0.10	LF1	35’-0	0.47	LF6	35’-0	0.47	LF6
115	40	10'-0	6"	High	20'-6	0.05	LF1	33’-0	0.26	LF6	33’-0	0.26	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

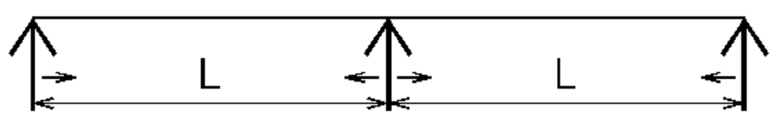
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE III (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	63	10	5"	Standard	12'-0	0.01	LF5	12'-0	0.01	LF5	12'-0	0.01	LF5
115	63	10	6"	Standard	11'-6	0.00	LF5	11'-6	0.00	LF5	11'-6	0.00	LF5
115	63	10	5"	Extra High	23'-0	0.10	LF1	28'-0	0.19	LF2	30'-0	0.25	LF3
115	63	10	6"	Extra High	20'-6	0.05	LF1	27'-6	0.13	LF2	30'-6	0.19	LF7
161	23	9'-0	3.5"	Standard	28'-0	0.45	LF1	32'-6	0.69	LF5	32'-6	0.69	LF5
161	23	9'-0	5"	Standard	23'-0	0.10	LF1	27'-0	0.17	LF5	27'-0	0.17	LF5
161	23	9'-0	6"	Standard	20'-6	0.05	LF1	24'-0	0.07	LF5	24'-0	0.07	LF5
161	23	14'-0	3.5"	Standard	28'-0	0.45	LF1	39'-0	1.42	LF5	39'-0	1.42	LF5
161	23	14'-0	5"	Standard	23'-0	0.10	LF1	31'-0	0.29	LF5	31'-0	0.29	LF5
161	23	14'-0	6"	Standard	20'-6	0.05	LF1	27'-0	0.12	LF5	27'-0	0.12	LF5
161	23	9'-0	3.5"	High	28'-0	0.45	LF1	44'-6	2.41	LF3	44'-6	2.41	LF3
161	23	9'-0	5"	High	23'-0	0.10	LF1	41'-6	0.92	LF6	41'-6	0.92	LF6
161	23	9'-0	6"	High	20'-6	0.05	LF1	37'-0	0.41	LF6	37'-0	0.41	LF6
161	23	14'-0	3.5"	High	28'-0	0.45	LF1	45'-6	2.64	LF4	45'-6	2.64	LF4
161	23	14'-0	5"	High	23'-0	0.10	LF1	48'-0	1.65	LF6	48'-0	1.65	LF6
161	23	14'-0	6"	High	20'-6	0.05	LF1	42'-0	0.68	LF6	42'-0	0.68	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.
Note: The bolt hole size and pattern changes for 115kV extra high strength insulators. To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.

DOUBLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE III (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
161	30	9'-0	3.5"	Standard	24'-6	0.26	LF5	24'-6	0.22	LF5	24'-6	0.22	LF5
161	30	9'-0	5"	Standard	21'-0	0.07	LF5	21'-0	0.06	LF5	21'-0	0.06	LF5
161	30	9'-0	6"	Standard	19'-0	0.03	LF5	19'-0	0.03	LF5	19'-0	0.03	LF5
161	30	14'-0	3.5"	Standard	28'-0	0.45	LF1	31'-0	0.56	LF5	31'-0	0.56	LF5
161	30	14'-0	5"	Standard	23'-0	0.10	LF1	26'-0	0.14	LF5	26'-0	0.14	LF5
161	30	14'-0	6"	Standard	20'-6	0.05	LF1	23'-0	0.06	LF5	23'-0	0.06	LF5
161	30	9'-0	3.5"	High	28'-0	0.45	LF1	36'-6	1.08	LF3	36'-6	1.08	LF3
161	30	9'-0	5"	High	23'-0	0.10	LF1	32'-6	0.34	LF6	32'-6	0.34	LF6
161	30	9'-0	6"	High	20'-6	0.05	LF1	30'-0	0.17	LF6	30'-0	0.17	LF6
161	30	14'-0	3.5"	High	28'-0	0.45	LF1	43'-0	2.08	LF3	43'-0	2.08	LF3
161	30	14'-0	5"	High	23'-0	0.10	LF1	40'-0	0.79	LF6	40'-0	0.79	LF6
161	30	14'-0	6"	High	20'-6	0.05	LF1	36'-0	0.36	LF6	36'-0	0.36	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE III (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
230	23	16	3.5"	Standard	28’-0	0.45	LF1	32’-0	0.65	LF5	32’-0	0.65	LF5
230	23	16	5"	Standard	23’-0	0.10	LF1	25’-0	0.12	LF5	25’-0	0.12	LF5
230	23	16	6"	Standard	20’-6	0.05	LF1	22’-0	0.05	LF5	22’-0	0.05	LF5
230	30	16	3.5"	Standard	26’-0	0.34	LF5	26’-0	0.28	LF5	26’-0	0.28	LF5
230	30	16	5"	Standard	21’-6	0.08	LF5	21’-6	0.07	LF5	21’-6	0.07	LF5
230	30	16	6"	Standard	19’-0	0.03	LF5	19’-0	0.03	LF5	19’-0	0.03	LF5
230	40	16	3.5"	Standard	19’-6	0.11	LF5	19’-6	0.09	LF5	19’-6	0.09	LF5
230	40	16	5"	Standard	16’-6	0.03	LF5	16’-6	0.02	LF5	16’-6	0.02	LF5
230	40	16	6"	Standard	15’-0	0.01	LF5	15’-0	0.01	LF5	15’-0	0.01	LF5
230	23	16	3.5"	High	28’-0	0.45	LF1	46’-0	2.76	LF4	46’-0	2.76	LF4
230	23	16	5"	High	23’-0	0.10	LF1	39’-0	0.72	LF6	39’-0	0.72	LF6
230	23	16	6"	High	20’-6	0.05	LF1	34’-0	0.29	LF6	34’-0	0.29	LF6
230	30	16	3.5"	High	28’-0	0.45	LF1	40’-0	1.56	LF6	40’-0	1.56	LF6
230	30	16	5"	High	23’-0	0.10	LF1	33’-0	0.37	LF6	33’-0	0.37	LF6
230	30	16	6"	High	20’-6	0.05	LF1	29’-6	0.16	LF6	29’-6	0.16	LF6
230	40	16	3.5"	High	28’-0	0.45	LF1	30’-0	0.50	LF6	30’-0	0.50	LF6
230	40	16	5"	High	23’-0	0.10	LF1	25’-6	0.13	LF6	25’-6	0.13	LF6
230	40	16	6"	High	20’-6	0.05	LF1	23’-6	0.07	LF6	23’-6	0.07	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

Application #1:

Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to Bus Support to Bus Support

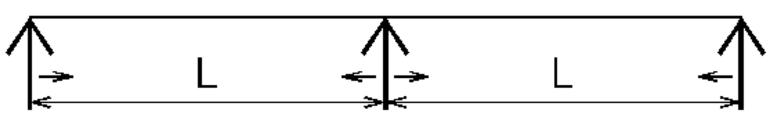
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE III (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Standard	28'-0	0.45	LF1	34'-0	0.82	LF5	34'-0	0.82	LF5
345	23	16	5"	Standard	23'-0	0.10	LF1	27'-0	0.17	LF5	27'-0	0.17	LF5
345	23	16	6"	Standard	20'-6	0.05	LF1	23'-6	0.07	LF5	23'-6	0.07	LF5
345	30	16	3.5"	Standard	27'-6	0.42	LF5	27'-6	0.35	LF5	27'-6	0.35	LF5
345	30	16	5"	Standard	22'-6	0.10	LF5	22'-6	0.08	LF5	22'-6	0.08	LF5
345	30	16	6"	Standard	20'-0	0.04	LF5	20'-0	0.03	LF5	20'-0	0.03	LF5
345	40	16	3.5"	Standard	20'-6	0.13	LF5	20'-6	0.11	LF5	20'-6	0.11	LF5
345	40	16	5"	Standard	17'-6	0.04	LF5	17'-6	0.03	LF5	17'-6	0.03	LF5
345	40	16	6"	Standard	16'-0	0.02	LF5	16'-0	0.01	LF5	16'-0	0.01	LF5
345	23	16	3.5"	High	28'-0	0.45	LF1	46'-0	2.76	LF4	46'-0	2.76	LF4
345	23	16	5"	High	23'-0	0.10	LF1	39'-0	0.72	LF6	39'-0	0.72	LF6
345	23	16	6"	High	20'-6	0.05	LF1	34'-0	0.29	LF6	34'-0	0.29	LF6
345	30	16	3.5"	High	28'-0	0.45	LF1	40'-0	1.56	LF6	40'-0	1.56	LF6
345	30	16	5"	High	23'-0	0.10	LF1	33'-0	0.37	LF6	33'-0	0.37	LF6
345	30	16	6"	High	20'-6	0.05	LF1	29'-6	0.16	LF6	29'-6	0.16	LF6
345	40	16	3.5"	High	28'-0	0.45	LF1	30'-0	0.50	LF6	30'-0	0.50	LF6
345	40	16	5"	High	23'-0	0.10	LF1	25'-6	0.13	LF6	25'-6	0.13	LF6
345	40	16	6"	High	20'-6	0.05	LF1	23'-6	0.07	LF6	23'-6	0.07	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE III (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
345	23	16	3.5"	Extra High	28'-0	0.45	LF1	46'-0	2.76	LF4	46'-0	2.76	LF4
345	23	16	5"	Extra High	23'-0	0.10	LF1	53'-6	2.53	LF7	53'-6	2.53	LF7
345	23	16	6"	Extra High	20'-6	0.05	LF1	47'-0	1.05	LF7	47'-0	1.05	LF7
345	30	16	3.5"	Extra High	28'-0	0.45	LF1	45'-0	2.50	LF3	45'-0	2.50	LF3
345	30	16	5"	Extra High	23'-0	0.10	LF1	45'-6	1.32	LF7	45'-6	1.32	LF7
345	30	16	6"	Extra High	20'-6	0.05	LF1	40'-6	0.58	LF7	40'-6	0.58	LF7
345	40	16	3.5"	Extra High	28'-0	0.45	LF1	36'-6	1.08	LF3	36'-6	1.08	LF3
345	40	16	5"	Extra High	23'-0	0.10	LF1	35'-0	0.46	LF7	35'-0	0.46	LF7
345	40	16	6"	Extra High	20'-6	0.05	LF1	32'-0	0.23	LF7	32'-0	0.23	LF7

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator

Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

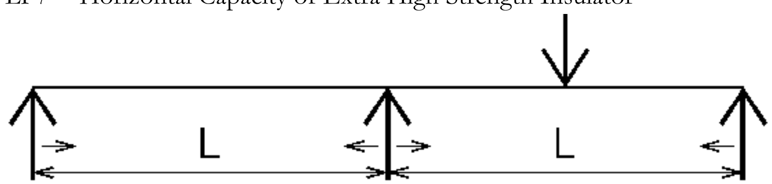
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE IV

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
12.5/13.8	30	3'-0	3.5"	Standard	18’-6	0.36	LF5	18’-6	0.36	LF5	18’-6	0.36	LF5
12.5/13.8	30	3'-0	5"	Standard	17’-6	0.14	LF5	17’-6	0.14	LF5	17’-6	0.14	LF5
12.5/13.8	30	4'-0	3.5"	Standard	23’-6	0.77	LF5	23’-6	0.78	LF5	23’-6	0.78	LF5
12.5/13.8	30	4'-0	5"	Standard	21’-6	0.28	LF5	21’-6	0.28	LF5	21’-6	0.28	LF5
23	20	4'-0	3.5"	Standard	28’-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
23	20	4'-0	5"	Standard	23’-0	0.35	LF1	35'-6	1.43	LF5	35'-6	1.43	LF5
23	20	5'-0	3.5"	Standard	28’-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
23	20	5'-0	5"	Standard	23’-0	0.35	LF1	39’-6	2.04	LF5	39’-6	2.04	LF5
34.5	20	4'-0	3.5"	Standard	28’-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
34.5	20	4'-0	5"	Standard	23’-0	0.35	LF1	35'-6	1.43	LF5	35'-6	1.43	LF5
34.5	20	6'-0	3.5"	Standard	28’-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
34.5	20	6'-0	5"	Standard	23’-0	0.35	LF1	42'-0	2.51	LF4	42'-0	2.51	LF4
69	20	5'-0	3.5"	Standard	28’-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
69	20	5'-0	5"	Standard	23’-0	0.35	LF1	29'-6	0.77	LF5	29'-6	0.77	LF5
69	20	8'-0	3.5"	Standard	28’-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
69	20	8'-0	5"	Standard	23’-0	0.35	LF1	35'-0	1.36	LF5	35'-0	1.36	LF5

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

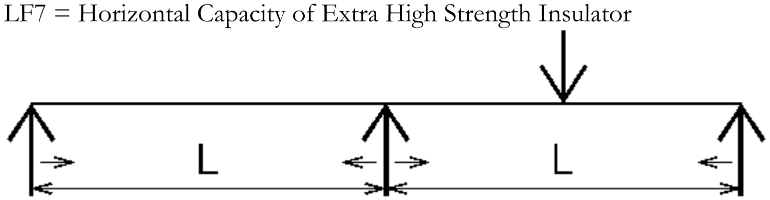
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE IV (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
115	23	8'-0	3.5"	Standard	28'-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
115	23	8'-0	5"	Standard	23'-0	0.35	LF1	36'-0	1.50	LF5	36'-0	1.50	LF5
115	23	8'-0	6"	Standard	20'-6	0.15	LF1	32'-6	0.68	LF5	32'-6	0.68	LF5
115	23	10'-0	3.5"	Standard	28'-0	1.39	LF1	30'-0	1.72	LF4	30'-0	1.72	LF4
115	23	10'-0	5"	Standard	23'-0	0.35	LF1	39'-6	2.04	LF5	39'-6	2.04	LF5
115	23	10'-0	6"	Standard	20'-6	0.15	LF1	35'-0	0.87	LF5	35'-0	0.87	LF5
115	40	8'-0	3.5"	Standard	22'-0	0.63	LF5	22'-0	0.63	LF5	22'-0	0.63	LF5
115	40	8'-0	5"	Standard	20'-0	0.22	LF5	20'-0	0.22	LF5	20'-0	0.22	LF5
115	40	8'-0	6"	Standard	18'-6	0.11	LF5	18'-6	0.11	LF5	18'-6	0.11	LF5
115	40	10'-0	3.5"	Standard	25'-6	1.02	LF5	25'-6	1.01	LF5	25'-6	1.01	LF5
115	40	10'-0	5"	Standard	23'-0	0.35	LF1	23'-0	0.34	LF5	23'-0	0.34	LF5
115	40	10'-0	6"	Standard	20'-6	0.15	LF1	21'-6	0.17	LF5	21'-6	0.17	LF5
115	40	8'-0	3.5"	High	27'-6	1.31	LF3	27'-6	1.29	LF3	27'-6	1.29	LF3
115	40	8'-0	5"	High	23'-0	0.35	LF1	30'-6	0.86	LF6	30'-6	0.86	LF6
115	40	8'-0	6"	High	20'-6	0.15	LF1	28'-6	0.44	LF6	28'-6	0.44	LF6
115	40	10'-0	3.5"	High	28'-0	1.39	LF1	30'-0	1.72	LF3	30'-0	1.72	LF3
115	40	10'-0	5"	High	23'-0	0.35	LF1	35'-0	1.36	LF6	35'-0	1.36	LF6
115	40	10'-0	6"	High	20'-6	0.15	LF1	33'-0	0.71	LF6	33'-0	0.71	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

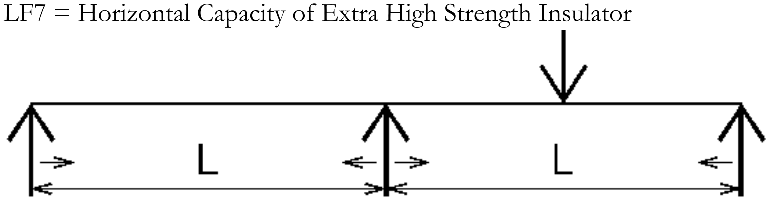
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE IV (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	63	10	5"	Standard	12'-0	0.04	LF5	12'-0	0.04	LF5	12'-0	0.04	LF5
115	63	10	6"	Standard	11'-6	0.02	LF5	11'-6	0.02	LF5	11'-6	0.02	LF5
115	63	10	5"	Extra High	23'-0	0.35	LF1	28'-0	0.65	LF2	30'-0	0.82	LF3
115	63	10	6"	Extra High	20'-6	0.15	LF1	27'-6	0.39	LF2	30'-6	0.55	LF7
161	23	9'-0	3.5"	Standard	28'-0	1.62	LF4	28'-0	1.61	LF4	28'-0	1.61	LF4
161	23	9'-0	5"	Standard	23'-0	0.39	LF1	27'-0	0.65	LF5	27'-0	0.65	LF5
161	23	9'-0	6"	Standard	20'-6	0.18	LF1	24'-0	0.29	LF5	24'-0	0.29	LF5
161	23	14'-0	3.5"	Standard	28'-0	1.62	LF4	28'-0	1.61	LF4	28'-0	1.61	LF4
161	23	14'-0	5"	Standard	23'-0	0.39	LF1	31'-0	0.91	LF5	31'-0	0.91	LF5
161	23	14'-0	6"	Standard	20'-6	0.18	LF1	27'-0	0.43	LF5	27'-0	0.43	LF5
161	23	9'-0	3.5"	High	28'-0	1.62	LF4	28'-0	1.61	LF4	28'-0	1.61	LF4
161	23	9'-0	5"	High	23'-0	0.39	LF1	40'-0	2.35	LF4	40'-0	2.35	LF4
161	23	9'-0	6"	High	20'-6	0.18	LF1	37'-0	1.21	LF6	37'-0	1.21	LF6
161	23	14'-0	3.5"	High	28'-0	1.62	LF4	28'-0	1.61	LF4	28'-0	1.61	LF4
161	23	14'-0	5"	High	23'-0	0.39	LF1	40'-0	2.35	LF4	40'-0	2.35	LF4
161	23	14'-0	6"	High	20'-6	0.18	LF1	42'-0	1.85	LF6	42'-0	1.85	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to Bus Support to Bus Support

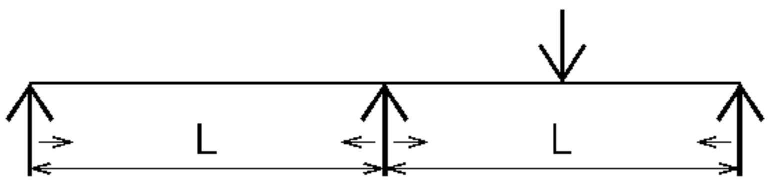
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The bolt hole size and pattern changes for 115kV extra high strength insulators. To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE IV (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
161	30	9'-0	3.5"	Standard	24'-6	1.05	LF5	24'-6	1.05	LF5	24'-6	1.05	LF5
161	30	9'-0	5"	Standard	21'-0	0.29	LF5	21'-0	0.29	LF5	21'-0	0.29	LF5
161	30	9'-0	6"	Standard	19'-0	0.14	LF5	19'-0	0.14	LF5	19'-0	0.14	LF5
161	30	14'-0	3.5"	Standard	28'-0	1.62	LF4	28'-0	1.61	LF4	28'-0	1.61	LF4
161	30	14'-0	5"	Standard	23'-0	0.39	LF1	26'-0	0.57	LF5	26'-0	0.57	LF5
161	30	14'-0	6"	Standard	20'-6	0.18	LF1	23'-0	0.26	LF5	23'-0	0.26	LF5
161	30	9'-0	3.5"	High	28'-0	1.62	LF4	28'-0	1.61	LF4	28'-0	1.61	LF4
161	30	9'-0	5"	High	23'-0	0.39	LF1	32'-6	1.19	LF6	32'-6	1.19	LF6
161	30	9'-0	6"	High	20'-6	0.18	LF1	30'-0	0.61	LF6	30'-0	0.61	LF6
161	30	14'-0	3.5"	High	28'-0	1.62	LF4	28'-0	1.61	LF4	28'-0	1.61	LF4
161	30	14'-0	5"	High	23'-0	0.39	LF1	40'-0	2.35	LF6	40'-0	2.35	LF6
161	30	14'-0	6"	High	20'-6	0.18	LF1	36'-0	1.11	LF6	36'-0	1.11	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

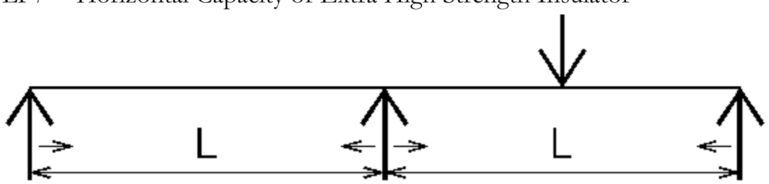
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE IV (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
230	23	16	3.5"	Standard	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
230	23	16	5"	Standard	23’-0	0.49	LF1	25’-0	0.65	LF5	25’-0	0.65	LF5
230	23	16	6"	Standard	20’-6	0.22	LF1	22’-0	0.28	LF5	22’-0	0.28	LF5
230	30	16	3.5"	Standard	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
230	30	16	5"	Standard	21’-6	0.40	LF5	21’-6	0.40	LF5	21’-6	0.40	LF5
230	30	16	6"	Standard	19’-0	0.17	LF5	19’-0	0.17	LF5	19’-0	0.17	LF5
230	40	16	3.5"	Standard	19’-0	0.65	LF5	19’-0	0.67	LF5	19’-0	0.67	LF5
230	40	16	5"	Standard	16’-6	0.17	LF5	16’-6	0.18	LF5	16’-6	0.18	LF5
230	40	16	6"	Standard	15’-0	0.08	LF5	15’-0	0.08	LF5	15’-0	0.08	LF5
230	23	16	3.5"	High	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
230	23	16	5"	High	23’-0	0.49	LF1	36’-0	2.09	LF4	36’-0	2.09	LF4
230	23	16	6"	High	20’-6	0.22	LF1	34’-0	1.11	LF6	34’-0	1.11	LF6
230	30	16	3.5"	High	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
230	30	16	5"	High	23’-0	0.49	LF1	33’-0	1.58	LF6	33’-0	1.58	LF6
230	30	16	6"	High	20’-6	0.22	LF1	29’-6	0.70	LF6	29’-6	0.70	LF6
230	40	16	3.5"	High	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
230	40	16	5"	High	23’-0	0.49	LF1	25’-0	0.65	LF6	25’-0	0.65	LF6
230	40	16	6"	High	20’-6	0.22	LF1	23’-0	0.32	LF6	23’-0	0.32	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

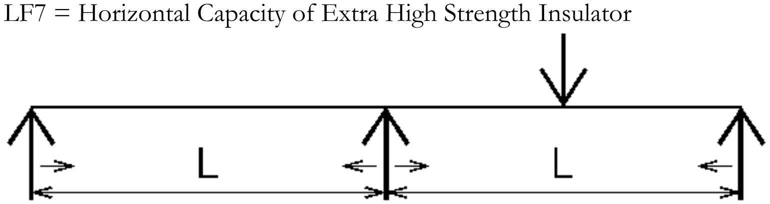
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE IV (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Standard	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
345	23	16	5"	Standard	23’-0	0.49	LF1	27’-0	0.83	LF5	27’-0	0.83	LF5
345	23	16	6"	Standard	20’-6	0.22	LF1	23’-6	0.34	LF5	23’-6	0.34	LF5
345	30	16	3.5"	Standard	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
345	30	16	5"	Standard	22’-6	0.46	LF5	22’-6	0.47	LF5	22’-6	0.47	LF5
345	30	16	6"	Standard	20’-0	0.20	LF5	20’-0	0.20	LF5	20’-0	0.20	LF5
345	40	16	3.5"	Standard	20’-0	0.77	LF5	20’-0	0.79	LF5	20’-0	0.79	LF5
345	40	16	5"	Standard	17’-6	0.21	LF5	17’-6	0.21	LF5	17’-6	0.21	LF5
345	40	16	6"	Standard	16’-0	0.10	LF5	16’-0	0.10	LF5	16’-0	0.10	LF5
345	23	16	3.5"	High	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
345	23	16	5"	High	23’-0	0.49	LF1	36’-0	2.09	LF4	36’-0	2.09	LF4
345	23	16	6"	High	20’-6	0.22	LF1	34’-0	1.11	LF6	34’-0	1.11	LF6
345	30	16	3.5"	High	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
345	30	16	5"	High	23’-0	0.49	LF1	33’-0	1.58	LF6	33’-0	1.58	LF6
345	30	16	6"	High	20’-6	0.22	LF1	29’-6	0.70	LF6	29’-6	0.70	LF6
345	40	16	3.5"	High	24’-0	1.38	LF4	24’-0	1.39	LF4	24’-0	1.39	LF4
345	40	16	5"	High	23’-0	0.49	LF1	25’-0	0.65	LF6	25’-0	0.65	LF6
345	40	16	6"	High	20’-6	0.22	LF1	23’-0	0.32	LF6	23’-0	0.32	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to Bus Support to Bus Support

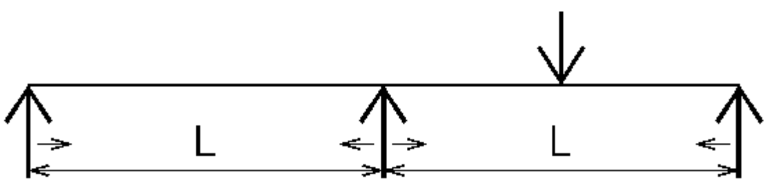
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

DOUBLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE IV (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Extra High	24'-0	1.38	LF4	24'-0	1.39	LF4	24'-0	1.39	LF4
345	23	16	5"	Extra High	23'-0	0.49	LF1	36'-0	2.09	LF4	36'-0	2.09	LF4
345	23	16	6"	Extra High	20'-6	0.22	LF1	44'-0	2.59	LF4	44'-0	2.59	LF4
345	30	16	3.5"	Extra High	24'-0	1.38	LF4	24'-0	1.39	LF4	24'-0	1.39	LF4
345	30	16	5"	Extra High	23'-0	0.49	LF1	36'-0	2.09	LF4	36'-0	2.09	LF4
345	30	16	6"	Extra High	20'-6	0.22	LF1	40'-6	1.98	LF7	40'-6	1.98	LF7
345	40	16	3.5"	Extra High	24'-0	1.38	LF4	24'-0	1.39	LF4	24'-0	1.39	LF4
345	40	16	5"	Extra High	23'-0	0.49	LF1	35'-0	1.91	LF7	35'-0	1.91	LF7
345	40	16	6"	Extra High	20'-6	0.22	LF1	32'-0	0.92	LF7	32'-0	0.92	LF7

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to Bus Support to Switch Pad (expansion fitting at one end)
Switch Pad to Bus Support to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to Bus Support to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to Bus Support to Switch Pad (expansion fitting at both ends)
Switch Pad to Bus Support to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to Bus Support to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to Bus Support to Bus Support

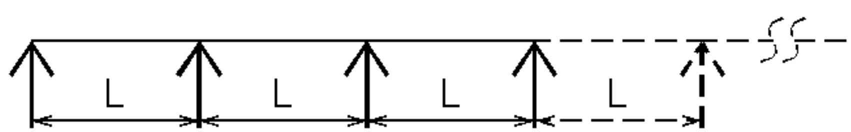
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center support may be moved up to 20% of L along the bus in either direction. An end support may freely move towards the center support.

MULTIPLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE V

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
12.5/13.8	30	3'-0	3.5"	Standard	21'-0	0.14	LF5	21'-0	0.15	LF5	21'-0	0.15	LF5
12.5/13.8	30	3'-0	5"	Standard	20'-0	0.06	LF5	20'-0	0.06	LF5	20'-0	0.06	LF5
12.5/13.8	30	4'-0	3.5"	Standard	25'-0	0.29	LF1	26’-6	0.38	LF5	26’-6	0.38	LF5
12.5/13.8	30	4'-0	5"	Standard	20'-0	0.06	LF1	24’-6	0.14	LF5	24’-6	0.14	LF5
23	20	4'-0	3.5"	Standard	25'-0	0.29	LF1	41'-0	2.20	LF3	41'-0	2.20	LF3
23	20	4'-0	5"	Standard	20'-0	0.06	LF1	40'-0	1.01	LF5	40'-0	1.01	LF5
23	20	5'-0	3.5"	Standard	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
23	20	5'-0	5"	Standard	20'-0	0.06	LF1	45'-0	1.61	LF5	45'-0	1.61	LF5
34.5	20	4'-0	3.5"	Standard	25'-0	0.29	LF1	41'-0	2.20	LF3	41'-0	2.20	LF3
34.5	20	4'-0	5"	Standard	20'-0	0.06	LF1	40'-0	1.01	LF5	40'-0	1.01	LF5
34.5	20	6'-0	3.5"	Standard	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
34.5	20	6'-0	5"	Standard	20'-0	0.06	LF1	48'-0	2.09	LF5	48'-0	2.09	LF5
69	20	5'-0	3.5"	Standard	25'-0	0.29	LF1	39’-6	1.89	LF5	39’-6	1.89	LF5
69	20	5'-0	5"	Standard	20'-0	0.06	LF1	33’-6	0.50	LF5	33’-6	0.50	LF5
69	20	8'-0	3.5"	Standard	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
69	20	8'-0	5"	Standard	20'-0	0.06	LF1	40'-0	1.01	LF5	40'-0	1.01	LF5

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

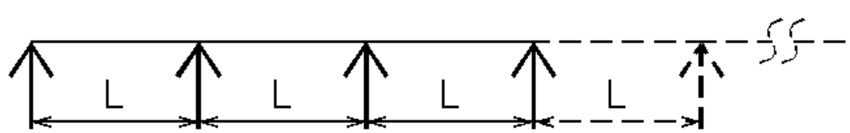
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE V (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	23	8'-0	3.5"	Standard	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
115	23	8'-0	5"	Standard	20'-0	0.06	LF1	41'-0	1.11	LF5	41'-0	1.11	LF5
115	23	8'-0	6"	Standard	18'-0	0.03	LF1	37'-0	0.52	LF5	37'-0	0.52	LF5
115	23	10'-0	3.5"	Standard	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
115	23	10'-0	5"	Standard	20'-0	0.06	LF1	45'-0	1.61	LF5	45'-0	1.61	LF5
115	23	10'-0	6"	Standard	18'-0	0.03	LF1	40'-0	0.70	LF5	40'-0	0.70	LF5
115	40	8'-0	3.5"	Standard	25'-0	0.29	LF5	25'-0	0.30	LF5	25'-0	0.30	LF5
115	40	8'-0	5"	Standard	20'-0	0.06	LF1	22'-6	0.10	LF5	22'-6	0.10	LF5
115	40	8'-0	6"	Standard	18'-0	0.03	LF1	21'-0	0.05	LF5	21'-0	0.05	LF5
115	40	10'-0	3.5"	Standard	25'-0	0.29	LF1	29'-0	0.55	LF5	29'-0	0.55	LF5
115	40	10'-0	5"	Standard	20'-0	0.06	LF1	26'-0	0.18	LF5	26'-0	0.18	LF5
115	40	10'-0	6"	Standard	18'-0	0.03	LF1	24'-6	0.10	LF5	24'-6	0.10	LF5
115	40	8'-0	3.5"	High	25'-0	0.29	LF1	30'-6	0.67	LF3	30'-6	0.67	LF3
115	40	8'-0	5"	High	20'-0	0.06	LF1	34'-6	0.56	LF6	34'-6	0.56	LF6
115	40	8'-0	6"	High	18'-0	0.03	LF1	32'-6	0.31	LF6	32'-6	0.31	LF6
115	40	10'-0	3.5"	High	25'-0	0.29	LF1	33'-6	0.91	LF3	33'-6	0.91	LF3
115	40	10'-0	5"	High	20'-0	0.06	LF1	40'-0	1.01	LF6	40'-0	1.01	LF6
115	40	10'-0	6"	High	18'-0	0.03	LF1	37'-6	0.54	LF6	37'-6	0.54	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to X# of Bus Supports

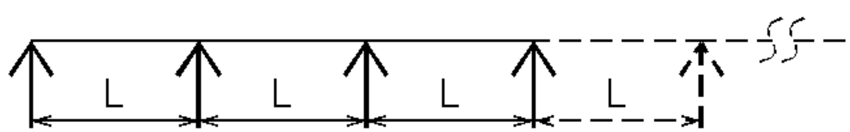
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE V (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
115	63	10	5"	Standard	13’-6	0.01	LF5	13’-6	0.01	LF5	13’-6	0.01	LF5
115	63	10	6"	Standard	13’-0	0.01	LF5	13’-0	0.01	LF5	13’-0	0.01	LF5
115	63	10	5"	Extra High	20’-6	0.07	LF1	26’-0	0.18	LF2	33’-6	0.50	LF3
115	63	10	6"	Extra High	18’-6	0.03	LF1	25’-6	0.12	LF2	34’-6	0.39	LF7
161	23	9'-0	3.5"	Standard	25'-0	0.29	LF1	37'-0	1.46	LF5	37'-0	1.46	LF5
161	23	9'-0	5"	Standard	20'-0	0.06	LF1	30'-0	0.32	LF5	30'-0	0.32	LF5
161	23	9'-0	6"	Standard	18'-0	0.03	LF1	27'-0	0.15	LF5	27'-0	0.15	LF5
161	23	14'-0	3.5"	Standard	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
161	23	14'-0	5"	Standard	20'-0	0.06	LF1	35'-0	0.59	LF5	35'-0	0.59	LF5
161	23	14'-0	6"	Standard	18'-0	0.03	LF1	31'-0	0.25	LF5	31'-0	0.25	LF5
161	23	9'-0	3.5"	High	25'-0	0.29	LF1	42’-6	2.53	LF4	42’-6	2.53	LF4
161	23	9'-0	5"	High	20'-0	0.06	LF1	47’-0	1.92	LF6	47’-0	1.92	LF6
161	23	9'-0	6"	High	18'-0	0.03	LF1	42’-0	0.86	LF6	42’-0	0.86	LF6
161	23	14'-0	3.5"	High	25'-0	0.29	LF1	42’-6	2.53	LF4	42’-6	2.53	LF4
161	23	14'-0	5"	High	20'-0	0.06	LF1	53’-0	3.11	LF4	53’-0	3.11	LF4
161	23	14'-0	6"	High	18'-0	0.03	LF1	48’-0	1.46	LF6	48’-0	1.46	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

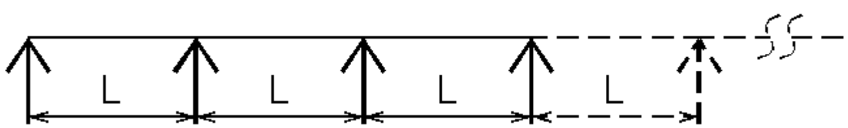
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.
Note: The bolt hole size and pattern changes for 115kV extra high strength insulators. To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.

MULTIPLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE V (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
161	30	9'-0	3.5"	Standard	25'-0	0.29	LF1	28’-0	0.48	LF5	28’-0	0.48	LF5
161	30	9'-0	5"	Standard	20'-0	0.06	LF1	24’-0	0.13	LF5	24’-0	0.13	LF5
161	30	9'-0	6"	Standard	18'-0	0.03	LF1	22’-0	0.06	LF5	22’-0	0.06	LF5
161	30	14'-0	3.5"	Standard	25'-0	0.29	LF1	35’-6	1.23	LF5	35’-6	1.23	LF5
161	30	14'-0	5"	Standard	20'-0	0.06	LF1	29’-6	0.30	LF5	29’-6	0.30	LF5
161	30	14'-0	6"	Standard	18'-0	0.03	LF1	26’-6	0.14	LF5	26’-6	0.14	LF5
161	30	9'-0	3.5"	High	25'-0	0.29	LF1	41’-0	2.20	LF3	41’-0	2.20	LF3
161	30	9'-0	5"	High	20'-0	0.06	LF1	37’-0	0.74	LF6	37’-0	0.74	LF6
161	30	9'-0	6"	High	18'-0	0.03	LF1	34’-0	0.37	LF6	34’-0	0.37	LF6
161	30	14'-0	3.5"	High	25'-0	0.29	LF1	42’-6	2.53	LF4	42’-6	2.53	LF4
161	30	14'-0	5"	High	20'-0	0.06	LF1	45’-6	1.69	LF6	45’-6	1.69	LF6
161	30	14'-0	6"	High	18'-0	0.03	LF1	40’-6	0.74	LF6	40’-6	0.74	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to X# of Bus Supports

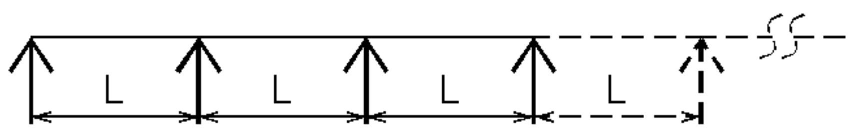
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.
Note: The bolt hole size and pattern changes for 115kV extra high strength insulators. To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.

MULTIPLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE V (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
230	23	16	3.5"	Standard	25'-0	0.29	LF1	36'-6	1.38	LF5	36'-6	1.38	LF5
230	23	16	5"	Standard	20'-0	0.06	LF1	29'-0	0.28	LF5	29'-0	0.28	LF5
230	23	16	6"	Standard	18'-0	0.03	LF1	25'-0	0.11	LF5	25'-0	0.11	LF5
230	30	16	3.5"	Standard	25'-0	0.29	LF1	29'-6	0.59	LF5	29'-6	0.59	LF5
230	30	16	5"	Standard	20'-0	0.06	LF1	24'-6	0.14	LF5	24'-6	0.14	LF5
230	30	16	6"	Standard	18'-0	0.03	LF1	22'-0	0.06	LF5	22'-0	0.06	LF5
230	40	16	3.5"	Standard	22'-0	0.17	LF5	22'-0	0.18	LF5	22'-0	0.18	LF5
230	40	16	5"	Standard	19'-0	0.05	LF5	19'-0	0.05	LF5	19'-0	0.05	LF5
230	40	16	6"	Standard	17'-6	0.03	LF5	17'-6	0.03	LF5	17'-6	0.03	LF5
230	23	16	3.5"	High	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
230	23	16	5"	High	20'-0	0.06	LF1	44'-0	1.48	LF6	44'-0	1.48	LF6
230	23	16	6"	High	18'-0	0.03	LF1	39'-0	0.64	LF6	39'-0	0.64	LF6
230	30	16	3.5"	High	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
230	30	16	5"	High	20'-0	0.06	LF1	37'-6	0.78	LF6	37'-6	0.78	LF6
230	30	16	6"	High	18'-0	0.03	LF1	33'-6	0.35	LF6	33'-6	0.35	LF6
230	40	16	3.5"	High	25'-0	0.29	LF1	34'-0	1.04	LF6	34'-0	1.04	LF6
230	40	16	5"	High	20'-0	0.06	LF1	29'-0	0.28	LF6	29'-0	0.28	LF6
230	40	16	6"	High	18'-0	0.03	LF1	26'-0	0.13	LF6	26'-0	0.13	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to X# of Bus Supports

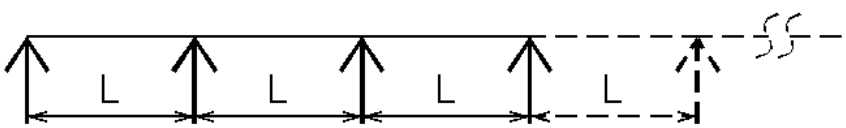
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE V (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Standard	25'-0	0.29	LF1	38'-6	1.71	LF5	38'-6	1.71	LF5
345	23	16	5"	Standard	20'-0	0.06	LF1	30'-6	0.34	LF5	30'-6	0.34	LF5
345	23	16	6"	Standard	18'-0	0.03	LF1	26'-6	0.14	LF5	26'-6	0.14	LF5
345	30	16	3.5"	Standard	25'-0	0.29	LF1	31'-6	0.76	LF5	31'-6	0.76	LF5
345	30	16	5"	Standard	20'-0	0.06	LF1	25'-6	0.17	LF5	25'-6	0.17	LF5
345	30	16	6"	Standard	18'-0	0.03	LF1	23'-0	0.08	LF5	23'-0	0.08	LF5
345	40	16	3.5"	Standard	23'-0	0.21	LF5	23'-0	0.22	LF5	23'-0	0.22	LF5
345	40	16	5"	Standard	20'-0	0.06	LF5	20'-0	0.06	LF5	20'-0	0.06	LF5
345	40	16	6"	Standard	18'-0	0.03	LF5	18'-0	0.03	LF5	18'-0	0.03	LF5
345	23	16	3.5"	High	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
345	23	16	5"	High	20'-0	0.06	LF1	44'-0	1.48	LF6	44'-0	1.48	LF6
345	23	16	6"	High	18'-0	0.03	LF1	39'-0	0.64	LF6	39'-0	0.64	LF6
345	30	16	3.5"	High	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
345	30	16	5"	High	20'-0	0.06	LF1	37'-6	0.78	LF6	37'-6	0.78	LF6
345	30	16	6"	High	18'-0	0.03	LF1	33'-6	0.35	LF6	33'-6	0.35	LF6
345	40	16	3.5"	High	25'-0	0.29	LF1	34'-0	1.04	LF6	34'-0	1.04	LF6
345	40	16	5"	High	20'-0	0.06	LF1	29'-0	0.28	LF6	29'-0	0.28	LF6
345	40	16	6"	High	18'-0	0.03	LF1	26'-0	0.13	LF6	26'-0	0.13	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

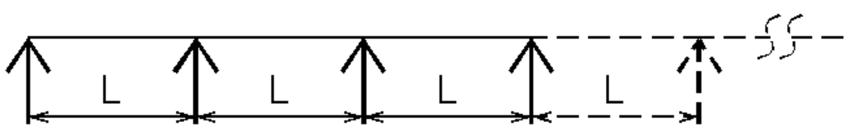
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITHOUT OVERBUS

TABLE V (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
345	23	16	3.5"	Extra High	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
345	23	16	5"	Extra High	20'-0	0.06	LF1	53'-0	3.11	LF4	53'-0	3.11	LF4
345	23	16	6"	Extra High	18'-0	0.03	LF1	53'-0	2.17	LF7	53'-0	2.17	LF7
345	30	16	3.5"	Extra High	25'-0	0.29	LF1	42'-0	2.42	LF4	42'-0	2.42	LF4
345	30	16	5"	Extra High	20'-0	0.06	LF1	51'-6	2.77	LF7	51'-6	2.77	LF7
345	30	16	6"	Extra High	18'-0	0.03	LF1	46'-0	1.23	LF7	46'-0	1.23	LF7
345	40	16	3.5"	Extra High	25'-0	0.29	LF1	40'-0	1.99	LF2	41'-0	2.20	LF3
345	40	16	5"	Extra High	20'-0	0.06	LF1	37'-0	0.74	LF2	40'-0	1.01	LF7
345	40	16	6"	Extra High	18'-0	0.03	LF1	35'-0	0.41	LF2	36'-6	0.49	LF7

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to X# of Bus Supports

Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE VI

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
12.5/13.8	30	3'-0	3.5"	Standard	21’-0	0.43	LF5	21’-0	0.44	LF5	21’-0	0.44	LF5
12.5/13.8	30	3'-0	5"	Standard	20’-0	0.18	LF5	20’-0	0.18	LF5	20’-0	0.18	LF5
12.5/13.8	30	4'-0	3.5"	Standard	25’-0	0.77	LF1	26’-6	0.95	LF5	26’-6	0.95	LF5
12.5/13.8	30	4'-0	5"	Standard	20’-0	0.18	LF1	24'-6	0.35	LF5	24'-6	0.35	LF5
23	20	4'-0	3.5"	Standard	25’-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
23	20	4'-0	5"	Standard	20’-0	0.18	LF1	40'-0	1.92	LF5	40'-0	1.92	LF5
23	20	5'-0	3.5"	Standard	25’-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
23	20	5'-0	5"	Standard	20’-0	0.18	LF1	44'-0	2.68	LF4	44'-0	2.68	LF4
34.5	20	4'-0	3.5"	Standard	25’-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
34.5	20	4'-0	5"	Standard	20’-0	0.18	LF1	40'-0	1.92	LF5	40'-0	1.92	LF5
34.5	20	6'-0	3.5"	Standard	25’-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
34.5	20	6'-0	5"	Standard	20’-0	0.18	LF1	43'-0	2.47	LF4	43'-0	2.47	LF4
69	20	5'-0	3.5"	Standard	25’-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
69	20	5'-0	5"	Standard	20’-0	0.18	LF1	33’-6	1.03	LF5	33’-6	1.03	LF5
69	20	8'-0	3.5"	Standard	25’-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
69	20	8'-0	5"	Standard	20’-0	0.18	LF1	40'-0	1.92	LF5	40'-0	1.92	LF5

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
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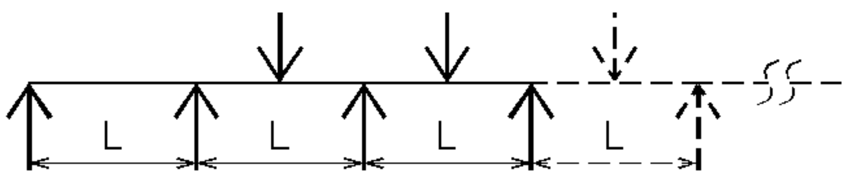


Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

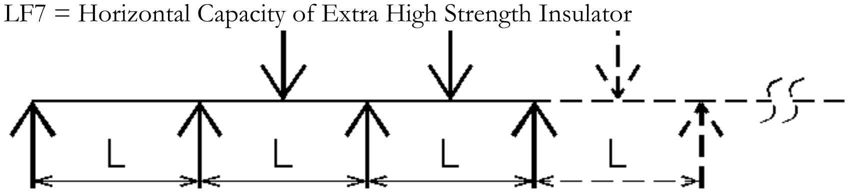
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE VI (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1			Application #2			Application #3		
					Maximum Span (L) (ft)	Expected Deflectio (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
115	23	8'-0	3.5"	Standard	25'-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
115	23	8'-0	5"	Standard	20'-0	0.18	LF1	41'-0	2.09	LF5	41'-0	2.09	LF5
115	23	8'-0	6"	Standard	18'-0	0.08	LF1	37'-0	0.95	LF5	37'-0	0.95	LF5
115	23	10'-0	3.5"	Standard	25'-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
115	23	10'-0	5"	Standard	20'-0	0.18	LF1	42'-0	2.28	LF4	42'-0	2.28	LF4
115	23	10'-0	6"	Standard	18'-0	0.08	LF1	40'-0	1.26	LF5	40'-0	1.26	LF5
115	40	8'-0	3.5"	Standard	25'-0	0.77	LF5	25'-0	0.78	LF5	25'-0	0.78	LF5
115	40	8'-0	5"	Standard	20'-0	0.18	LF1	22'-6	0.26	LF5	22'-6	0.26	LF5
115	40	8'-0	6"	Standard	18'-0	0.08	LF1	21'-0	0.13	LF5	21'-0	0.13	LF5
115	40	10'-0	3.5"	Standard	25'-0	0.77	LF1	29'-0	1.30	LF5	29'-0	1.30	LF5
115	40	10'-0	5"	Standard	20'-0	0.18	LF1	26'-0	0.43	LF5	26'-0	0.43	LF5
115	40	10'-0	6"	Standard	18'-0	0.08	LF1	24'-6	0.23	LF5	24'-6	0.23	LF5
115	40	8'-0	3.5"	High	25'-0	0.77	LF1	30'-6	1.54	LF3	30'-6	1.54	LF3
115	40	8'-0	5"	High	20'-0	0.18	LF1	34'-6	1.14	LF6	34'-6	1.14	LF6
115	40	8'-0	6"	High	18'-0	0.08	LF1	32'-6	0.60	LF6	32'-6	0.60	LF6
115	40	10'-0	3.5"	High	25'-0	0.77	LF1	32'-0	1.82	LF4	32'-0	1.82	LF4
115	40	10'-0	5"	High	20'-0	0.18	LF1	40'-0	1.92	LF6	40'-0	1.92	LF6
115	40	10'-0	6"	High	18'-0	0.08	LF1	37'-6	1.00	LF6	37'-6	1.00	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

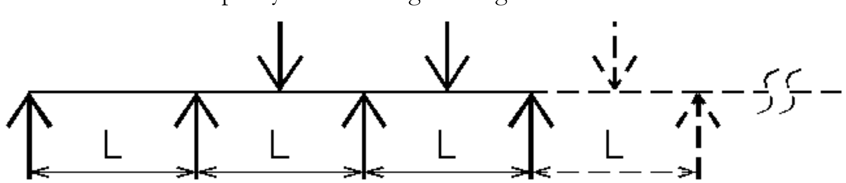
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE VI (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
115	63	10	5"	Standard	13’-6	0.05	LF5	13’-6	0.05	LF5	13’-6	0.05	LF5
115	63	10	6"	Standard	13’-0	0.03	LF5	13’-0	0.03	LF5	13’-0	0.03	LF5
115	63	10	5"	Extra High	20’-0	0.18	LF1	26’-0	0.43	LF2	33’-0	0.98	LF3
115	63	10	6"	Extra High	18’-0	0.08	LF1	25’-6	0.26	LF2	34’-6	0.74	LF7
161	23	9'-0	3.5"	Standard	25’-0	0.89	LF1	31'-0	1.84	LF4	31'-0	1.84	LF4
161	23	9'-0	5"	Standard	20’-0	0.19	LF1	30'-0	0.76	LF5	30'-0	0.76	LF5
161	23	9'-0	6"	Standard	18’-0	0.09	LF1	27'-0	0.36	LF5	27'-0	0.36	LF5
161	23	14'-0	3.5"	Standard	25’-0	0.89	LF1	31'-0	1.84	LF4	31'-0	1.84	LF4
161	23	14'-0	5"	Standard	20’-0	0.19	LF1	35'-0	1.30	LF5	35'-0	1.30	LF5
161	23	14'-0	6"	Standard	18’-0	0.09	LF1	31'-0	0.58	LF5	31'-0	0.58	LF5
161	23	9'-0	3.5"	High	25’-0	0.89	LF1	31'-0	1.84	LF4	31'-0	1.84	LF4
161	23	9'-0	5"	High	20’-0	0.19	LF1	42’-0	2.44	LF4	42’-0	2.44	LF4
161	23	9'-0	6"	High	18’-0	0.09	LF1	42’-0	1.66	LF6	42’-0	1.66	LF6
161	23	14'-0	3.5"	High	25’-0	0.89	LF1	31'-0	1.84	LF4	31'-0	1.84	LF4
161	23	14'-0	5"	High	20’-0	0.19	LF1	42’-0	2.44	LF4	42’-0	2.44	LF4
161	23	14'-0	6"	High	18’-0	0.09	LF1	48’-0	2.65	LF6	48’-0	2.65	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

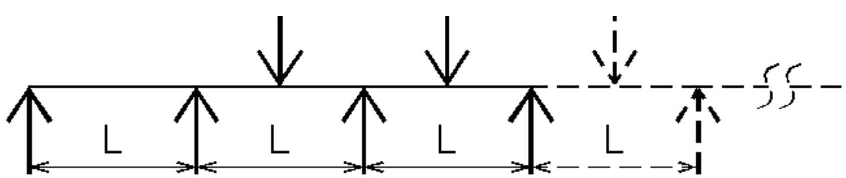
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The bolt hole size and pattern changes for 115kV extra high strength insulators. To maintain standard insulator height with the 115kV extra high strength insulator, a Locke Insulator or equal should be used.
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE VI (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
161	30	9'-0	3.5"	Standard	25'-0	0.89	LF1	28'-0	1.31	LF5	28'-0	1.31	LF5
161	30	9'-0	5"	Standard	20'-0	0.19	LF1	24'-0	0.36	LF5	24'-0	0.36	LF5
161	30	9'-0	6"	Standard	18'-0	0.09	LF1	22'-0	0.18	LF5	22'-0	0.18	LF5
161	30	14'-0	3.5"	Standard	25'-0	0.89	LF1	31'-0	1.84	LF4	31'-0	1.84	LF4
161	30	14'-0	5"	Standard	20'-0	0.19	LF1	29'-6	0.72	LF5	29'-6	0.72	LF5
161	30	14'-0	6"	Standard	18'-0	0.09	LF1	26'-6	0.34	LF5	26'-6	0.34	LF5
161	30	9'-0	3.5"	High	25'-0	0.89	LF1	31'-0	1.84	LF4	31'-0	1.84	LF4
161	30	9'-0	5"	High	20'-0	0.19	LF1	37'-0	1.58	LF6	37'-0	1.58	LF6
161	30	9'-0	6"	High	18'-0	0.09	LF1	34'-0	0.71	LF6	34'-0	0.71	LF6
161	30	14'-0	3.5"	High	25'-0	0.89	LF1	31'-0	1.84	LF4	31'-0	1.84	LF4
161	30	14'-0	5"	High	20'-0	0.19	LF1	42'-0	2.44	LF4	42'-0	2.44	LF4
161	30	14'-0	6"	High	18'-0	0.09	LF1	40'-6	1.46	LF6	40'-6	1.46	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

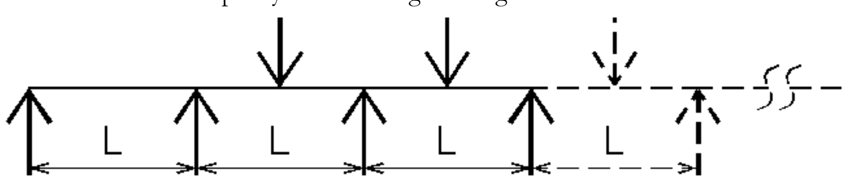
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE VI (Contd.)

Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Application #1 Maximum Span (L) (ft)	Application #1 Expected Deflection (in)	Application #1 Limiting Factor	Application #2 Maximum Span (L) (ft)	Application #2 Expected Deflection (in)	Application #2 Limiting Factor	Application #3 Maximum Span (L) (ft)	Application #3 Expected Deflection (in)	Application #3 Limiting Factor
230	23	16	3.5"	Standard	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
230	23	16	5"	Standard	20'-0	0.24	LF1	29'-0	0.83	LF5	29'-0	0.83	LF5
230	23	16	6"	Standard	18'-0	0.11	LF1	25'-0	0.33	LF5	25'-0	0.33	LF5
230	30	16	3.5"	Standard	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
230	30	16	5"	Standard	20'-0	0.24	LF1	24'-6	0.48	LF5	24'-6	0.48	LF5
230	30	16	6"	Standard	18'-0	0.11	LF1	22'-0	0.22	LF5	22'-0	0.22	LF5
230	40	16	3.5"	Standard	22'-0	0.79	LF5	22'-0	0.80	LF5	22'-0	0.80	LF5
230	40	16	5"	Standard	19'-0	0.21	LF5	19'-0	0.21	LF5	19'-0	0.21	LF5
230	40	16	6"	Standard	17'-6	0.10	LF5	17'-6	0.10	LF5	17'-6	0.10	LF5
230	23	16	3.5"	High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
230	23	16	5"	High	20'-0	0.24	LF1	40'-0	2.46	LF4	40'-0	2.46	LF4
230	23	16	6"	High	18'-0	0.11	LF1	39'-0	1.48	LF6	39'-0	1.48	LF6
230	30	16	3.5"	High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
230	30	16	5"	High	20'-0	0.24	LF1	37'-6	1.98	LF6	37'-6	1.98	LF6
230	30	16	6"	High	18'-0	0.11	LF1	33'-6	0.88	LF6	33'-6	0.88	LF6
230	40	16	3.5"	High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
230	40	16	5"	High	20'-0	0.24	LF1	29'-0	0.83	LF6	29'-0	0.83	LF6
230	40	16	6"	High	18'-0	0.11	LF1	26'-0	0.37	LF6	26'-0	0.37	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to X# of Bus Supports

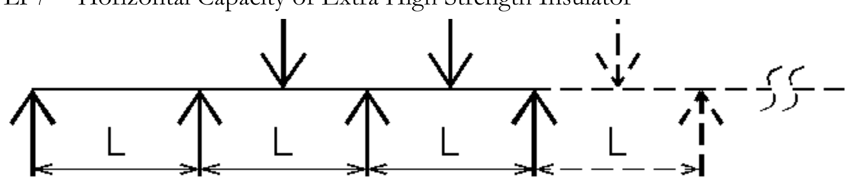
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE VI (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Standard	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	23	16	5"	Standard	20'-0	0.24	LF1	30'-0	0.93	LF5	30'-0	0.93	LF5
345	23	16	6"	Standard	18'-0	0.11	LF1	26'-6	0.40	LF5	26'-6	0.40	LF5
345	30	16	3.5"	Standard	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	30	16	5"	Standard	20'-0	0.24	LF1	25'-6	0.54	LF5	25'-6	0.54	LF5
345	30	16	6"	Standard	18'-0	0.11	LF1	23'-0	0.25	LF5	23'-0	0.25	LF5
345	40	16	3.5"	Standard	23'-0	0.92	LF5	23'-0	0.92	LF5	23'-0	0.92	LF5
345	40	16	5"	Standard	20'-0	0.24	LF5	20'-0	0.25	LF5	20'-0	0.25	LF5
345	40	16	6"	Standard	18'-0	0.11	LF5	18'-0	0.11	LF5	18'-0	0.11	LF5
345	23	16	3.5"	High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	23	16	5"	High	20'-0	0.24	LF1	40'-0	2.46	LF4	40'-0	2.46	LF4
345	23	16	6"	High	18'-0	0.11	LF1	39'-0	1.48	LF6	39'-0	1.48	LF6
345	30	16	3.5"	High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	30	16	5"	High	20'-0	0.24	LF1	37'-6	1.98	LF6	37'-6	1.98	LF6
345	30	16	6"	High	18'-0	0.11	LF1	33'-6	0.88	LF6	33'-6	0.88	LF6
345	40	16	3.5"	High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	40	16	5"	High	20'-0	0.24	LF1	29'-0	0.83	LF6	29'-0	0.83	LF6
345	40	16	6"	High	18'-0	0.11	LF1	26'-0	0.37	LF6	26'-0	0.37	LF6

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:
Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:
Bus Support to X# of Bus Supports

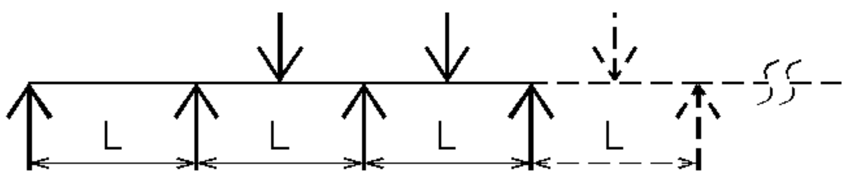
Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

MULTIPLE SPAN BUS CONFIGURATIONS WITH OVERBUS

TABLE VI (Contd.)

					Application #1			Application #2			Application #3		
Nominal Voltage (kV)	Fault Current (kA)	Phase Spacing (ft)	Bus Type (in)	Insulator Strength	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor	Maximum Span (L) (ft)	Expected Deflection (in)	Limiting Factor
345	23	16	3.5"	Extra High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	23	16	5"	Extra High	20'-0	0.24	LF1	40'-0	2.46	LF4	40'-0	2.46	LF4
345	23	16	6"	Extra High	18'-0	0.11	LF1	47'-0	2.81	LF7	47'-0	2.81	LF7
345	30	16	3.5"	Extra High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	30	16	5"	Extra High	20'-0	0.24	LF1	40'-0	2.46	LF4	40'-0	2.46	LF4
345	30	16	6"	Extra High	18'-0	0.11	LF1	46'-0	2.61	LF7	46'-0	2.61	LF7
345	40	16	3.5"	Extra High	25'-0	1.20	LF1	28'-0	1.74	LF4	28'-0	1.74	LF4
345	40	16	5"	Extra High	20'-0	0.24	LF1	37'-0	1.89	LF2	40'-0	2.46	LF4
345	40	16	6"	Extra High	18'-0	0.11	LF1	35'-0	1.02	LF2	36'-6	1.18	LF7

LF1 = Switch Pad Moment Capacity Limited to 4,000 in-lb
LF2 = Horizontal Capacity of Switch
LF3 = Fiber Stress of the Bus Limited to 25,000 psi
LF4 = Maximum Deflection Limited to L/200
LF5 = Horizontal Capacity of Standard Strength Insulator
LF6 = Horizontal Capacity of High Strength Insulator
LF7 = Horizontal Capacity of Extra High Strength Insulator



Application #1:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at one end)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (fixed fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (fixed fitting at switch)

Application #2:

Switch Pad to X# of Bus Supports to Switch Pad (expansion fitting at both ends)
Switch Pad to X# of Bus Supports to A-Frame Bus Tap (expansion fitting at switch)
Switch Pad to X# of Bus Supports to Bus Support (expansion fitting at switch)

Application #3:

Bus Support to X# of Bus Supports

Note: Use an expansion fitting at the switch if overbus is in the same span as the switch.
Note: The center and end supports may be moved as long as no single span is greater than the allowable maximum span L.

System Voltages **(1)**			Electrical Clearances and Spacings of Live Parts **(2) (3) (4) (5)**						Working Clearances to Live Parts							
Nominal	Maximum	Impulse Withstand	**Minimum**			**NSP Recommended ⁋**			Guard Zone Radius "R" **(7)**		Clearances to Live Parts From Any Permanent Supporting Surface for Personnel **(8)**				Clearances between Bare Overhead Conductor and Roadways	
			Phase-to-Phase **(6)**		Ph-to-Gnd	Phase-to-Phase **(6)**		Ph-to-Gnd			Vertical **(9) (10)**		Horizontal			
(Ph-Ph)	(Ph-Ph)	(BIL)	C-to-C Spacings	S-to-S Clearances	S-to-S Clearances	C-to-C Spacings	S-to-S Clearances	S-to-S Clearances	Minimum ‡	NSP ⁋	Minimum ‡	NSP ⁋	Minimum ‡	NSP ⁋	Minimum ‡‡	NSP ⁋
(kV)	(kV)	(kV)	(ft-in)††	(ft-in)†	(ft-in)†	(ft-in)	(ft-in)	(ft-in)	(ft-in)	(ft-in)	(ft-in) **(11)**	(ft-in)	(ft-in)	(ft-in)	(ft-in) **(12)**	(ft-in)
2.4	2.54	95	1-3	0-7	0-6	1-6	**0-10**	**0-9**	0-3	0-3	8-9	10-9	3-4	3-4	18-6	20-0
4.16	4.4	95	1-3	0-7	0-6	1-6	**0-10**	**0-9**	0-3	0-3	8-9	10-9	3-4	3-4	18-6	20-0
12.5	13.2	110	£	£	£	3-0	**1-0**	**0-10**	£	0-6	£	11-0	£	3-6	18-6	20-0
13.8	14.52	110	2-0	1-0	0-7	3-0	**1-0**	**0-10**	0-6	0-6	9-0	11-0	3-6	3-6	18-6	20-0
23	24.34	150	2-6	1-3	0-10	3-0	**1-6**	1-3	0-9	0-9	9-3	11-3	3-9	3-9	18-7	20-0
34.5	36.51	200	3-0	1-6	1-1	3-6	1-6	**1-4**	1-0	1-0	9-6	11-6	4-0	4-0	19-0	22-0
69	72.5	350	5-0	2-7	2-1	5-0	**2-10**	**2-4**	1-11	1-11	10-5	12-5	4-11	4-11	20-2	23-0
115	121	550	7-0	4-5	3-6	8-0	**5-0**	**4-0**	3-1	3-1	11-7	13-7	6-1	6-1	21-10	25-0
161	169	750	9-0	6-0	4-2	9-0	**6-3**	**5-0**	4-4	4-10	12-10	14-10	7-4	7-10	23-5	26-0
230*	242	900	11-0	7-5	5-11	11-0	**8-6**	7-0	6-4	6-4	14-10	16-10	9-4	8-6	25-10	27-0
345*	362	1300	§	§	§	16-0	**11-0**	10-0	8-8	8-8	17-2	19-2	11-8	11-8	29-10	§
500*	550	1800	§	§	§	§	§	15-0	12-0	12-0	20-6	22-6	15-0	19-0	36-1	§

( ) Indicates an application note listed on the next sheet.

* EHV clearances are shown for reference only and should be verified with engineering before using.

⁋ NSP Recommended Clearances are NSP Company adopted values that are always greater than or equal to Minimum values taken from accepted national code publications. NSP recommended values shown in **BOLD** text were revised 12/03/96 to follow industry accepted criteria concerning phase-to-phase and phase-to-ground clearance comparisons discussed in section 4 of ED4.02.02. Care should be taken when applying these clearances that an appropriate ratio of phase-to-phase, surface-to-surface and phase-to-ground, surface-to-surface clearances is maintained.

† Minimum values taken from NEC Table 710-33 "Minimum Clearance of Live Parts."

‡ Minimum values taken from NESC Table 124-1 "Clearance From Live Parts."

†† Minimum values taken from NEMA Standards Publication No. SG6-1974 (R1979), Appendix A, Table 1 "Outdoor Substations -Basic Parameters," under column heading "Recommended Phase Spacing Center to Center for Bus Supports..."

‡‡ Minimum values taken from NESC Table 232-1, Cases 1 and 2, for Open Supply Conductors, see application note (12).

§ Indicates that the value is not available.

£ NESC Minimum clearance and spacing values for the 12.5kV system voltage level are not available. Minimum 12.5kV values shall be identical to those used at the 13.8kV system voltage level

S-to-S and C-to-C stand for Surface-to-Surface and Center-to-Center respectively.

OUTDOOR ELECTRICAL AND WORKING CLEARANCES

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE **12/03/96**		**0**	**SHEET 1**	**ED 4.02.02.01**

(1) System voltage designations are taken from ANSI Standard C84.1-1989, "Voltage Ratings (60 Hertz) for Electric Power Systems and Equipment", and NSP Engineering and Design Standard ED 4.01.02.01 "Basic Impulse Insulation Levels".

(2) The Electrical Clearances and Spacings shown in this table shall not apply to interior portions or exterior terminals of equipment designed, manufactured, and tested in accordance with accepted national standards. For NSP Recommended Clearances between external live parts of power transformers, see Standard ED 4.02.02.02 "Outdoor Equipment Phase Spacings".

(3) For clearance measurements, live metallic hardware electrically connected to line conductors shall be considered to be a part of the line conductors. Metallic bases of potheads, surge arresters, and similar devices shall be considered a part of the grounded supporting structure *(NESC rule 230B).*

(4) The Minimum Electrical Clearances and Spacings shown in this table are for rigid parts and bare conductors under favorable conditions. These clearances should be increased, to NSP recommended values or greater, if excess conductor movement or unfavorable service conditions exist.

(5) The Electrical Clearances and Spacings shown in this table apply to both rigid bus and short-span strain bus conductors. The conductor type, short circuit magnetic forces, and wind and ice loading conditions, should be considered in the design.

(6) The adopted NSP phase-to-phase clearance between live parts of different voltages shall be determined by the sum of the phase-to-ground clearances of each voltage level (i.e. assume a ground plane exists between the live parts).

(7) The clearance values for the Guard Zone Radius "R" are for guidance when installing a physical shield where the live part is not adequately guarded by location, isolation, or insulation *(NESC table 124-1, note 1).*

(8) Parts of indeterminate potential, such as ungrounded neutral connections, ungrounded frames, ungrounded parts of insulators or surge arresters, or ungrounded instrument cases connected directly to a high voltage circuit, shall be guarded in accordance with NESC Rule 124A1 on the basis that the maximum voltage may be present on the surface of that part. The vertical clearance above grade[1] to the bottom of such a part shall be not less than 8 ft.-6 in. (unless it is enclosed or guarded in accordance with Rule 124C) *(NESC rule 124A3).*

(9) The Minimum Vertical Working Clearances shown in this table may be reduced (provided surge-protective devices are applied to protect live parts) to a height not less than 8'-6" plus the electrical clearance between energized parts and ground as limited by the surge protective device *(NESC Table 124-1, note 1).*

---

[1] For NSP Substations, top-of-concrete elevations, not grade, will always be used as the general design basis for establishing the required vertical clearances to live parts.

(10) The NSP Recommended Vertical Clearances to Live Parts include two (2) feet of additional height over Minimum values for compacted snow depths. Vertical Working Clearance requirements for pedestal-mounted equipment do not include additional height for snow accumulation under the assumption that snow can be safely removed from the access area around this type of equipment.

(11) The Minimum Vertical Working Clearance dimension is calculated by adding the Guard Zone Radius "R" to the 8'-6" minimum dimension from grade to the bottom parts of indeterminent potential (see application note (8) above).

(12) The Minimum values for Clearances between Bare Overhead Conductors and Roadways is equal to the vertical clearance requirements in NESC Table 232-1, Cases 1 and 2, for "Open Supply Conductors 22kV and below". The vertical clearance dimensions for voltages above 22kV are specified by NESC Rule 232C1a, which increases this dimension at a rate of 0.4 inches per kilovolt above 22kV based on the maximum system operating voltage. e.g.: For 34.5kV, H = [(36.5kV–22kV)×(0.4) ÷ 12]+18.5 = 18.98 feet (rounded up to 19'-0").

System Voltages		Switch Spacings Measured Center-to-Center						Clearances	
Nominal	Impulse Withstand	Vertical Break Disconnect Switches and Non-Vented Fuse Units		Side Break Disconnect Switches (Center, Single-End and Double-End)		Vertical and Side Break Horn-Gap Switches and Vented Fuse Units [g]		External Live Parts of Power Transformers **(3)**	
(Ph-Ph)	(BIL)	Minimum [a]	NSP [b]	Minimum [a]	NSP [b]	Minimum [c]	NSP [b]	(Ph-Grd)	(Ph-Ph)
(kV)	(kV)	(ft-in) **(1)**	(ft-in)	(ft-in) **(1)**	(ft-in)	(ft-in)	(ft-in)	(ft-in)	(ft-in)
2.4-7.2	95	1-6	3-0	2-6	3-0	3-0	4-0	0-4½	0-5
13.8	110	2-0	3-0	2-6	3-0	3-0	4-0	0-6	0-6½
23	150	2-6	3-0	3-0	4-0	4-0	5-0	0-8	0-9
34.5	200	3-0	3-0	4-0	4-0	4-3 [f]	6-0	1-0	1-1
69	330	5-0	7-0	6-0	7-0	7-0	8-0	1-11	2-1
115	550	7-0	9-0	9-0	9-0	9-0	10-0	3-1	3-5
161	750	9-0	9-0	13-0	13-0	13-0	14-0	4-4	4-9
230 [d]	900	11-0	11-0	16-0	16-0	16-0	16-0	6-4	7-0
345 [d]	1300	14-6	14-6	[e]	16-0 (2)	16-0	16-0 (2)	[e]	[e]

( ) Indicates an application note below.

[a] Minimum values taken from NEMA Standards Publication No. SG6-1974 (R1979), Appendix A, Table 1 “Outdoor Substations -Basic Parameters,” under column heading “Recommended Phase Spacing Center to Center for ...Vertical Break Disconnect Switches and Non-Expulsion Type Power Fuses... ”

[b] NSP Recommended Switch Spacings are NSP Company adopted values that are always greater than or equal to Minimum values taken from accepted national code publications.

[c] Minimum values taken from NEMA Standards Publication No. SG6-1974 (R1979), Appendix A, Table 1 “Outdoor Substations -Basic Parameters,” under column heading “Recommended Phase Spacing Center to Center for Horn Gap Switches and Expulsion Type Fuses.”

[d] EHV spacings are shown for reference only.

[e] Indicates that the value is not available.

[f] Value increased from Minimum NEMA Standard value to obtain required switch clearances with some suppliers.

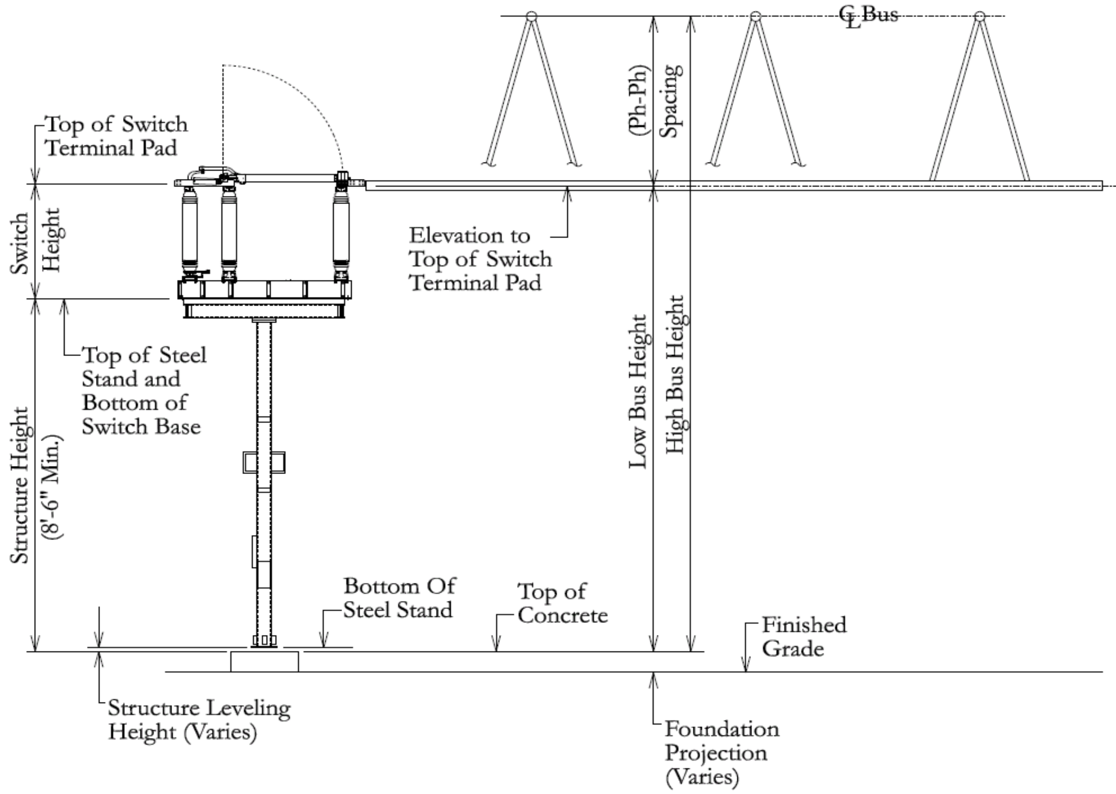
[g] The standard arcing contacts specified in the Xcel Energy Standard EMS-J.08-001 “Outdoor High-Voltage Air Switches and Operating Mechanisms” are arcing horns that do not affect phase separation. Vertical break switches with these standard arcing horns can be mounted with the spacings listed in column 4, “Vertical Break Disconnect Switches and Non-Vented Fuse Units”. Solid material fuses normally used in substations (such as S&C SM and SMD fuses) are considered non-venting and can also be mounted with these column 4 spacings. Switches with optional arcing whips will need to be reviewed for proper phase separation.

(1) The Minimum values for vertical and side break switches may be reduced dependent upon the switch manufacturer. However, in no case should the surface-to-surface distance between energized parts be less than that shown in Standard ED 4.02.02.01.

(2) The NSP values for 345kV side break and horn-gap switches are based on a double break disconnect switch.

(3) The surface-to-surface clearance values used for external live parts of power transformers are based on NEMA Standards Publication TR1-0.15.

Low-Profile Bus Height Measurements



Nominal Voltage System (Ph-Ph) (kV)	Maximum System Voltage (Ph-Ph) (kV)	Impulse Withstand Voltage (BIL) (kV)	Xcel Energy Standard Switch Height (ft-in) (1)	Low-Profile Bus Heights (2) (3) (4) (5)			
				Low Bus Height		High Bus Height	
				Minimum † (ft-in) (6) (7)	Xcel Energy ℘ (ft-in) (8)	Minimum (ft-in) (10)	Xcel Energy ℘ (ft-in) (11)
15	15.5	110	2-3	9-0	14-3 (9)	11-0	17-3
34.5	36.51	200	2-6	9-6	14-3 (9)	12-6	17-9
69	72.5	350	3-8	10-5	12-6	15-5	17-6
69	72.5	350	3-4 (V-Style)	£	£	£	£
115	121	550	5-4	11-7	14-0	18-7	22-0
161	169	750	6-8	12-10	15-2	21-10	24-2
230*	242	900	8-6	14-10	17-0	25-10	28-0
345*	362	1300	11-0	§	21-2	§	37-2
500*	550	1800	16-2	§	31-2	§	53-2

( ) Indicates an application note on the next sheet.

* EHV bus heights are based on past Xcel Energy practice and have not been updated.

℘ Xcel Energy-North Recommended Low-Profile Bus Heights are Company adopted values that are always greater than or equal to Minimum values taken from accepted national code publications.

† Minimum values taken from NESC Table 124-1 "Clearance From Live Parts".

£ V-style switches are for package substations only.

§ Indicates that the value is variable.

LOW PROFILE BUS HEIGHTS

(1) Xcel Energy-North Standard Switch Heights are measured from the bottom of the switch base to the top of the switch terminal pad. These dimensions are required for all Xcel Energy-North specified switches.

(2) The Structure Height is measured from the top of concrete to the bottom of the switch base and is calculated by subtracting the Switch Height from the Xcel Energy-North Low-Bus Height dimension. The variable Structure Leveling Height is included in this structure height dimension. In no case shall the Structure Height be less than 8 feet-6 inches.

(3) All low profile bus heights listed in this Standard are measured from the top of concrete to the top of the switch pad. This bus height dimension does not include projection heights of foundations above finished grade. Dimensions shown on project drawings should be shown accordingly.

(4) These low profile bus heights do not include special conditions such as buses over driveways or connections to power transformers or circuit breakers. Additional clearance requirements should be anticipated in these cases.

(5) The Phase-to-Phase dimension between the low bus and the high bus is measured centerline-to-centerline.

(6) The Minimum Low Bus Height is equal to the Minimum Vertical Working Clearance requirement shown in Standard ED 4.02.02.01.

(7) The Minimum Low Bus Height may be reduced (provided surge-protective devices are applied to protect live parts) to a height not less than 8 feet-6 inches plus the electrical clearance between energized parts and ground as limited by the surge protective device *(NESC Table 124-1, note 1)*.

(8) The Xcel Energy-North Recommended Low Bus Height shall always be equal to or greater than the Minimum Vertical Working Clearance (see Standard ED 4.02.02.01) plus 2 feet of additional height for average compressed snow conditions. The Xcel Energy-North Recommended Low Bus Height shall not be less than the Xcel Energy-North Standard Switch Height plus 8 feet-6 inches.

(9) The Xcel Energy-North Recommended Low-Bus heights at 15kV and 34.5kV are designed to meet switchgear bus requirements and exceed Minimum Low Bus Height requirements.

(10) The Minimum High-Bus Height is calculated by adding the Minimum Low Bus Height to the Minimum Center-to-Center Electrical Spacing dimension (see Standard ED 4.02.02.01).

(11) The Xcel Energy-North Recommended High Bus Height of all system voltage levels, except 500kV, are calculated by adding the Xcel Energy-North Recommended Low-Bus Height to the Xcel Energy-North Recommended Center-to-Center Electrical Spacing dimension (see Standard ED 4.02.02.01).

Nominal System Voltage (Ph-Ph) (kV)	Maximum System Voltage (Ph-Ph) (kV)	Impulse Withstand Voltage **(1)** (BIL) (kV)	Indoor Electrical Clearance Between Live Parts Measured Surface-to-Surface **(2) (3) (4) (5)**			
			Phase-Phase		Phase-to-Ground	
			Minimum † (inches)	NSP • (inches)	Minimum † (inches)	NSP • (inches)
2.4	2.54	45	4.5	4.5	3.0	3.0
4.16	4.4	60	4.5	4.5	3.0	3.0
12.5	13.2	95	§	7.5	§	5.0
13.8	14.52	95	7.5	7.5	5.0	5.0
23	24.34	125	10.5	13.0	7.5	7.5
34.5	36.51	200	18.0	18.0	13.0	13.0

( ) Indicates an application note below.

• NSP Recommended Clearances are NSP Company adopted values that are always greater than or equal to Minimum values taken from accepted national code publications.

† Minimum values taken from NEC Table 710-33 “Minimum Clearance of Live Parts.”

§ Indicates that the value is not available

(1) The BIL voltages listed in this table are for indoor applications.

(2) These values are the required clearances for rigid parts and bare conductors under favorable service conditions (no dust or moisture). The values should be increased to allow for conductor movement, when operating under unfavorable service conditions or whenever space limitations permit *(NEC Article 710-33).*

(3) The minimum phase-to-phase centerline spacing of indoor switches and fuses, without the use of barriers, shall be equal to the maximum width of live parts plus the minimum surface-to-surface clearances in this table.

(4) These values do not apply to interior portions or exterior terminals of equipment designed, manufactured, and tested in accordance with accepted national standards *(NEC Article 710-33).*

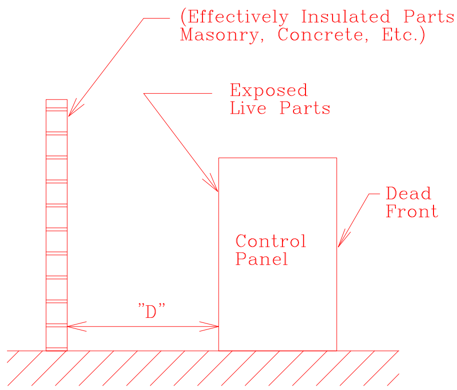
(5) The proper installation of adequate insulating barriers between phases or between phase and ground may permit the reduction of these clearance values.

INDOOR ELECTRICAL CLEARANCES (ABOVE 600 VOLTS)

Nominal System Voltage Phase-Ground	"D" Minimum Indoor Working Clearance in Front of Electric Equipment **(1) (2) (3) (4)**		
	Case 1*	Case 2*	Case 3*
(Volts)	(ft-in)	(ft-in)	(ft-in)
0-150	3-0	3-0	3-0
151-600	3-0	3-6	4-0

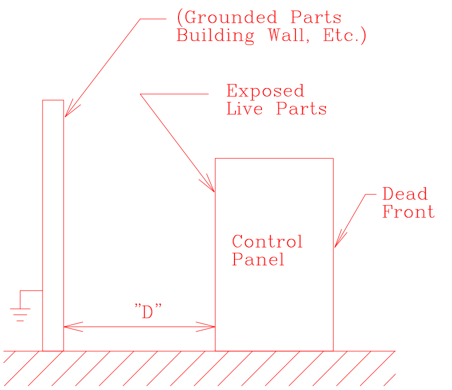
( ) Indicates an application note listed on the next sheet.

* See the case descriptions and sketches below.



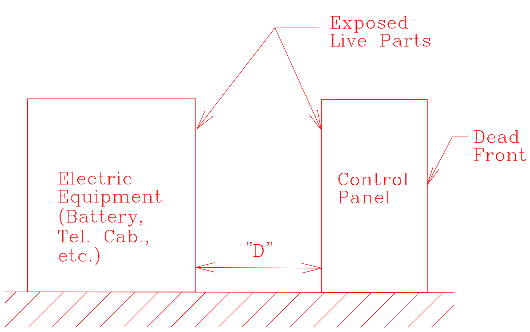
Case 1

Case 1: Exposed live parts on one side and no live or grounded part on the other side of the working space, or exposed live parts effectively guarded by suitable insulating materials. Insulated wire or insulated busbars operating at not over 300 volts shall not be considered live parts. *(NESC Table 125-1, note 1).*



Case 2

Case 2: Exposed live parts on one side and grounded parts on the other side. *(NESC table 125-1, note 2).*



Case 3

Case 3: Exposed live parts on both sides of the work space with the operator between. *NESC Table 125-1, note 3).* Where there is an enclosure on opposite sides of the work space, the clearance is required for only one work space. *(NESC Handbook, Figure 110-12).*

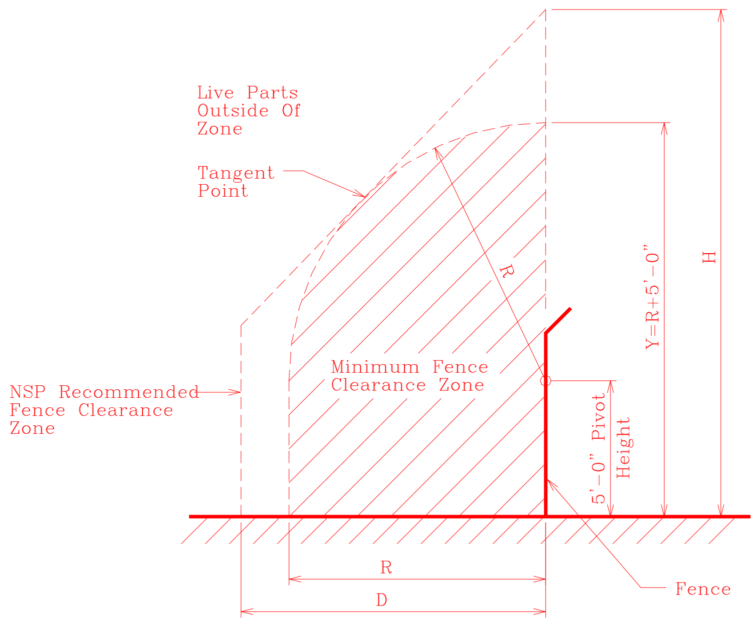
INDOOR WORKING CLEARANCES (600 VOLTS AND BELOW)

(1) Working space is not required in back of equipment such as dead-front switchboards or controls assemblies if there are no renewable or adjustable parts such as fuses or switches on the back, and if all connections are accessible from locations other than the back. Where it is necessary to work on de-energized parts in the back of enclosed equipment, a minimum horizontal working space of 30 inches is required. *(NESC Table 125-1)*.

(2) Working areas about equipment shall be clear, unobstructed space and shall not be used for storage. *(NESC Rule 125A1).*

(3) Distances shall be measured either from the live parts, if such are exposed, or from the enclosure front or rear if the live parts are enclosed. *(NESC Rule 125A3).*

(4) Equipment must not be installed so close to walls that the equipment door or hinged panel cannot open at least 90 degrees. Where doors or hinged panels are wider than 3 feet, work space, greater than 3 feet, must be provided to meet the 90 degree requirement. *(NEC Article 110-16a).*



Clearance Zone for Substation Perimeter Fences

Nominal System Voltage (Ph-Ph) (kV)	Maximum System Voltage (Ph-Ph) (kV)	Impulse Withstand Voltage (BIL) (kV)	Fence Clearance Zone **(1)** Minimum Zone		NSP Recommended Zone	
			Dimension "R" (ft-in) **(2)**	Dimension "Y" (ft-in) **(3)**	Dimension "D" (ft-in) **(4)**	Dimension "H" (ft-in) **(5)**
up to 7.2	——	——	10-0	15-0	15-0	20-0
13.8	14.52	110	10-2	15-2	15-0	20-0
23	24.34	150	10-4	15-4	15-0	20-0
34.5	36.51	200	10-7	15-7	15-0	22-0
69	72.5	350	11-7	16-7	15-0	23-0
115	121	550	13-0	18-0	15-0	25-0
161	169	650	14-4	19-4	15-0	26-0
230	242	900	15-5	20-5	20-0	27-0
345	362	1300	16-5	21-5	20-0	§
500	550	1800	17-4	22-4	20-0	§

( ) Indicates an application note shown on the next sheet.

§ Indicates that the value is not available.

PERIMETER FENCE CLEARANCES

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE **11/14/96**		**0**	**SHEET 1**	**ED 4.02.02.06**

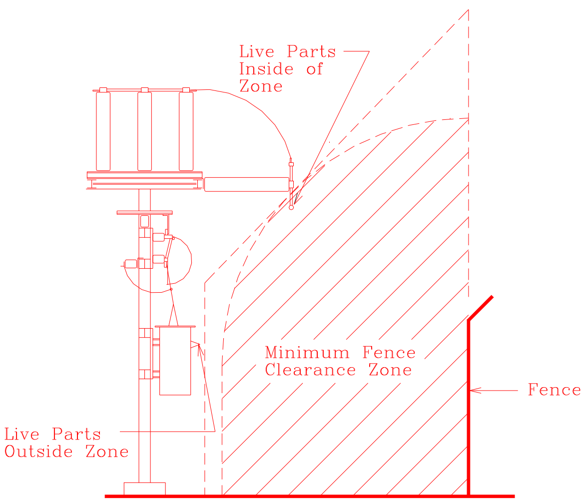
(1) For nominal phase-to-phase voltages of 115kV and above, the dimensions should be increased 3% for each 1000 ft. in excess of 3300 ft. above mean sea level[1]

(2) The values for dimension "R" are taken from NESC Rule 110A2, CP 1828, Fence Safety Clearance Zone.

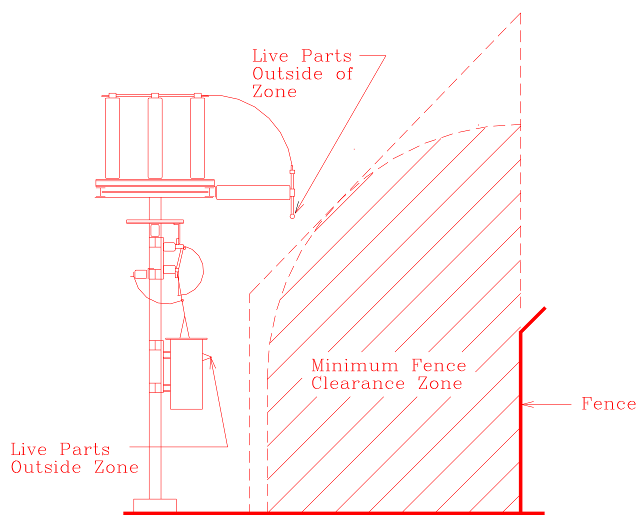
(3) The Minimum values for dimension "Y" are equal to the Minimum value of "R" plus a pivot height of five (5) feet (see note 2 above).

(4) The NSP Recommended values for dimension "D" are the adopted values for equipment access, maintenance and snow removal. This dimension should be increased to provide additional equipment access and drive space when required.

(5) The NSP Recommended value for dimension "H" is equal to the NSP Recommended Vertical Clearance between Bare Overhead Conductors and Roadways as shown in Standard ED 4.02.02.01 "Outdoor Electrical and Working Clearances".



Example 1
Illustration Showing Inadequate Fence Clearance



Example 2
Illustration Showing Adequate Fence Clearance

Example 1: As shown in the illustration above, the proposed fence location allows the live parts, located on the structure column, to meet the NSP Recommended Fence Clearance requirement. However, in the same example, the live parts located overhead extend into the clearance zone making this arrangement unacceptable.

Example 2: As shown in the illustration above, the proposed fence location allows both the live parts located on the structure column and the live parts located overhead to meet the NSP Recommended Fence Clearance requirement.

Refer to ANSI C2-1993, National Electric Safety Code (NESC), 1993 Edition, Part 2, "Safety Rules for the Installation and Maintenance of Overhead Electric Supply and Communication Lines", Rule 232C1b.

PERIMETER FENCE CLEARANCES

Electrical and Working Clearance Standard Subcommittee Approval

J.E. Harbinson Substation Construction, NSP	S.J. McNelly P.E. Technical Lead, Substations, NSP
R.D. Hargreaves Substation Operations, NSP	R.E. Judkins P.E. Technical Lead, Substations, NSP
T.L. Pilla Team Leader, Electric Health & Safety - NSP	E.J. Smith Project Engineer, Substations, NSP
J.W. Murphy Safety Specialist, NSP	M.P. Emmerling Substation Engineer, POWER Engineers Inc.

Table of Contents

1. INTRODUCTION

1.1. Purpose

This standard provides electrical clearance guidelines and design application information for outdoor, open-bus type electrical substation installations. Requirements for accessibility about electric equipment inside substation control buildings and aisle-type, medium voltage, switchgear units are also discussed. These clearances will aid in the design of safe and reliable substations under normal and anticipated abnormal operating conditions with a minimum of system disruptions.

While proper application of these standards is necessary to achieve the above mentioned goals, ultimately, it is the user's level of understanding of this document, familiarity with national and local code requirements, knowledge of the unique project requirements, and good engineering judgment that will lead to safe substation construction, maintenance and operation.

1.2. Scope

This standard addresses outdoor electrical and working clearance requirements within effectively grounded electric supply substations that are accessible only to qualified or authorized personnel. System voltages from 2.4kV through 161kV, with corresponding BIL voltages currently used in NSP transmission and distribution substations, are accepted as a basis for this clearance standard. Clearances for EHV levels (230kV through 500kV) are included in some tables but are for reference purposes only. Design procedures for establishing EHV clearances and spacings, based on BIL or switching surge factors, are not within the scope of this standard. All clearances in this standard assume non-contaminated air or insulation surfaces.

1.2.1. Engineering and Design Standards

The following NSP Electric Delivery Standards for Substation Engineering and Design supplement this Design Criteria:

- ED 4.02.02.01: Included in this standard is a listing of minimum and NSP Recommended Electrical and Working Clearances. This table includes specific design application notes to explain and clarify the use of the values in the table. This table of values is a key element of this standard and should be referred to when establishing clearance requirements.
- ED 4.02.02.02: Phase spacings of air-break switches, power fuses, and external live parts of power transformers are tabulated in this standard.
- ED 4.02.02.03: Standard bus heights and switch heights for low-profile substations are presented in this table.
- ED 4.02.02.04: A table of Minimum and NSP Recommended Indoor Electrical Clearances is included in this standard. These values provide guidance in verifying electrical clearances for switchgear and pad-mounted distribution equipment.

- ED 4.02.02.05: Working space requirements for qualified/authorized personnel are covered in this standard for the area around electrical equipment, switchgear breaker cubicles and panelboards within control buildings and metal-enclosed switchgear.
- ED 4.02.02.06: Guidelines for enclosing outdoor electrical equipment with fences are discussed in this standard which includes supplemental sketches and design application notes.

1.2.2. New and Existing Installations

The NSP Recommended Electrical and Working Clearances and Spacings specified within this Standard shall be applied to all new substation installations and additions to existing substations. It is recognized, however, that structural dimensions, equipment locations, vehicle access requirements, and limited land area may not permit the application of the NSP Recommended values. In these cases, clearances and spacings shall meet or exceed the Minimum values shown in Standard ED 4.02.02.01.

1.2.2.1. Uprating and Compacting

In no case should clearances and spacings be used that are less than the Minimum values shown in Standard ED 4.02.02.01 unless insulation coordination studies, and system transient analysis data on switching surges indicate that reduced minimum phase-to-phase clearances and spacings may be applied.

Methods of utilizing calculated magnitudes of over-voltage stresses or the protective action of surge arresters to determine reduced minimum phase-to-phase clearances for the uprating or compacting of high voltage substations are not addressed in this standard[1, 2].

1.2.3. Exclusions

This standard does not include guidelines for the following applications and installations:

- Overhead electric supply and communications lines, and pole-top mounted equipment [3].
- Working clearances around energized lines and equipment[4].

1 Refer to IEEE Working Group 59.1, IEEE Transactions, Vol. 91, 1972 “Minimum Line-to-Ground Electrical Clearances for EHV Substations Based on Switching Surge Requirements”.

2 Refer to IEEE Transactions, Vol. PAS-98, No. 3, May/June 1979, Sebo, S., Caldecott, R., “Scale Model Studies of AC Substation Electric Fields,”

3 Refer to ANSI C2-1993, National Electric Safety Code (NESC), 1993 Edition, Part 2, “Safety Rules for the Installation and Maintenance of Overhead Electric Supply and Communication Lines.”

4 Refer to ANSI C2-1993, National Electric Safety Code (NESC), 1993 Edition, Part 4, “Rules for the Operation of Electric Supply and Communications Lines and Equipment.”

2. REFERENCES

The following standards and publications are referred to in the text of this document. Material taken from a specific reference is indicated by the use of brackets [ ], with a number corresponding to the following list:

2.1. Industry Standards

[1] ANSI C2-1993, National Electric Safety Code (NESC),1993 Edition Part 1, “Rules for the Maintenance of Electric Supply Stations and Equipment.”

[2] National Electric Safety Code Handbook, Third Edition, “A Discussion of the Grounding Rules, General Rules, and Parts 1, 2, 3, and 4 of the 3rd (1920) through 1993 Editions of the National Electric Safety Code, ANSI C2.”

[3] National Electric Code Handbook, Seventh Edition, based on the 1996 Edition of the National Electric Code (NEC), NFPA 70-1996. Note: Although the scope of the NEC does not include Electric Supply Stations, some clearance and workspace requirements are applicable to this type of installation..

[4] ANSI/IEEE 1119-1988, “Guide for Fence Safety Clearances in Electric-Supply Stations.” This standard is referenced in lieu of its incorporation into the NESC under Rule 110A2.

[5] ANSI C84.1-1989, “Voltage Ratings (60 Hertz) for Electric Power Systems and Equipment.”

[6] NEMA SG6, “Power Switching Equipment.”

[7] ANSI/IEEE Standard 100-1988, “IEEE Standard Dictionary of Electrical and Electronics Terms.”

2.2. Industry Approved Research Publications

[8] Panek, J., Elahi, H., Sublich, M., “Criteria for Phase-to-Phase Clearances of HV Substations,” IEEE Paper No. 89 SM 619-8 PWRD, IEEE/PES 1989 Summer Meeting.

[9] Udo, T., “Minimum Phase-to-Phase Electrical Clearances for Substations Based on Switching Surges and Lightning Surges,” IEEE Transactions, Vol. PAS-85, No. 8, August 1966.

2.3. NSP Standards for Substation Engineering and Design

[10] ED 4.09.03, “Fencing System.”

[11] ED 7.02.01, “Location Drawing - Title Function and Reference.”

3. DEFINITIONS OF TERMS

The following definitions are used in this Standard and are taken from the references indicated. Definitions without a reference are adopted by NSP for this Standard. For a listing of terms used in this document, but not shown below, see Reference [7].

Apparatus Bushing: See "Insulator."

Basic Impulse Insulation Level (BIL): An insulation strength expressed in terms of the crest value of a standard 1.2x50μs impulse wave having a rise time (1.2μs) and duration (50μs) similar to a lightning surge for which the insulation of electrical equipment experiences a very low probability of failure when subjected to a specific number of tests under specific conditions [7].

Clearance: The unobstructed distance between two objects measured surface-to-surface [1].

Effectively Grounded: A ground connection or connections intentionally connected to earth through a sufficiently low impedance such that for all system conditions the ratio of zero-sequence reactance to positive-sequence reactance (X_0/X_1) is positive and less than 3, and the ratio of zero-sequence resistance to positive-sequence reactance (R_0/X_1) is positive and less than 1. The ground connection or connections shall also have sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazard to connected equipment or to persons [1].

Electric Supply Station: Any building, room, or separate space within which electric supply equipment is located and the interior of which is accessible only to qualified persons. This includes generating stations, substations, and does not include facilities such as pad-mounted equipment and installations in manholes and vaults [1].

Energized Parts: See "Live Parts."

Finished Grade: The elevation of the compacted crushed-rock surfacing of a substation site that is typically four inches above the rough grade.

Guarded: Covered, fenced, enclosed, or otherwise protected by means of suitable covers or casings, barrier rails or screens, mats or platforms designed to minimize the possibility, under normal conditions, of dangerous approach or accidental contact by persons or objects [1].

Guard Zone: A well-defined space, established by the NESC surrounding a live part within which a person shall not enter nor extend a conductive object while the part is energized.

Handhole: An access opening, provided in equipment or in a below-the-surface enclosure in connection with underground lines, into which personnel reach but do not enter for the purpose of installing, operating, or maintaining equipment or cable or both [1].

Insulated: Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current [1].

Insulator: Insulating material such as porcelain, polymer, or epoxy compound, designed to support or isolate an energized conductor physically and electrically from another conductor or object. An indeterminate voltage exists along the outer surface of the insulator, therefore, "live parts" includes the insulator body itself [1]. See Figure 1.

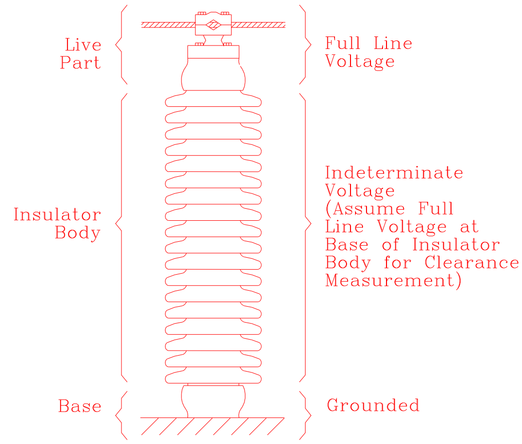


Figure 1
Voltage Classification of Insulator Parts

Live Parts: Those parts that are designed to operate at a voltage different from that of the earth [1].

Maximum System Voltage: The highest rms phase-to-phase voltage that occurs under normal operating conditions, and the highest rms voltage at which electrical apparatus and equipment is designed for satisfactory continuous operation without derating of any kind [5].

Minimum Clearances: The minimum values taken from accepted national code publications.

Nominal System Voltage: The rms phase-to-phase voltage by which a portion of the system is designated, and to which certain operating characteristics of the system are related [5].

NSP Recommended Clearances: NSP Company adopted values that are always greater than or equal to Minimum Clearances.

Pad Mounted Equipment: A general term describing enclosed equipment, the exterior of which enclosure is at ground potential, positioned on a surface-mounted pad [1].

Qualified: Having adequate knowledge of the installation, construction, or operation of the apparatus and the hazards involved [3].

Spacing: The unobstructed distance between two objects measured centerline to centerline [1].

Switching Surge Factor: An expression of the maximum switching-surge crest voltage in terms of the maximum operating line-to-neutral crest voltage of the power system [1].

4. OUTDOOR ELECTRICAL CLEARANCES

As defined above, *clearances* in this Standard shall be measured from surface-to-surface and all *spacings* shall be measured center-to-center [1], see Figure 2. The industry accepted criteria used in determining phase-to-phase electrical clearances for voltages up to 230kV comes from the comparison of phase-to-ground clearances with phase-to-phase clearances such that a flashover, due to a standard 1.2x50µs lightning impulse wave, will occur phase-to-ground rather than phase-to-phase or across an open switch [8].

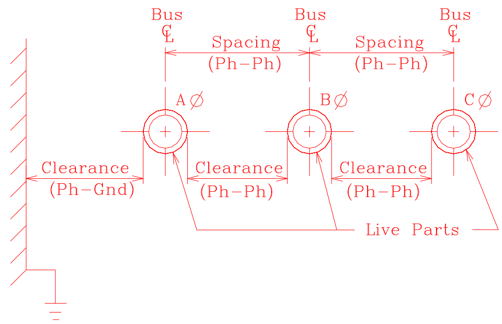


Figure 2
Clearance and Spacing Measurements

As a result of this criteria, the NSP recommended phase-to-ground and surface-to-surface clearances for some voltage classes were revised to be in compliance.

An example of when this criteria should be applied is when factory-installed switch insulators are proposed to be replaced with longer insulators (and a corresponding increase in BIL rating) to increase the height of the live parts. This action may compromise the BIL coordination of the switch insulators with the flash-over distance of the open-switch air gap and is not a recommended NSP practice.

4.1. Rigid Bus

Bus height, clearance, and spacing requirements given in Standard ED 4.02.02.01 can be used for general rigid bus design applications. This standard has been established primarily because of the effort, within NSP, to standardize both the structural support heights and the dimensions of the disconnect switches from the bottom of the switch base to the top of the switch terminal pad. Refer to Standard ED 4.02.02.03 for a table of bus heights for low-profile substations.

Electrical clearances between rigid and short-span strain bus conductors that cross over each other, within the substation fence, are not strictly governed by code requirements. Therefore, this standard applies the same criteria for crossover clearances as those used for horizontal bus clearances. See Standard ED 4.02.02.01. This interpretation of the code is based on the fact that conductor and bus movement is controlled more carefully in the restricted area of a substation than in typical overhead conductor environments [2].

4.2. Strain Bus

When non-rigid (strain) conductors are used for overhead bus installations in a substation, the movement of the conductors, caused by wind and ice loads, extreme temperature changes, and short-circuit forces must be considered when determining strain bus clearances and spacings.

Short strain-bus spans (less than 40 feet), typically used for box structures, may follow the same electrical clearances and spacings that are applied to rigid bus conductors because the typical dead-ending configurations and mid-span bus taps help limit conductor movement.

The electrical clearances and spacings of long strain-bus spans (greater than 40 feet) within a substation should be greater than those used for rigid bus because wind and short-circuit magnetic forces can cause a temporary, though significant, reduction in conductor spacing. The practice of increasing the minimum rigid bus spacings and clearances by fifty (50) percent for long span strain-bus applications is an accepted method. The spacing of slack spans dead-ending at the substation should be at least the same spacing as the transmission line structure. Spans that have a vertical-to-horizontal transposition or do not terminate perpendicular to the substation dead-end structure require special clearance and spacing consideration. If sag and tension data of the span is known, more precise clearances and spacings can be determined for vertical clearances.

4.3. Electrical Apparatus

The following electrical apparatus are designed, manufactured, and tested in accordance with accepted national standards and are not designed for a particular installation:

- Power Transformers
- Power Circuit Breakers
- Power Circuit Reclosers
- Instrument Transformers (CT, VT, CCVT)
- Surge Arresters (including grading rings)
- Cable Terminators

The manufacturer of these items is assumed to provide the necessary electrical clearances within, or on the apparatus [2][3]. NSP does, however, require that certain minimum clearances between external live parts of power transformers comply with NEMA Standards Publication No. TR1-0.15. See Standard ED 4.02.02.02 for these required dimensions.

4.4. Switches and Fuses

In determining Electrical Clearances, live metallic hardware, electrically connected to line conductors shall be considered to be a part of the line conductors [1]. Standard ED 4.02.02.02 includes a table of NSP Recommended switch spacings which should be applied to all installations, if possible. Adequate clearances must be maintained for switches in the open or closed positions and anywhere between the open and closed positions. Vertical-break, side-break, center-side-break, and double-end-break type switches each have clearance issues specific to the style of switch and manufacturer; clearances that are acceptable for one type of switch may not apply to a different type of switch. All spacings of switches and power fuse holders shall be verified against specific manufacturer recommendations and the clearance requirements shown in Standard ED 4.02.02.01.

Minimum Electrical Clearances must be maintained between live metallic hardware on the switch poles including, but not limited to, such devices as arcing horns, vacuum interrupter attachments, grounding switch attachments, corona hardware and bus expansion terminals. High velocity, whip-type interrupter attachments require additional overhead clearances and the installation of these devices shall follow manufacturer recommendations. Hookstick-operated disconnect switches frequently include switch blade stops that limit the travel of the blade to avoid interference with equipment cable connections and to maintain phase-to-ground clearances. It should be noted that items such as grounding stirrups and surge arrester attachments may also reduce clearances. Clearance measurements must take these design issues into consideration to ensure an acceptable final installation.

5. INDOOR ELECTRICAL CLEARANCES

Although the primary purpose of this clearance standard is to provide clearance guidelines for open-bus (outdoor) type substations, Standard ED 4.02.02.04 is included to provide guidance in verifying electrical clearances for switchgear and pad-mounted distribution equipment.

6. OUTDOOR WORKING CLEARANCES

Every effort must be made at NSP substation installations to maintain adequate working clearances. It is important to note that, because of the competing requirements for inspection, repair or adjustment, and quick access to equipment, guarding live parts will always be less than foolproof or perfect [2]. See Standard ED 3.04.03 for equipment access and removal requirements.

In the effort to safeguard authorized personnel within an NSP substation installation, all live parts must be guarded either by *location, physical isolation,* or *insulation*.

6.1. Guarding by Location

Live parts installed according to Standard ED 4.02.02.01 are guarded by *location*, meaning that no physical shield exists but that the energized part is located safely out of reach. See Figure 3. The NESC has established a "Guard Zone" distance to ensure that live parts of indeterminate potential (e.g. insulators and bushings) are guarded on the basis that the maximum line potential may be present at the base of the insulator body. By subtracting this Guard Zone distance from the Minimum Vertical Working Clearance dimension, a height of 8 feet 6 inches results as the closest allowable approach distance to a live part guarded by location [2]. This 8 foot 6 inch dimension shall be maintained to the base of

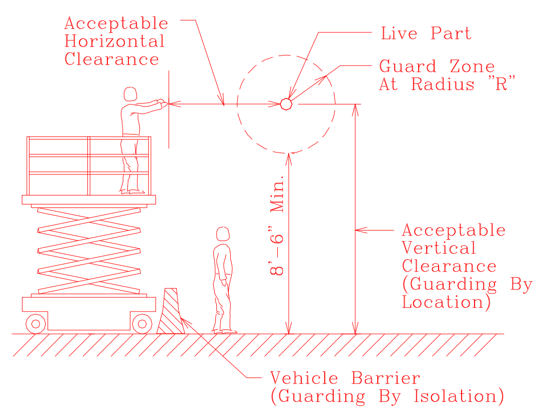


Figure 3
Guarding Live Parts by Location and Isolation

all insulators and apparatus bushings for any voltage class, regardless of their height, unless appropriate enclosures or physical guards are used.

6.1.1. Measuring to Live Parts

The NESC states that "...if a raised concrete foundation extends out far enough for a worker to stand on it without conscious effort, the required clearance is to be measured from the top of the foundation. Otherwise, the height of the foundation above ground contributes to meeting the vertical clearances" [2].

For NSP substations, however, top-of-concrete elevations shall always be used as the general design basis for establishing the required vertical clearances to live parts *even when a worker cannot stand on the top surface of the supporting foundation*. This practice provides a consistent basis for establishing vertical working clearances since site grading requirements and non-uniform rock surfacing depths hamper efforts to determine the exact finished grade elevations.

6.1.2. Electrical Apparatus

Working Clearances for safe personnel movement must be provided around all electrical apparatus in its final installation. The Vertical and Horizontal Clearances, given in Standard ED 4.02.02.01, are required between any permanent supporting surface (defined by NSP as the top of concrete) and live parts of all electrical apparatus [2]. The required working clearance to live, unguarded parts of electrical apparatus can be achieved by meeting either of the following criteria:

- The Horizontal Working Clearance via permanent guards or rails (see "Guarding by Isolation in this Design Criteria).
- The Vertical Working Clearance dimension.
- The "Taut String Distance" equal to the required Vertical Clearance See Figure 4.

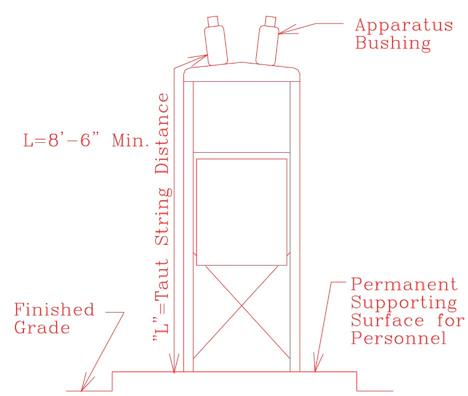


Figure 4
"Taut String" Measurement

6.1.3. Pedestal Mounted Equipment

For the purpose of establishing Vertical Clearance requirements, grounded metallic bases of potheads, surge arresters, current and potential transformers, capacitive voltage transformers, and similar devices shall be considered to be a part of the supporting structure [1]. An example of this application is the installation of an outdoor potential transformer with a grounded metallic base, bolted to the structure, and a porcelain bushing attached to the top of the base. See Figure 5.

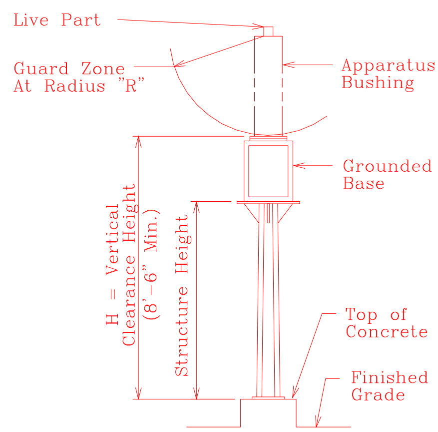


Figure 5
NSP Vertical Clearance Measurement

In this example, the Minimum Vertical Working Clearance measurement required by the NESC (resulting in the shortest structure) is taken from the finished grade to the top of the grounded equipment base (bottom of the bushing).

However, as in the case of electrical apparatus installations in an NSP substation, Vertical Working Clearances should always be measured from the supporting concrete surface to the bottom of the bushing and not measured from the finished grade elevation. If the exact outline dimensions of the equipment are not known at the design stage of the project, a minimum structure height of 8 feet 6 inches shall be used to ensure adequate Vertical Working Clearances.

6.1.4. Mobile and Portable Equipment

Clearances for portable electrical equipment such as mobile transformers are based on maintenance procedure requirements and personnel safety. For voltages below 230kV, an accepted vertical clearance is obtained by considering the maximum height of the mobile or maintenance equipment, and providing a normal line-to-ground clearance plus a margin of 10-15%. Clearances given in Standard ED 4.02.02.01 can be used for the general applications of conductors over roadways. However, applications involving mobile equipment should be verified with specific equipment dimensions.

Clearance must be provided beneath energized buses where a roadway for such equipment is to be placed. Roadways within the substation fence should be carefully planned, using vehicle turning radius templates for the expected equipment, to prevent difficult and/or unsafe entry and exit paths. Signs, mounted on all vehicle entrance gates of substation installations, shall warn of limited overhead clearances [11].

6.2. Guarding by Isolation

Live parts are guarded by *isolation* if all access paths are locked, barricaded, or roped off, and warning signs are posted at all entrances (Live parts within a substation fence are not, according to the NESC, inherently guarded by isolation) [1]. The NESC requires that "... spaces in which electric supply conductors or equipment are installed shall be so arranged with fences, screens, partitions or walls to form an enclosure as to minimize the possibility of entrance of unauthorized persons or interference by them with equipment inside" [1]. See Figure 6.

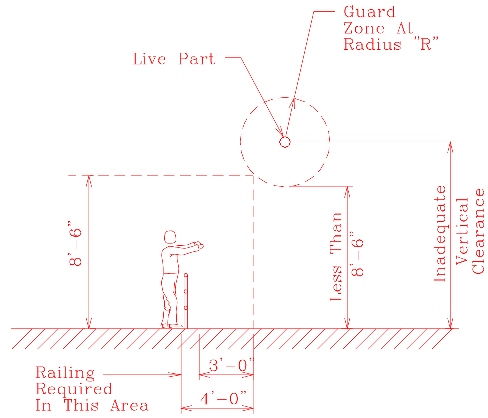


Figure 6
Guarding by Isolation Using Railings

6.2.1. Permanent Guards

Permanent electrical guards, if carefully planned and installed, may allow safe repairs near energized parts without requiring temporary protective devices or outages of adjacent circuits. Permanent guards also tend to prevent accidental short circuits and the inadvertent spread of outages beyond the place of origin [2]. Apparatus bushing guards are an example of such a device.

6.2.2. Removable or Temporary Barriers

Operations involving repairs, maintenance, construction, reconstruction and extensions to existing equipment may expose unqualified personnel to unfamiliar hazards. The use of temporary barriers, guards, warning signs or other special care is necessary under these circumstances. Electrical and working clearances that apply to a substation in its normal state of operations (Standard ED 4.02.02.01) also apply to the substation undergoing construction changes or additions [1], see Figures 3 and 6.

6.2.3. Railings

Railings, while not a substitute for complete and permanent guards, can be used to limit the opportunity for persons within the substation to inadvertently contact energized parts located below the Minimum Vertical Clearances required in Standard ED 4.02.02.01. If the required vertical clearance cannot be realized, and railings are used, they shall be located at a horizontal distance of at least three (3) feet, and not more than four (4) feet from the nearest point of the guard zone that is 8'-6" above the floor [1], see Figure 6. The location requirements for the railing are given so that an authorized person may be aware of which live part the railing is guarding. No portion of a perimeter fence may be used for such a railing. This NESC rule is intended to clearly limit access to a dangerous area and to require a conscious effort for persons to climb up-to or into an area where live parts are located.

6.2.4. Fence Clearances

The intent of fence clearance requirements is to provide a reasonable clearance zone so that "someone inserting an object through a substation fence, partition, or wall, installed to minimize the possibility of entrance of unauthorized persons, should not contact live parts or come close enough to the live parts to violate the required live-part-to-ground clearance requirements" [4].

As illustrated in Figure 7 and defined in Standard ED 4.02.02.06, the Fence Clearance Zone inside the substation perimeter fence is defined by certain boundaries. All live metallic hardware of equipment, throughout the range of motion of the energized part, shall be located outside the clearance zone [4].

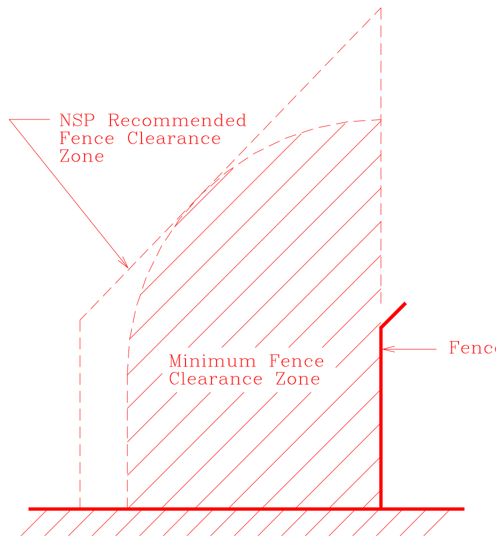


Figure 7
Fence Clearance Zone

Adopted NSP practice is to provide a minimum of fifteen (15) feet from the perimeter fence to any structure for equipment access, maintenance, and snow removal requirements. All new NSP substation installations shall be designed using the NSP Recommended Fence Clearance Zone. All existing substation installations shall maintain at least a Minimum Fence Clearance Zone.

The fence clearance zones are not applicable to fences within the perimeter fence of a substation. This would include, but not be limited to, fences around capacitor banks and reactors [4].

When an impenetrable fence or wall is used, with no openings through which sticks or other objects can be inserted, live parts may be located within the Fence Clearance Zone provided the live parts are below a horizontal line projected from the top of the impenetrable fence or wall [4].

6.2.5. Fence Height and Construction

Refer to NSP Standard ED 4.09.03 [10], and the NESC Handbook, Rule 110A [2], for detailed information on fencing materials and applications.

6.2.6. Warning Signs

Warning signs on the fence and at entrances to enclosed areas enhance the effectiveness of the fence. "Such warning signs should be conspicuously located on or near the door, gate, removable barriers, or other entrance area" [2].

Openings not intended as entrances, such as windows or ventilation grills, are not subject to the warning sign requirements. "Unauthorized entry through such openings is usually considered 'breaking and entering' and subject to the penalties thereof" [2]. Unattended entrances to buildings and substations must be kept locked.

Warning signs shall be installed on all NSP substation fences, gates and building doors. For application and for mounting instructions and descriptions of the signs, refer to Standard ED 7.02.04.

Substation installations that are partially or totally bounded on one or more sides by a building meet the requirements of the NESC for adequate equipment enclosure with the following conditions [2]:

- Access to the building is permitted only to qualified or authorized personnel.
- Access to the enclosed substation yard via the building is physically blocked to unqualified and unauthorized persons.

6.2.7. Fencing Adjoining Areas

The fence requirements of the NESC, that apply to areas containing energized electrical parts, do not apply to adjoining areas of substations such as coal storage and handling areas, ash and sludge disposal areas, and intake and discharge water ponds of remotely located generating stations. Stranded barbed-wire fencing is a practical alternative for perimeter fences around the nearby areas of these installations [2]. All perimeter fencing of this type shall be electrically isolated from the substation fence or from any structure connected to the substation grounding system to avoid transferred potentials during a fault condition. See Standard ED 4.03.00 "Grounding System" for more on this topic.

6.3. Guarding by Insulation

Conductors and live parts are guarded by *insulation* under the following conditions:

- The conductors have an insulation covering of a type and thickness suitable for the voltage and conditions under which they are expected to be operated and have an effectively grounded metallic insulation shield or semi-conducting shield [1]. This insulation may be used in lieu of a guard even if the clearances of Standard ED 4.02.02.01 are not met, see Figure 8.

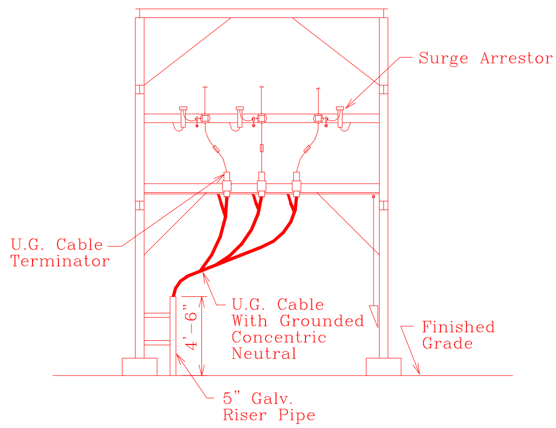


Figure 8
Guarding by Insulation

- The conductors or live parts have barriers or enclosures that are electrically and mechanically suitable for the conditions under which they are expected to be operated [1] (e.g. bus duct, padmounted distribution equipment, dead-tank circuit breakers and power transformers).

6.4. Environmental Conditions

Environmental conditions such as air contamination, lightning, and snow depths may affect the clearances requirements of a substation installation. Air contamination effects, as mentioned previously, is not within the scope of this Standard. For engineering considerations regarding lightning protection, see Standard ED 4.01.03.01 "Outdoor Substation Direct Stroke Lightning Protection."

6.4.1. Snow Accumulation

All NSP Recommended Vertical Working Clearances in Standard ED 4.02.02.01 and Standard Bus Heights in ED 4.02.02.03, include a minimum of two (2) feet of additional clearance for average compressed snow conditions. Vertical Working Clearance requirements for pedestal-mounted equipment do not include additional height for snow accumulation under the assumption that snow can be safely removed from the access area around this type of equipment.

For substation installations in regions where very high snow depths and severe wind drifting of snow is common, a determination must be made, based on factors such as frequency of deep-snow events, critical maintenance areas and cost, whether extra bus heights should be considered or if only additional warning signs are needed.

7. INDOOR WORKING CLEARANCES

This section covers all switchboards, panelboards and distribution boards installed for the control of lighting and power circuits. Although relaying and control panel installations in a control house or isle-type switchgear are not bound by the clearance requirements of the NEC, it is recommended that these clearance requirements be incorporated into the design.

As with Outdoor Working Clearances, indoor live parts, 600 volts or less, shall be guarded against accidental contact by *location*, *isolation* or *insulation*. Because of the relatively low voltage levels, the main methods used to guard live parts 600 volts or less are as follows:

Guarding by Location:
- Provide proper working space around equipment.
- Elevate the live parts a minimum of 8 feet above the floor.

Guarding by Isolation:
- Locate the live part inside a room, vault or similar enclosure that is accessible only to qualified persons.
- Install physical shields such as cabinets or box enclosures.

7.1. Front Working Space

In all cases, where there are live parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than three feet [3]. The electrical equipment is not required to be directly centered in the front working space if it can be shown that the space is sufficient for the safe operation and maintenance of such equipment [3]. No equipment, electrical or otherwise is allowed in the defined workspace. See Standard ED 4.02.02.05 for examples of Front Working Space requirements. See Figure 9.

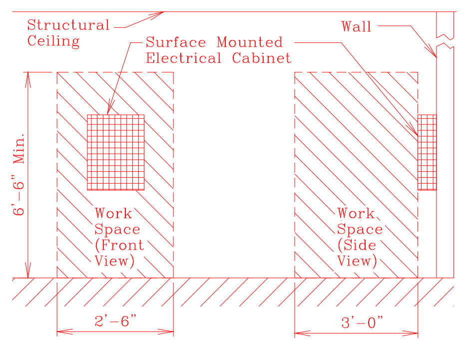


Figure 9
Front and Headroom Working Space

7.2. Headroom Working Space

The minimum headroom for working spaces around electric equipment such as service equipment, switchboards, panelboards or motor control centers shall be 6 feet-6 inches [1]. An exception to this rule is for service equipment or panelboards in existing buildings that do not exceed 200 amperes.

To provide for cable and conduit access, an exclusively dedicated space with a width and depth equal to the equipment and extending to a maximum height of 25 feet (or the height to the structural ceiling) is required over an electrical cabinet mounted to a wall. Dropped or suspended ceilings, not intended to add strength to the building structure, are not considered to be structural ceilings [3].

7.3. Entrance and Access to Work Space

The working space requirements for access to live parts requiring examination, adjustment, servicing, or maintenance while energized shall not be less than that shown in Standard ED 4.02.02.05. If the equipment is de-energized before inspection or maintenance, this standard does not apply [3].

At least one entrance shall be provided to give access to the working space about electric equipment inside substation control buildings and aisle-type switchgear.

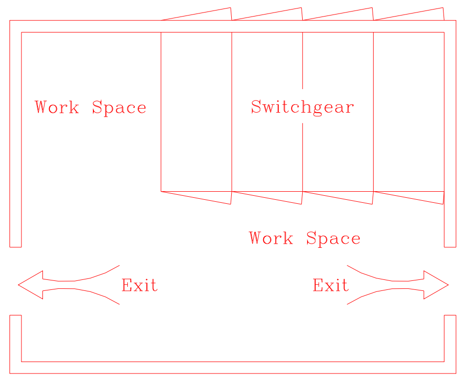


Figure 10
Access to Equipment in Switchgear Building

For equipment, such as switchgear, rated 1200 amperes or more and over 6 feet wide, an entrance is required at each end of the equipment lineup (see Figure 10), unless the following conditions are met:

- Equipment location permits a continuous and unobstructed way of exit travel.
- The minimum required workspace is doubled and the edge of the entrance nearest the equipment is the minimum clear distance away from the equipment [2].

1. General Description

A substation grounding system provides for protection of employees inside the sub, the public outside the substation, and equipment. The ground system is designed to dissipate fault currents through equipment into the earth without causing injury to people. The ground system also provides a low resistance path such that when a fault occurs the protective relay system can sense the fault and "trip" breakers before damaging equipment or adversely affecting service to customers.

For the purposes of this document, the substation grounding system is divided into two main portions; below grade equipment and above grade equipment. Below grade, the ground rods and mat must provide adequate means to dissipate electric current into the earth without exceeding operating or equipment limits and assures that personnel are not subjected to the danger of electric shocks. Above grade, equipment design must provide low resistance connections between the grid and all equipment. In addition, attachment locations must be provided for personal grounding assemblies. Personal grounding assemblies are not included in this grounding standard (they are included in the *Personal Grounding Practices & Procedures* manual).

2. Function/Application

The ground system is designed for an ultimate fault current of 50,000 amperes and to provide a reliable ground grid for the life of the substation. Presently fault current on the system is less than the 50,000 ampere capacity of the grid. When fault current exceeds this level larger conductor may be required between the equipment or steel and the grid. Because the current divides at each connection, the main grid will carry the current without modification. All conductor sizes are based on a 125o C temperature rise.

Reliability is affected by grid to earth resistance, which is dependent on soil moisture content. Moisture content is more variable at the surface therefore the grid is buried at 18 inches below rough grade with ground rods driven to 20 feet or more. Corrosion limits the life span of the grid and its ability to carry fault current. Soil tests (see ED 4.03.01) should be performed to determine if corrosive conditions exist. If so, then cathodic protection of the grid may be required. Normally, use of 4/0 19-strand soft drawn copper and ¾" ground rods provides the desired life expectancy and exothermic (welded) type connectors prevent corrosion within the connectors.

3. Protective Relaying/Control/Metering

Protective relaying monitors current and voltage levels in the substation and on transmission and distribution lines. A low resistance ground path must be provided to insure adequate ground currents for the relaying to operate correctly. Calibration of the relaying is based on the transformer to earth impedance. Because this impedance varies with soil moisture content, the relaying should be adjusted for "worst case" impedance which is winter conditions.

4. Operating and Maintenance Characteristics

Provisions must be made for attachment of personal grounds. All steel shall have a minimum of one grounding bracket per structure capable of holding 6 beam clamps. Transformers shall have a 5" X 18" grounding bracket mounted 5' up from the bottom, on the side of the tank. These brackets shall be pre drilled to accept two NEMA 4-hole pads.

Connection of conductor to transformer bushings should be installed to provide a ground attachment point which is parallel to grade. If transformer connections can't be made to provide an easy ground attachment point an approved stirrup, such as the multi angle stirrup, should be installed. Stirrups shall be installed on conductor 2' or more outside the bushings/surge arresters to provide an easily accessible grounding point.

Although the ground system is a static system, there are operating concerns (corona may be caused by the grounding stirrups and studs), but no maintenance concerns. Periodic inspection for corrosion of the grid connections is highly recommended, details of this inspection process are provided in the supporting documentation for this standard.

5. Electrical Testing Requirements

After installation of the ground system it is important to measure the grid resistance for verification against design values. Grid resistance design values will vary from site to site; therefore, no general grid resistance value will be specified. The grid resistance design value should be included on the ground layout drawings so the foreman can compare with actual installed values. Normally testing is performed by construction and the results recorded on the grounding drawing, details of this test are provided in the supporting documentation for this standard.

6. Ground Grid Design Considerations

The ground grid must be designed to assure safety from step and touch potentials within and directly outside the substation fence. There are several critical parameters, which are site-dependent, that have significant impact on grid design. These are maximum grid current (I_G), fault duration (t_f), shock duration (t_s), soil resistivity (p), high resistance surface material (p_s), and grid geometry. To minimize the variability this standard will use I_G = 50,000 ampere, $t_f = t_s$ = 30 cycles (this is the time required for secondary relaying to clear a fault), and p_s = 5000 ohm/meter. Grid geometry will vary based on soil resistance and substation layout. Design guidelines are discussed in the supporting documentation.

7. Major Components

7.1. Ground Grid

The ground grid is a system of conductors and rods imbedded in the earth, which is used to dissipate fault current into the earth. The grid is made of 4/0 19-strand soft drawn copper conductor, ¾" threaded ground rods at least 20' long, and appropriate welded fittings. The conductor is run as a continuous loop when attaching to ground rods, fence, structures, and most equipment (transformers are the exception). The double 4/0 provides greater capacity than 350 MCM and is much more flexible and easier to work with.

The grid extends to 3' outside the substation fence. The grid is buried 18" below rough grade. The ground grid is attached to equipment at two different points such as opposite corners of a transformer or each leg of a switch stand. The grid is welded to all steel structures and fence posts.

The grid is bolted to aluminum structures, transformers, breakers, or other equipment, which may be removed. A NEMA 2-hole or 4-hole pad is welded to the grid and bolted to the equipment. When equipment such as a CCPD is installed on a stand, weld the grid to the base of the stand and weld a 4/0 jumper near the top of the stand. This jumper is then bolted to the grounding pad on the equipment (see master drawings NF-160158-1 and -2, NH-43213, NH-44306, NH-72802).

7.2. Surface Material

Crushed rock, ¾-inch diameter, is applied to the surface of the substation site to provide a high resistance between the grid and an operator. Rock is installed after all other work on the ground system is complete. Because it is very difficult to provide the same size, type, and depth of rock at each site, a minimum depth of 4 inches is specified. If the rock is deeper than 8 inches vehicles become stuck. The rock should extend 2 feet past outside the grid, this means 5 feet past the fence.

7.3. Foundation Reinforcing Cages

Foundation reinforcing cages are not connected to the grid through the side of the foundations as was previously done. Reinforcing cages are grounded through the equipment anchor bolts only.

7.4. Steel Structure Connections

All steel structures shall have the ground grid welded directly to the steel. The 4/0 grid conductor shall be run as a continuous loop up the foundation to the steel, then welded as indicated on the grounding drawing.

7.5. Aluminum Structure Connections

All aluminum structures shall have the ground grid bolted to the structure. Anti-corrosion compound shall be applied to the bolted connection.

7.6. Fence Connections

All substation fences shall be connected to the ground grid. Fence posts will have welded connections. Fence fabric will no longer be connected to the ground grid. A grounding jumper will be installed between the gateposts and gate to insure adequate connection. A #4 soft drawn copper bonding wire shall be welded to the top fence support and connected to the barb wire by split bolt connectors (see Master Drawing NF-160158-1 and -2).

7.7. Transformer Connections

Transformers will be bolted to the ground grid via NEMA 2-hole or 4-hole pads. These connections shall be at opposite corners of the tank. Surge arresters shall be grounded by installing a 4/0 copper wire or a ¼" X 3" copper bar between the mounting bracket or NEMA 2-hole pads when available on the tank, and the arrester base. A spacer must be installed under the other "feet" of the arrester too. The neutral bushings will be terminated at a NEMA 4-hole pad on the top of the transformer, using ¼" X 3" copper bar, or to the steel using flexible conductor rated for 1/3 the capacity of the phase conductors. The transformer tank and steel structures are adequate to carry the neutral current therefore a copper bus bar does not need to be installed down the tank to ground.

7.8. Circuit Breaker Connections

The ground grid shall be bolted to breakers. If the breaker is mounted on a steel stand the ground grid shall be bolted at the base of the stand. Bolted joints, such as legs of the stand or stand to breaker, provide an adequate ground path.

7.9. Capacitor Bank Connections

Most capacitor banks are installed on aluminum structures, use bolted connections. Capacitor banks require single-point or peninsular connection to the ground grid. Single-point connections prevent high frequency currents from back-to-back switching from flowing in the ground grid. Peninsular connections allow the neutral potential to rise during switching but provides a low impedance path between capacitor banks. See the Capacitor Bank Standard ED 5.02.01 or ANSI/IEEE 37.99.

7.10. Switchgear Building Connections

Switchgear buildings shall have exterior ground connections welded at each of the corners. The ground bus inside the building shall be ¼" X 2" aluminum bus bar, this shall be bolted to the ground grid (see master drawings NH44306, NH72802).

7.11. Disconnect Switch Connections

All disconnect switches shall be grounded by bolting a flexible grounding jumper to the steel structure and the vertical operating pipe (see master drawing NF-160158-1 and -2). If a flexible grounding jumper is not provided with the switch, an exothermic connection shall be used. If the switch is mounted on a wood structure then the flexible grounding jumper should be bolted to the vertical operating pipe and to the ground wire, which is attached to the structure.

7.12. PT/CT Connections

Metering PTs/CTs which have their neutral bolted to the steel will continue to be bolted to the steel. PTs/CTs, which are mounted on steel structures, are adequately grounded through the mounting bolts, no additional grounding is necessary. Steel structures are welded directly to the grid. If PT/CT is mounted on a wood structure it should be attached to the ground grid with 1/0 copper as indicated in the Wood Structures section.

7.13. Wood Structures

Substations with wood structures are normally in locations with little fault current. These substations will have a 4/0 ground grid to insure long life. The ground wire, which is attached to the structure, shall remain 1/0 copper. All connections to the 1/0 shall be bolted with the existing clamps. The ground grid shall be Cadwelded to the 1/0.

8. Personal Grounding

Personal grounds are required when working on equipment. It is necessary to provide grounding attachment locations on equipment for the beam clamps, C-clamps, or socket clamps, which are used on personal ground assemblies. See Standard ED 4.09.05 for application of grounding attachment point devices. Bus work and conductors must also include either attachments such as stirrups or studs or have clamps available on site for grounding directly to the bus (ED 4.09.05). Studs or stirrups, when used, must be easily accessible from grade, bucket truck, or lift devices. Stirrups, when necessary, shall be attached to the lead 2' or more outside any surge arresters.

9. References

ANSI/IEEE STD80-1986 IEEE Guide For Safety In AC Substation Grounding

ANSI/IEEE 81-1983 Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System, Guide for Measuring

IEEE Transactions on Power Delivery, Vol. PWRD-2 No. 3, July 1987

Xcel Energy Equipment Specifications/Standards

Steel Design Standard
Circuit Breaker Specification
Transformer Specification
Capacitor Bank Standard

Soil Testing

Since the grid design is dependent on soil conditions, tests must be performed to determine moisture content, soil resistance, and acidity. Guide lines for performing these test can be found in ANSI/IEEE 81-1983.

The Four-Point or Wenner method of testing is best suited to NSP's needs. This test involves driving four rods into the soil, injecting a known current through the outer two and measuring the potential across the inner two. Use Ohms Law to calculate the resistance. Tests should be performed to obtain readings at 10, 20, and 30 foot depths. These readings should be taken at the locations shown on the Soil Resistivity Test Result Form. If it is not possible to get soil resistivity tests, use the resistivity from ANSI/IEEE 80-1986 table 1 which is shown below.

Average Resistivity Of The Ground

Type Of Ground	Resistivity ρ, Ohm-Meters
Wet organic soil	10
Moist soil	100 (normal NSP conditions)
Dry soil	1,000
Bed rock	10,000

Soil resistivity impacts the ability to dissipate fault current into the soil. Therefore grid resistance and voltage gradients within the substation increase with soil resistivity. Soil resistivity is primarily dependent on moisture content which is affected by soil type, compaction, and grain size.

The resistivity of most soils rises abruptly when the moisture content is less than 15% of the soil weight. The rate of change slows until about 22% when further saturation has little impact on soil resistivity.

Temperature also affects soil resistivity. When water freezes the resistivity increases, by almost a factor of ten. Surprisingly, grid resistance during the winter is nearly as good as during the summer. This is because the soil freezes from the top down and the high resistance surface layer, normally just rock, now includes the frozen soil. Spring condition are actually the worst for grid performance. The lower layers remain frozen while the surface layer thaws providing a low resistance layer over a high resistance layer. Not a desirable condition! When performing grid calculations be sure to check the spring conditions.

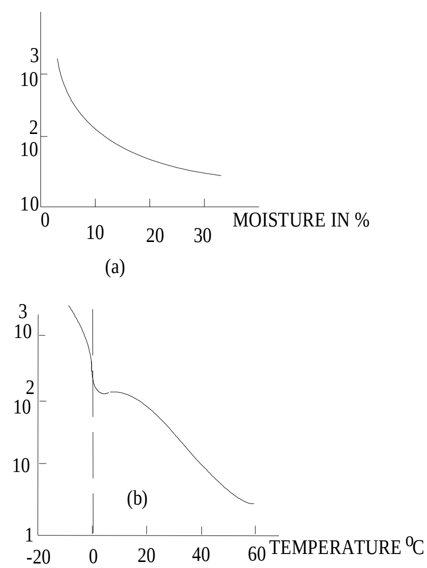


FIG 1. from IEEE Std 81-1983

It is also important to test the acidity level of the soil. Acidity does not affect soil resistivity but will eat away the grid if the soil is too acidic. If this is the case, cathodic protection may be needed.

Design Procedure

This procedure is a general guide to designing a ground grid for a new substation. Design calculations (see IEEE Std 80-1986) may be verified using the Substation Grounding Workstation, an EPRI program, or Excel spreadsheet \\Black\Team\DSC\Forms\Sub\Calcs\Grndg.xlt.

All design data and assumptions should be recorded in the Ground Grid Design Data section of the grounding drawing.

1. Estimate size of area to be grounded (can be estimated from substation location plan).

2. Determine soil resistivity profile and soil model (soil testing is recommended or use the approximation from ED 4.03.00).

3. Verify minimum conductor size (is conductor >4/0 required) based on 125^{O}C rise at the expected fault current level.

4. Determine maximum step and touch potential. Based on the design criteria these values should be less than:

   $E_{step70} = (R_B + R_{2Fs})I_B = 1{,}775\ V$

   $E_{touch70} = (R_B + R_{2Fp})I_B = 606\ V$

   assumptions based on 4" rock

   $I_B = 0.216$ *amps* (*Eq 5, 70kg body weight)*

   $R_B = 1{,}000$ *ohms* *(Eq 7)*

   $R_{2Fs} = 7{,}200$ *ohms* *(Eq 16, p=2000 ohm-meter)*

   $R_{2Fp} = 1{,}800$ *ohms* *(Eq 17, p=2000 ohm-meter)*

5. Develop preliminary design. A counter poise should be run around the exterior of the sub. Grid density is dependent on proximity to the bus work. Conductor spacing should be 20' apart near the bus. Further from the bus grid spacing may be increased. At the interior corners of the fence you may need to decrease grid spacing because step potential may be too high. Ground Rods should be at least 20' long and placed at 50' - 70' intervals along the counterpoise. Place ground rods underneath the outer phases at all line entrance locations. Other ground rods should be placed at lightning arresters, control panels on transformers and breakers, all corners of the control house, and near the entrance gate.

6. Estimate the grid resistance.

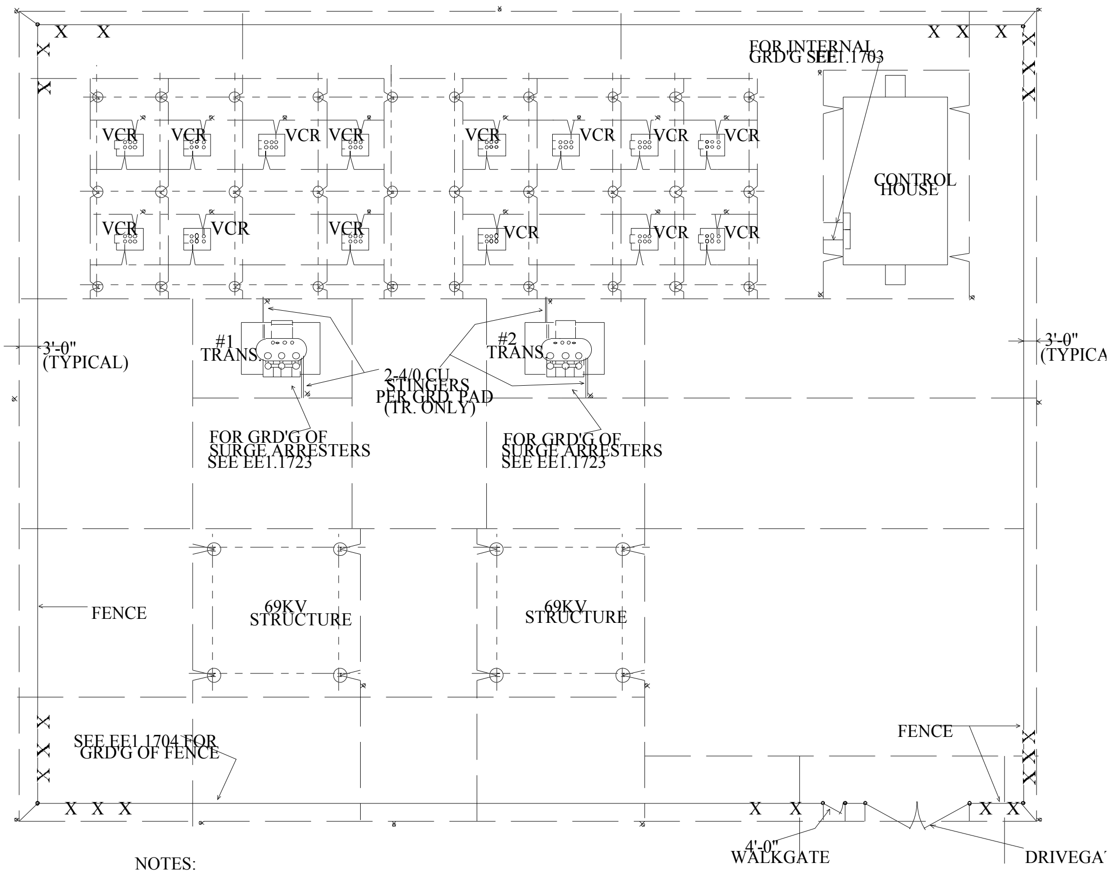
   R_g = *(earth resistivity/4)(pi/grid area in m²)*$^{0.5}$

7. Determine the grid current (*Ig*). The grid current can be as high as the fault current which is the zero sequence current, $3I_0$. Normally it has been assumed that all fault current flows through the grid. This may not be correct, when the transmission lines and feeders are connected there is a current division which occurs (see "Determination of Maximum Substation Grounding System Fault Current Using Graphical Analysis") and drastically reduces the apparent grid current.

8. Calculate the ground potential rise**,** *GPR*. It should be less than the tolerable touch potential, $E_{touch70}$. If not, then preliminary design must be refined, possibly by reducing grid spacing, adding more rods, increasing grid area, installing a well, etc.

   $GPR = I_g * R_g$

The desired resistance reading for a large substation is **less than 1 ohm** and for a small substation it is **less than 3 ohms**, (max. 6 feeders or 15 MVA capacity).



NOTES:

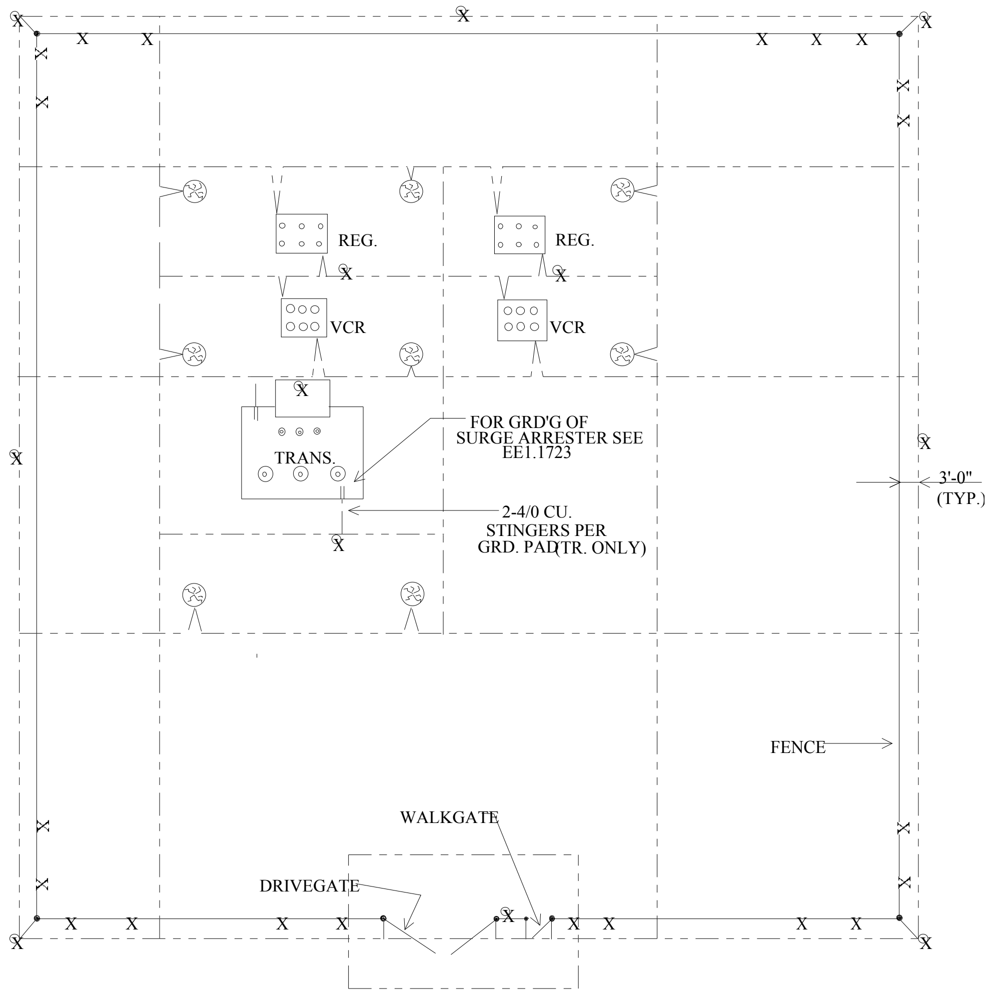
1. GRID SYSTEM INSTALLED WHERE ROCK OR CONDITIONS PROVIDE POOR GROUNDING POTENTIAL. PROVIDE CONNECTIONS TO REMOTE GROUND IF NECESSARY.
2. GROUND GRID SPACING BETWEEN CONDUCTORS DETERMINED BY SOIL CONDITIONS AND SUBSTATION FAULT CURRENT.
3. GRID CONDUCTOR SHALL BE RUN AS A CONTINUOUS LOOP UP THE FOUNDATION TO THE STEEL.
4. FOUNDATION REINFORCING CAGES ARE GROUNDED THROUGH ANCHOR BOLTS ONLY.

LEGEND

- GROUND ROD-TWO OR MORE 3/4 " X 10'-0" COUPLED COPPER CLAD RODS DRIVEN TO A DEPTH REQUIRED TO OBTAIN AN INITIAL GROUND RESISTANCE NOT GREATER THAN 30 OHMS PER ROD-MIN. DEPTH 20'-0" FENCE RODS AVERAGE DEPTH OF STATION RODS.
- BURIED WIRE-4/0 BARE SOFT DRAWN CU. WIRE 18" BELOW ROUGH GRADE.
- EXPOSED CONDUCTOR-4/0 CU. WIRE
- EXPOSED CONDUCTOR-BAR
- X FENCE
- FENCE CORNER AND GATE POST

SUBSTATION GROUNDING

Substation Grounding - Design Guide



LEGEND

ROD ELECTRODE - TWO OR MORE 3/4 " DIA. x 10'-0" COUPLED RODS DRIVEN TO A DEPTH REQUIRED TO OBTAIN AN INITIAL RESISTANCE NOT GREATER THAN 30 OHMS PER ELECTRODE DEPTH 20'-0". ACTUAL DRIVEN DEPTHS OF ALL RODS TO BE S FIELD FOREMAN. DEPTH OF GROUND RODS ON FENCE ARE APPROXIMATE AVERAGE OF STATION RODS.

BURIED CONDUCTOR - #4/O BARE SOFT DRAWN CU WIRE 18" ROUGH GRADE.

EXPOSED CONDUCTOR - #1/O BARE CU WIRE

EXPOSED CONDUCTOR - 2"x 1/4 " COPPER BAR

X STEEL FENCE

STEEL FENCE CORNER AND GATE POSTS

INDICATES 2"x 1/4 " COPPER BAR UP STAND TO EQUIPMENT PEI STANDARD EE1.1725

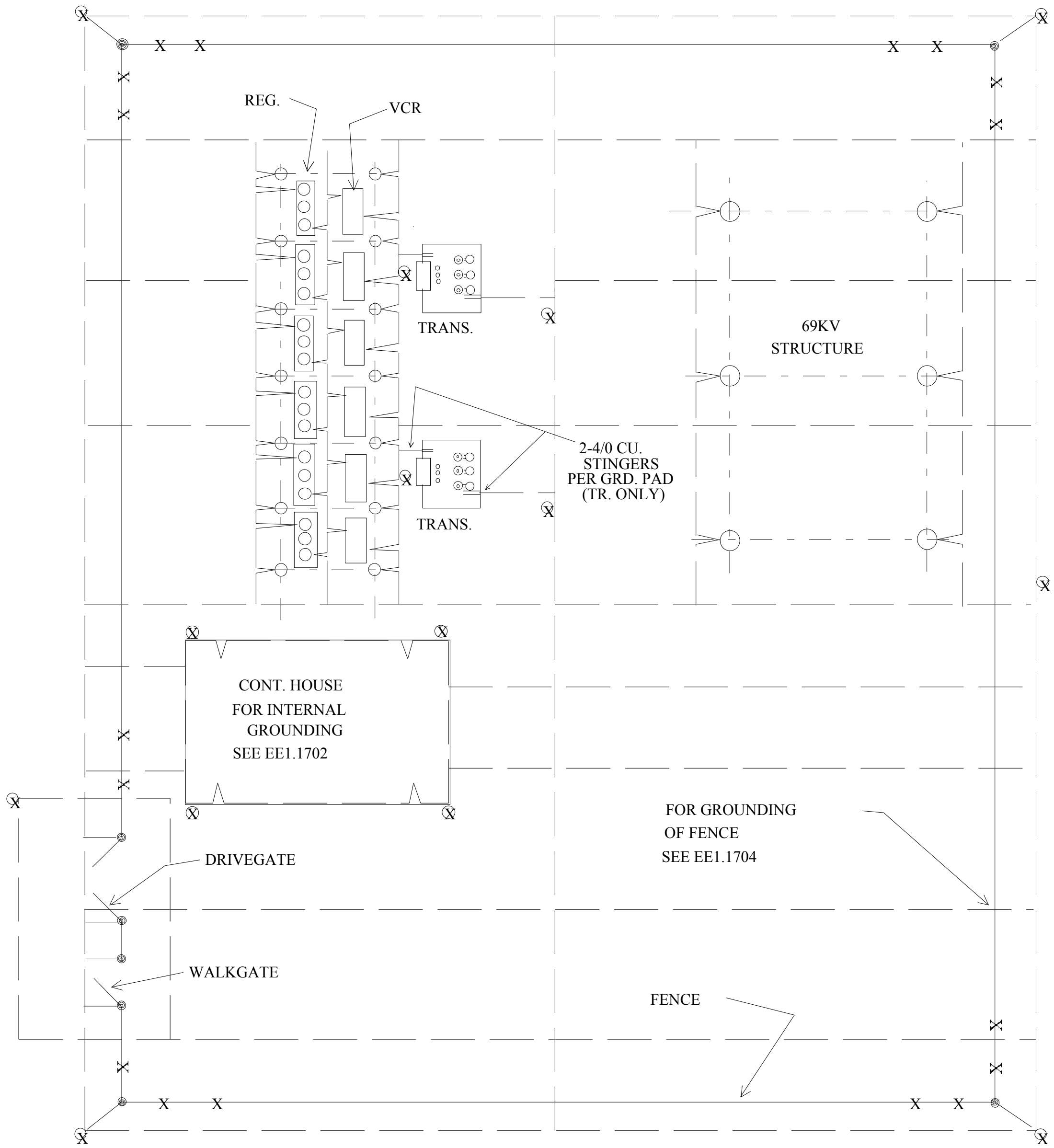
NOTES:

1. 1/0 COPPER CONDUCTOR RUN UP ALL POLES TO STATION NEUTRAL BUSES, SURGE ARRESTERS, INSTRUMENT AND AUXILIARY TRANSFORMERS, SWITCH AND FUSE BASES, BUS SUPPORTS 23KV AND ABOVE AND STRAIN INSULATOR ANCHOR BOLTS.
2. GROUND GRID SPACING BETWEEN CONDUCTORS DETERMINED BY SOIL CONDITIONS AND SUBSTATION FAULT CURRENT.
3. GRID CONDUCTOR SHALL BE RUN AS A CONTINUOUS LOOP UP THE FOUNDATION TO THE STEEL.
4. FOUNDATION REINFORCING CAGES ARE GROUNDED THROUGH ACHOR BOLTS ONLY.

WOOD STRUCTURE GROUNDING SYSTEM

Substation Grounding - Design Guide

Xcel Energy - North	Date: 08/07/2001	Approved:	Rev. 1	Substation Engineering & Design Standards	
				Sheet 4 of 6	ED 4.03.02



NOTES:

1. GRID SYSTEM INSTALLED WHERE ROCK OR CONDITIONS PROVIDE POOR GROUNDING POTENTIAL. PROVIDE CONNECTIONS TO REMOTE GROUND IF NECESSARY.
2. GROUND GRID SPACING BETWEEN CONDUCTORS DETERMINED BY SOIL CONDITIONS AND SUBSTATION FAULT CURRENT.
3. GRID CONDUCTOR SHALL BE RUN AS A CONTINUOUS LOOP UP THE FOUNDATION TO THE STEEL.
4. FOUNDATION REINFORCING CAGES ARE GROUNDED THROUGH ANCHOR BOLTS ONLY.

LEGEND

ROD ELECTRODE- TWO OR MORE 3/4 " DIA. X 10'-0" COUPLED COPPER RODS DRIVEN TO A DEPTH REQUIRED TO OBTAIN AN INITIAL GROUND RESISTANCE NOT GREATER THAN 30 OHMS PER ELECTRODE- MINIMUM DEPTH OF 20'-0". ACTUAL DRIVEN DEPTHS OF ALL RODS TO BE SHOWN BY FIELD FOREMAN. DEPTH OF GROUND RODS ON FENCE ARE APPROXIMATE AVERAGE OF STATION RODS .

BURIED CONDUCTOR-4/0 BARE SOFT DRAWN CU. WIRE 18" BELOW ROUGH GRADE.

EXPOSED CONDUCTOR - 2" X 1/4 " COPPER BAR

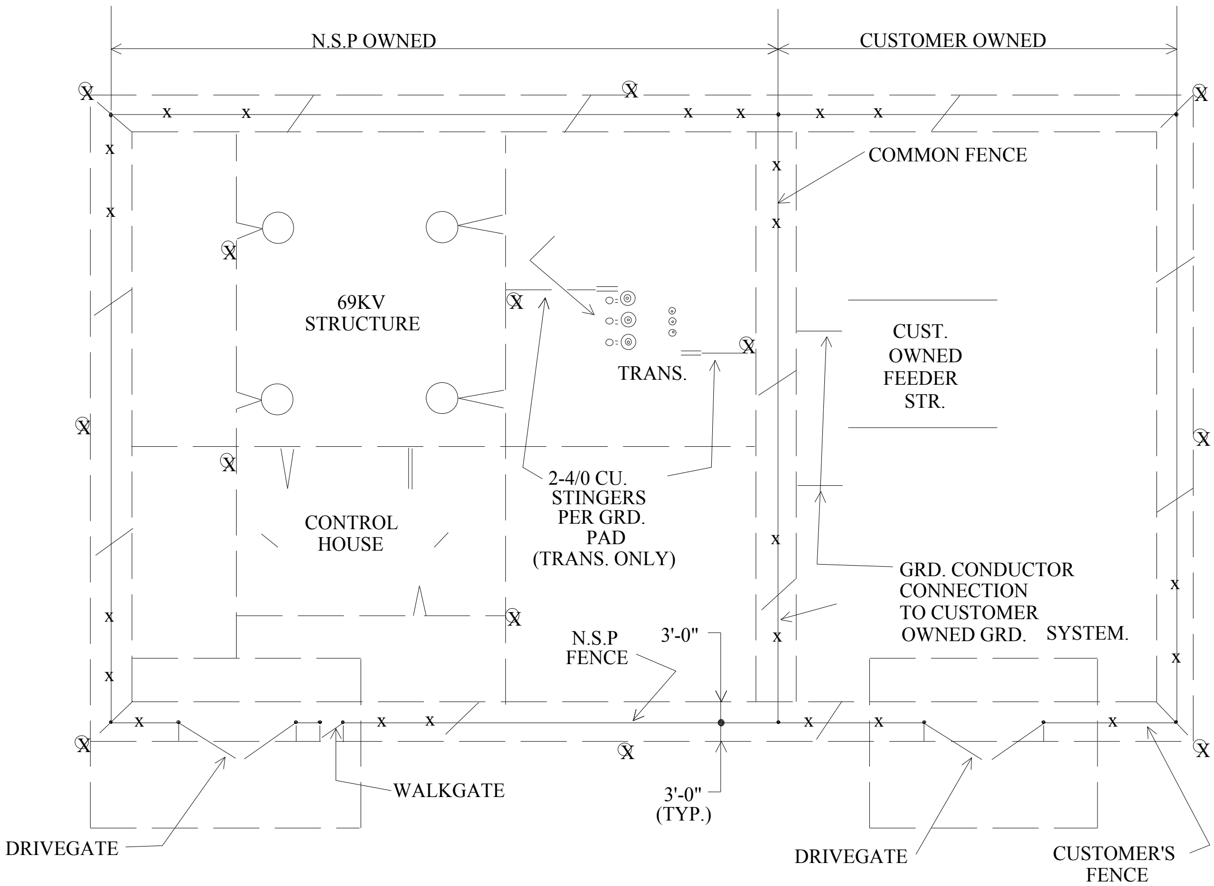
X STEEL FENCE

STEEL FENCE CORNER AND GATE POSTS

INDICATES COPPER BAR UP STAND TO EQUIPMENT PER N.S.P COMPANY STANDARD EE1.1725

GRID SYSTEM

Substation Grounding - Design Guide



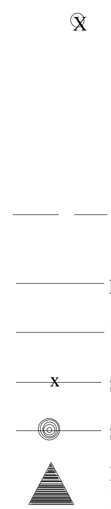
NOTES:

1. WHEN A COMMON FENCE IS INSTALLED BETWEEN AN N.S.P AND CUSTOMER'S SUBSTATION, BOTH GROUNDING SYSTEMS MUST BE INTERCONNECTED AND TIED INTO THE FENCES WITH A COUNTERPOISE 3'-0" EACH SIDE OF THE FENCE. ADEQUATE GROUND CONNECTIONS SHALL BE MADE TO ALL ELECTRICAL EQUIPMENT, STRUCTURES AND FENCE SO THAT, UNDER FAULT CONDITIONS, ALL COMPONENTS OF THE SUBSTATION ARE AT THE SAME POTENTIAL.

2. IF THE N.S.P AND CUSTOMERS FENCES ARE SEPERATED BY A MINIMUM OF 10'-0" BOTH FENCES AND STATION GROUNDING SYSTEMS WILL BE ISOLATED IN ACCORDANCE WITH OUR USUAL PRACTICE. THERE WILL BE NO COMMON TIE BETWEEN THE TWO GROUNDING SYSTEMS EXCEPT FOR THE NEUTRAL CONDUCTOR, WHICH MUST BE HEAVY ENOUGH TO CARRY THE FAULT CURRENT WITHOUT DAMAGE. IF THERE IS NO NEUTRAL, BEING A DELTA CONNECTED LOW VOLTAGE SYSTEM, PROVIDE AN OVERHEAD TIE BETWEEN THE TWO GROUNDING SYSTEMS OF ADEQUATE SIZE TO CARRY FUTURE FAULT CURRENTS IF CONVERTED TO A WYE SYSTEM.

3. IN ALL CASES WE WILL RECOMMEND TO THE CUSTOMER THAT HE DESIGN HIS GROUNDING SYSTEM SIMILAR TO OURS.

LEGEND



X GROUND ROD-TWO OR MORE 3/4 " X 10'-0" COUPLED COPPER CLAD RODS DRIVEN TO A DEPTH REQUIRED TO OBTAIN AN INITIAL GROUND RESISTANCE NOT GREATER THAN 30 OHMS PER ELECTRODE - MINIMUM DEPTH 20'-0" .

BURIED CONDUCTOR-#4/0 BARE SOFT DRAWN COPPER WIRE 18" BELOW GRADE.

EXPOSED CONDUCTOR-#1/0 CU. WIRE

EXPOSED CONDUCTOR-2"X 1/4 " COPPER BAR OR OTHER.

x STEEL FENCE

STEEL FENCE CORNER AND GATE POSTS.

INDICATES 2" X 1/4 " COPPER BAR UP STAND T EQUIPMENT PER N.S.P CO. STANDARD EE1.1725

SUBSTATION GROUNDING

Substation Grounding - Design Guide

Xcel Energy - North	Date: 08/07/2001	Approved:	Rev. 1	Substation Engineering & Design Standards Sheet 6 of 6	ED 4.03.02

Control House Grounding

Control house grounding is covered in this section. The following Master Drawings should be referenced for details:

NH-44306	Control House with Access Floor - Miscellaneous Equipment Details
NH-72802	Control House without Access Floor - Miscellaneous Equipment Details
NH-160332-1,2 & 3	Control House Equipment Layout

Use the following rules as design guides:

1. The substation grounding system conductor must encircle each control house.

2. The building ground bus shall be tied to the substation grounding system in two places, at opposite sides of the control house. In most cases, this will consist of bringing a ground in through a cable entrance on one side and through the control house wall on the other as indicated below and detailed on the appropriate Master Drawing for grounding methods in buildings with and without access floors.

   Two #4/0 copper ground conductors shall enter the building through cable openings in the floor and connect to the building ground bus system via two 2" x 1/4" aluminum bars inside the terminal cabinet.

   One #4/0 copper ground conductor shall enter the building through a 3/4" diameter x 12" long copper rod which is tied to the building ground bus via a 2" x 1/4" aluminum bar up the building wall.

3. The building ground bus shall be 2" x 1/4" aluminum bar mounted approximately 7'-6" high on the side walls only and shall be long enough to accommodate connections to equipment. The side wall mounted building ground buses shall be interconnected across the ceiling at each end with 2" x 1/4" aluminum bar supported by the unistrut light fixture hangers.

4. A #4 bare copper wire must be run from the building ground bus directly to the internal neutral or ground bus of all A.C. distribution, auxiliary transformer and telephone equipment cabinets and also shall connect to the housing of all other cabinets and electrical equipment.

5. In buildings without access floor the ground bus of each panel row must be connected to the building ground bus with 2" x 1/4" aluminum bar mounted on a panel brace. The ultimate installation should provide a connection near each end of each panel row and once in the middle.

6. Take special care in masonry buildings to see that any conduit, box or equipment not effectively grounded through raceway or trough is bonded to the building ground bus.

7. If toilet facilities are to be provided, the water pipe shall be connected to the control house ground bus as shown in ED 4.03.08.

Grounding of Cable Trench Conductor

One #4/0 bare copper conductor is to be laid in all precast or direct burial cable trench as detailed on Master Drawing NH-43213. The ground conductor is required to protect control cables from stray ground currents or signals usually present in high voltage installations by equalizing the potential along the length of the cables.

The trench ground conductor must be connected to the station grounding system at every intersection and at the ends of each trench. The cable trench ground conductor connections will be shown on the Grounding Layout drawing and, in the case of direct buried trenches, the ground conductor shall be incorporated into the system grounding design.

In precast trenches, the ground conductor may be located below all the cables, mixed in with the control cables, placed on top of the control cables or attached to the side of the precast trench depending on when it is installed and construction preferences. In any case, future installations of additional control cables should be of primary consideration.

Branches from the main cable trench, that are lighting circuits or are less than 25 feet in length, do not *require* the trench ground conductor to be extended to the equipment, however, consideration should be given in extending the ground conductor in the branches to the equipment, especially in new installations.

In existing non-grounded precast or direct buried trenches, where the trench is opened to replace or install new control cables, one #4/0 bare copper conductor shall be installed.

Switch Handle Grounding

Introduction

The problem is that of protecting employees operating manually operated air-break switches from the accidental energization of the operating mechanism, which may occur during the operation of the switch. This energization may result from mechanical failure dropping an energized part on the operating mechanism, base or frame of the switch, or from a flashover resulting from transient overvoltage during switching.

Rules

1. No appreciable hazard exists at 2.4 kV and 4.16 kV due to the type of system and switching equipment used.

2. The present practice of using rubber gloves and hard hats when operating any type of air-break switch at any voltage shall be continued.

3. Persons not operating the switch should stay at least 10 ft. away from the operator and also stay out from under any portion of the switch itself.

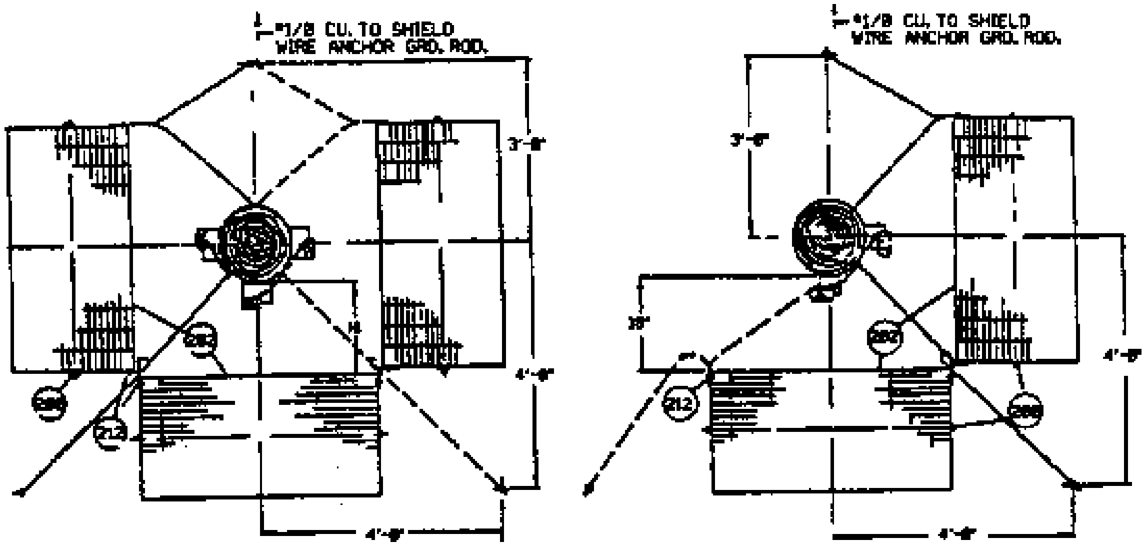
4. The grounding system in stations, if provided as detailed in Standard ED 4.03.00, makes unnecessary any additional grounding or stands for the operators.

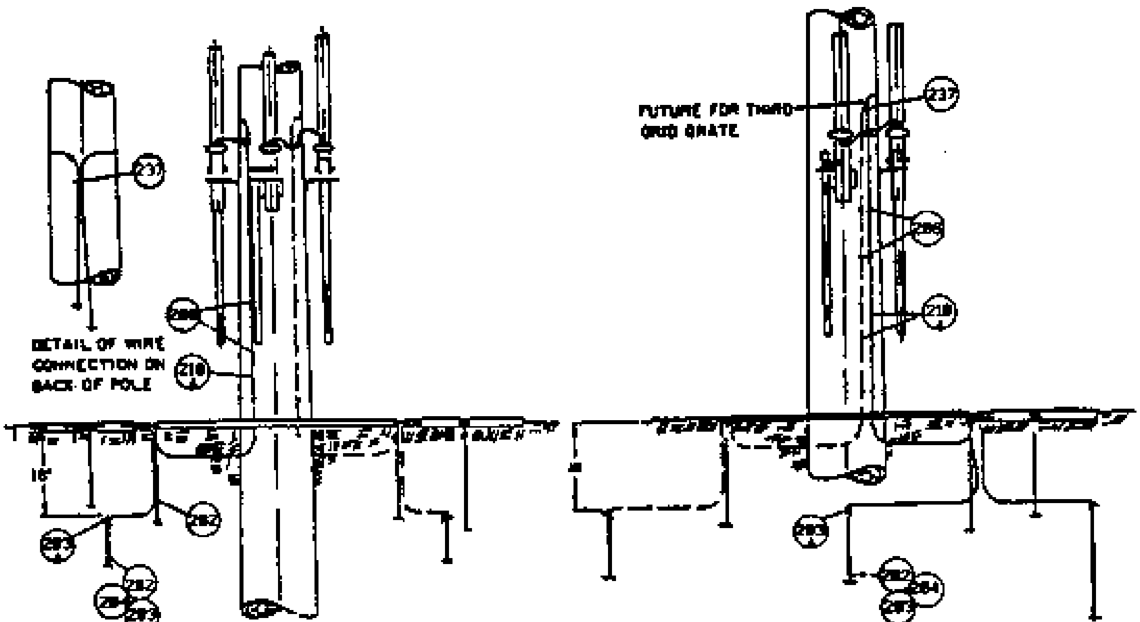
5. On line switches at 12.5 kV or above (including 13.8, 23, 34.5, 69 and 115 kV) the operating mechanism, to which the handle is electrically connected, should be tied solidly to the line neutral or static wire, if there is one available. This connection should be made below any porcelain or wood members, which may be in the operating rod. If the switch frame is grounded, connecting the frame itself to the neutral or static wire will meet this requirement.

6. The connection to the neutral or static wire should be duplicated so that the tie wire will exist even if one connection becomes broken, burned off, or dislodged.

7. For switches 23 kV and above, outside of station grounding areas, a metallic grating or grid shall be provided on which the operator can stand when operating the switch. This grating or grid should be tied solidly to the switch handle or operating mechanism with at least two-connections, to provide for breakage of one connection. The handle or mechanism should also be tied to two or more ground rods driven in the vicinity of the pole. A steel grating mounted approximately flush with the surface of the ground is the most desirable and safe. Details are shown on sheet 2.

8. For switches mounted on steel structures, the operating pipe shall be bonded to the steel using a flexible grounding jumper. If a flexible grounding jumper is not provided with the switch, an exothermic connection shall be used.

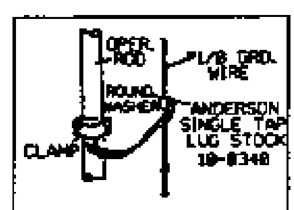




GS-15
3-WAY GOAB SWITCH

GS-16
3-WAY GOAB SWITCH
ONE SIDE BUSSED

NOTE:
WIRES SHOWN BY SOLID OR DOTTED LINES TO BE INSTALLED IN CONTIN-UOUS SEGMENTS OF WIRE.
GROUND RODS ATTACHED TO GRID GATE ARE 5 FT SECTIONS. (10 FT ROD CUT IN HALF.

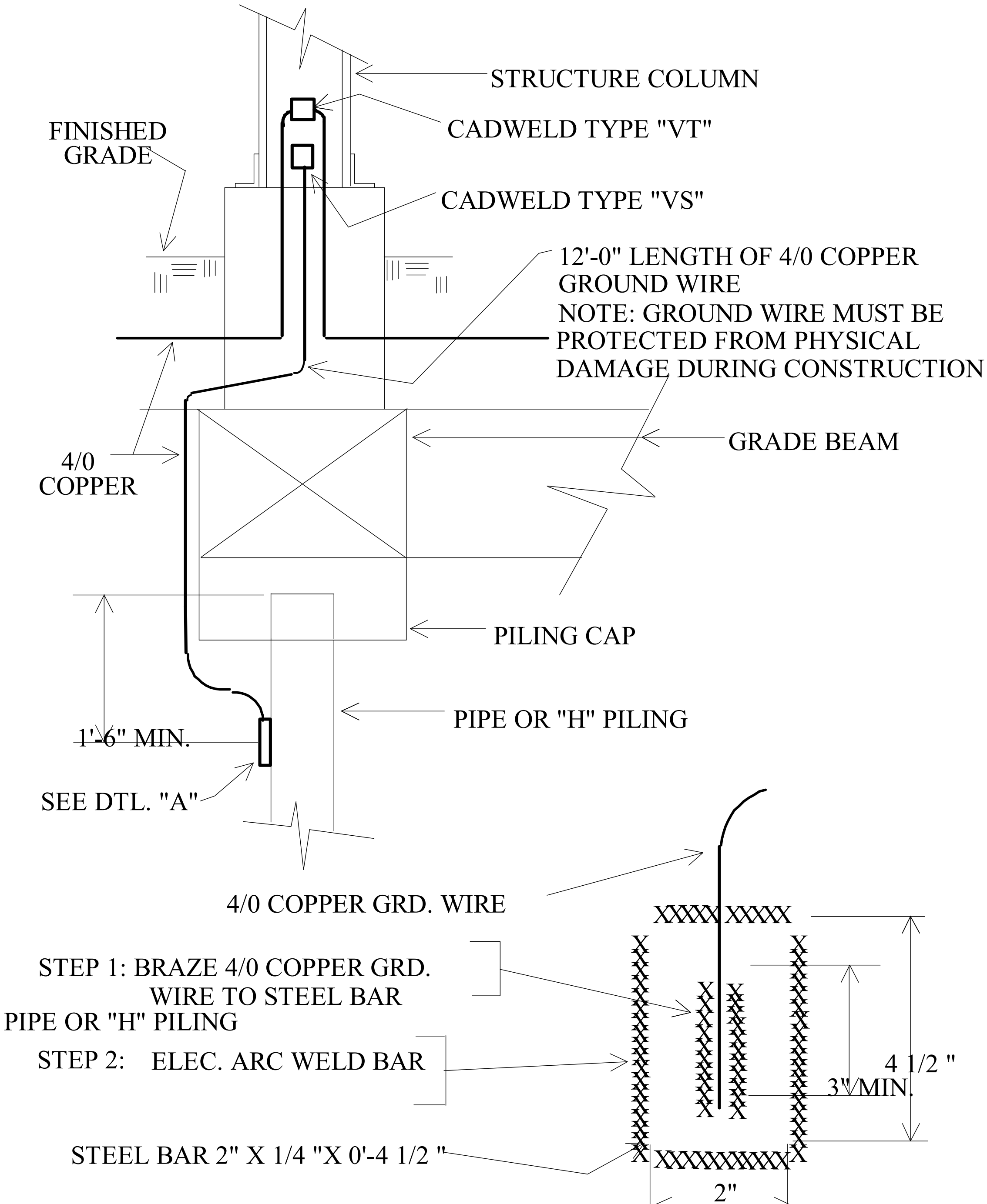


DETAIL "A"

ITEM	QUAN GS-15	QUAN GS-16	DESCRIPTION	NSP CO STOCK #
202	0	0	⅝" X 10' STAR SECTIONAL GROUND ROD	07-2912
203	3	3	⅝" STAR COUPLING	07-2916
204	3	3	⅝" STAR HALF TWIST BIT	07-2938
205A	4	4	⅝" GROUND ROD CLAMP	07-2942
208	30	30	2" CEMENT COATED FENCE STAPLES	07-2938
209	6	4	GROUND ROD CLAMP (BURNDY GJ111)	
210A	50'	50'	#1/0 STRANDED BARE COPPER WIRE	03-1055
212	6	5	GROUND WIRE CLAMP (BURNDY GC-26-26-T4)	07-2952
213	2	1	ANDERSON TAP LUG	10-8540
237	1	1	SOLDERLESS CONNECTORS (#1/0 COPPER WIRE	03-6252
262	3	2	GRID GRATE, NSP CO. DWG. NO-24707	

Switch Handle Grounding System

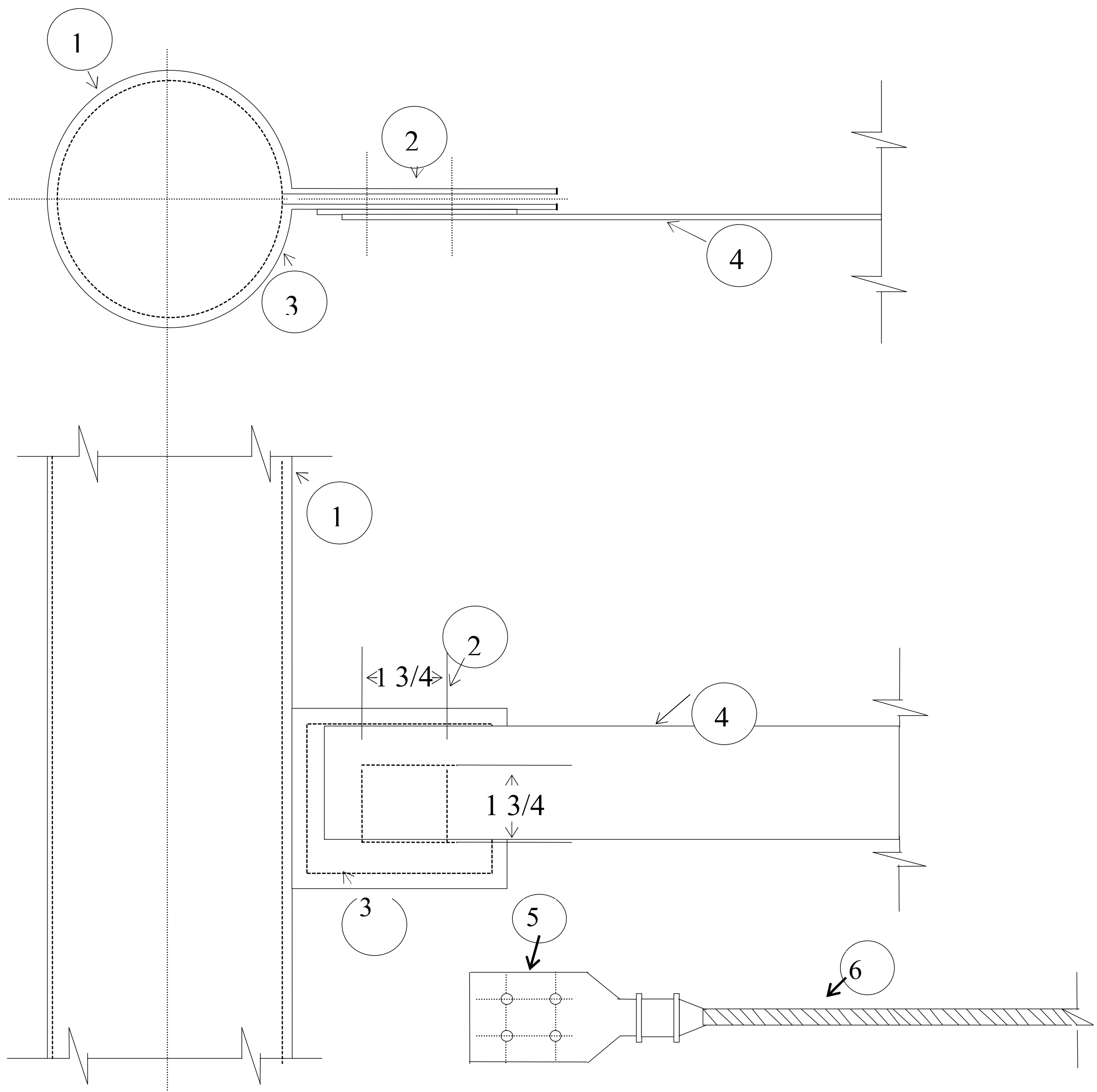
NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 11/4/98		1	SHEET 2 of 2	ED 4.03.05



BEFORE USING THIS METHOD ON A JOB, CHECK WITH PROJECT ENGINEER IF NEEDED.

Method Of Grounding Pipe Or "H" Piling

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE **9/1/94**		**1**	**SHEET 1**	**ED 4.03.0.7**



NO.	DESCRIPTION
1.	Steel casings, conduit or pipe
2.	Steel plates welded to copper conduit or pipe
3	Copper bar or plate to steel plate
4	Copper bar bolted to cooper plate
5	Copper clamp (conductor to flat pad)
6	Copper stranded conductor

Method Of Connecting Copper Ground Bar Or Conductor To A Steel Casing, Conduit Or Pipe

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS
	CHECKED	APPROVED		
	DATE 9/1/94		1	SHEET 1 — ED 4.03.0.8

Ground System Design Data Block

A ground grid "Design Data Block" will be added to Grounding Layout drawing near the drawings General Notes. This block of information records the data used to design the grounding system shown on this drawing and the completed system tested results. The blocks design data is filled out by the Engineer and Designer before project drawings are transmitted and the systems test results by the field on "as built" markups. Field should inform Project Teams Physical Engineer of test results before considering the projects grounding installation complete. Poor readings may require grid system additions.

Ground grid design data

DESIGN IS BASED ON IEEE STD. 80-1986 USING THE FOLLOWING DATA:

1. TOP LAYER SOIL MODEL
   TOP LAYER RESISTIVITY __________OHM-METER
   TOP LAYER DEPTH __________FEET
   BOTTOM LAYER RESISTIVITY __________OHM-METER
   MOISTURE CONTENT __________SOIL TEMPERATURE

2. SURFACE ROCK RESISTIVITY __________OHM-METER
3. SURFACE ROCK DEPTH __________INCHES
4. MAXIMUM SYSTEM FAULT __________CURRENT AMPS.
5. FAULT DURATION __________CYCLES
6. GRID CURRENT __________OF MAXIMUM FAULT CURRENT
   BASED ON PARALLEL GROUND PATH WITH: TRANSMISSION LINE CONNECTED Y N
   FEEDERS CONNECTED Y N

<u>STEP POTENTIAL</u>
CALCULATED: ________VOLTS ALLOWABLE: __________VOLTS

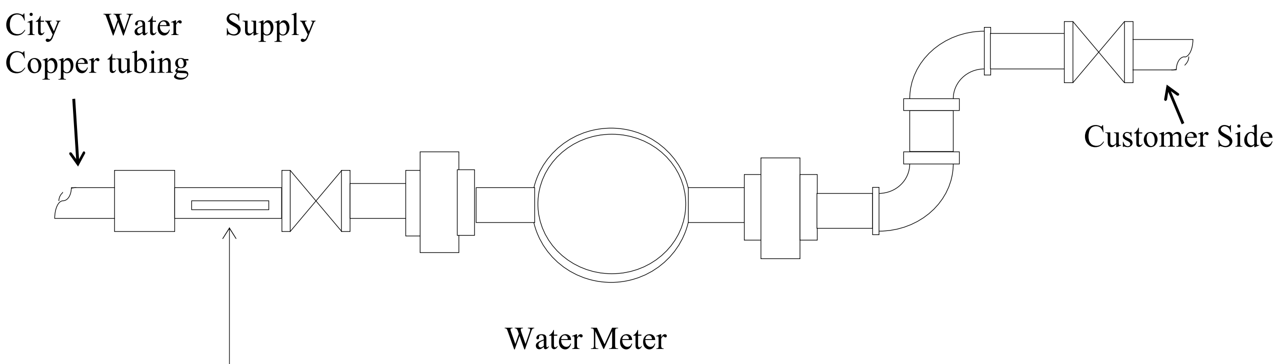
<u>TOUCH POTENTIAL</u>
CALCULATED: ________VOLTS ALLOWABLE: __________VOLTS

<u>GRID RESISTANCE</u>
CALCULATED: ________OHMS # OF TRANSMISSION LINES CONNECTED__________
OF FEEDERS CONNECTED _________

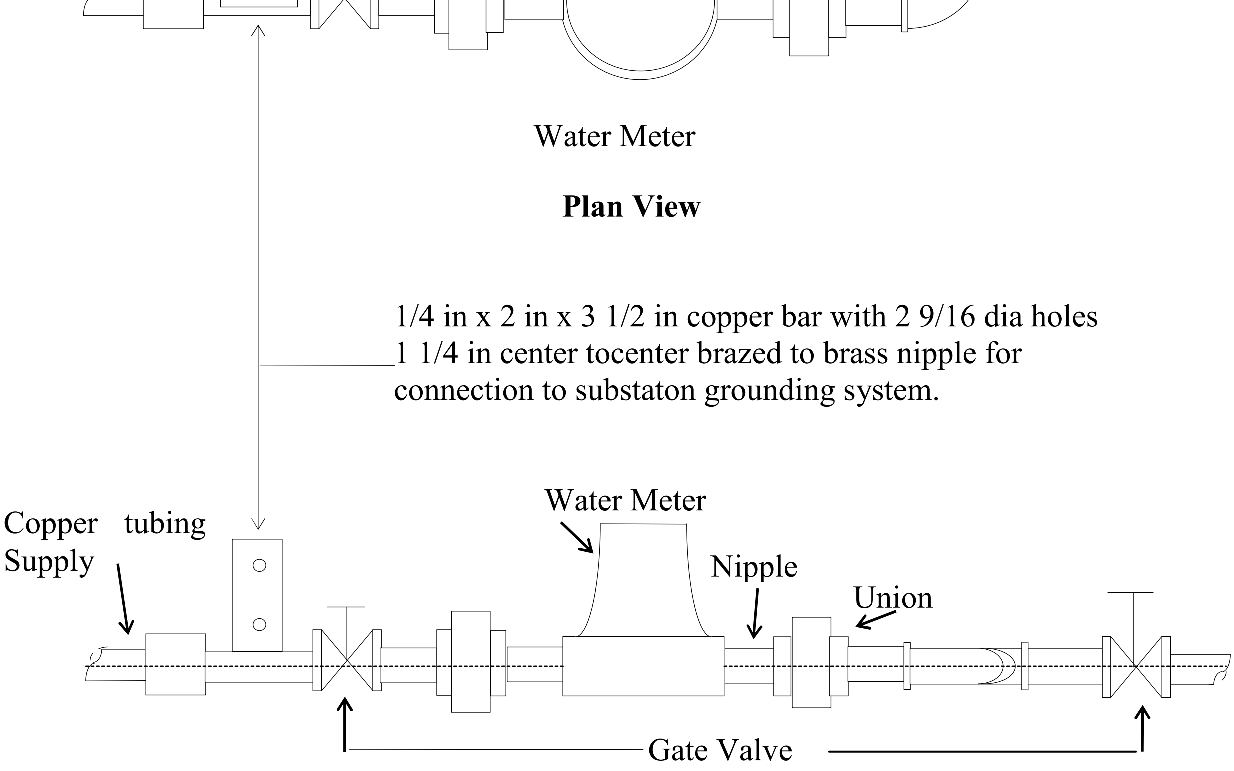
BY FIELD
MEASURED: __________OHMS # OF TRANSMISSION LINES CONNECTED
OF FEEDERS CONNECTED__________
DATE OF TEST__________

Ground System Design Data Block

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE **9/1/94**		**1**	**SHEET 1**	**ED 4.03.09**



Plan View



Side View

Connection Of Substation Grounding System To Water Supply

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE **9/1/94**		**0**	**SHEET 1**	**ED 4.03.10**

Substation AC Auxiliary Systems

This document describes Xcel Energy's practices with respect to alternating current (AC) auxiliary systems in substations.

Recommended references for AC auxiliary systems are:

- National Fire Protection Association 70, National Electric Code (NEC)
- IEEE Std 141, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).
- IEEE Std 242, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).

It is the philosophy and intent of this standard to comply with the National Electric Code (NEC). There are a few practices which do not follow the NEC; in these cases, this standard will describe the situation and explain the reasons for the deviation from the NEC.

1. General

Typically, substation AC systems are used to supply power to loads such as transformer cooling, oil pumps and load tap changers (LTCs); circuit breaker auxiliaries and control circuits; outdoor equipment heaters, lighting and receptacles; and control house lighting, receptacles, heating, ventilating, air conditioning and battery chargers. The AC auxiliary system can consist of the following components:

a. High-side fused disconnect(s)
b. Auxiliary transformer
c. Secondary fused disconnects
d. Automatic transfer switch (ATS)
e. Main circuit breaker panelboard
f. AC power and lighting cabinets

Most Xcel Energy North substations utilize a single-phase, 120/240 VAC, three-wire auxiliary supply system for lighting, heating, maintenance, and other site-specific electrical needs. In some substations, a three-phase system is used because it is the more economical choice or because it is required to supply three-phase loads such as breaker heat, compressors, or transformer pumps. (The general rule which has been used is that if using a single-phase system would require equipment with ratings greater than 400A, then a three-phase system should be used.)

Substations are usually provided with both a preferred and an emergency station auxiliary source. Any relayed substation that has station batteries always requires two sources. Distribution substations using series-trip reclosers and having no batteries generally do not require an emergency auxiliary source. Site-specific requirements must be considered in determining whether an emergency auxiliary source is required.

For standard schematic drawings of auxiliary systems, refer to the CE Master Drawings NH-110-11-1, NH-110-11-2, and NH-110-11-5.

2. Station Auxiliary Sources

In distribution substations, it is common for the auxiliary supplies to be taken from the distribution bus, with the preferred source on one bus and the emergency source on another bus. In transmission substations, auxiliary supplies are frequently supplied from transformer tertiaries. For single power transformer substations requiring an emergency auxiliary source, the emergency source is normally supplied from a distribution source outside the station. It is important to verify that this external source comes from a feeder from a different substation.

In some cases, where distribution voltage is not available in the substation, it may be more cost effective to utilize a station-service voltage transformer connected to the transmission voltage than to bring in local distribution. This may be used to provide an emergency source in instances where there is only one power transformer, or to provide the preferred source in cases where there is no transformer (such as a switching station or a capacitor bank station).

When a second source is not available, a single source has sometimes been used until either a second transformer is installed or an external source becomes available.

In substations with a preferred and an emergency source, an ATS is normally used so that the substation loads can be supplied from either of the auxiliary sources. However, in order to limit the size of the ATS and other downstream equipment, power transformer cooling loads are connected ahead of the ATS. Each transformer should provide the auxiliary power source for its own cooling loads, so that each transformer can operate independently. This means that for substations with more than two power transformers, an additional auxiliary transformer (beyond those used for the preferred and emergency source) is required for each additional power transformer to service its auxiliary power requirements. It is important, however, that each LTC should be connected downstream of the ATS, to allow operation of the LTC (for maintenance purposes) when the transformer is out of service.

3. Auxiliary Transformer Connections

This section provides general guidelines on how to choose the transformer high-side connections for substation auxiliary systems. Careful consideration should be given to the specific requirements of each substation.

3.1. Single-Phase Auxiliary Systems

The auxiliary transformers in single-phase auxiliary systems are typically connected line-ground on the primary side. However, there are cases where this connection should not be used. For instance, for connection to any ungrounded or potentially ungrounded system (such as a delta tertiary or a delta-connected system that uses grounding banks) a line-ground connection should not be used, because the auxiliary transformer will become a ground point for the system.

The secondary connection for a single-phase auxiliary shall be 120/240V, three-wire with the center-tap grounded.

3.2. Three-phase Auxiliary Systems

When connecting a three-phase auxiliary system to a distribution bus (voltages ranging from 12.5kV to 34.5kV), the preferred transformer connection is two-legged-grounded, open-wye primary to open-delta secondary. The reasons for using a wye connection on the primary, rather than a delta connection, is that it is preferable to have a grounded auxiliary system when possible, and that, in our experience, a wye connection has less ferroresonance problems than a delta connection.

When connecting to a transformer tertiary, the preferred transformer connection is two-legged, open-delta primary to open-delta secondary. The reason for this is that tertiaries are typically delta-connected, and a grounded-wye primary connection on the auxiliary transformers would cause the auxiliary system to become a ground point for the system.

There are concerns associated with a closed-delta secondary connection and, as a rule, this connection should be avoided. For a closed-delta to closed-delta system, if one phase of the secondary cables fails, ferroresonance and high voltages on the primary can result. For a grounded-wye to closed-delta system, the auxiliary transformer bank provides an additional ground source which desensitizes protective relays. If a wye-to-closed-delta system is desired, it may be done if the primary side is not grounded (two-bushing transformers would be required).

If the kVA rating of a two-legged, open-delta secondary auxiliary system needs to be increased, it is usually preferable to replace the two transformers with two larger transformers, rather than add the third transformer to the bank.

The secondary connection for three-phase auxiliary systems shall be delta (normally two-legged, open-delta). The center-tap point of one transformer shall be grounded. This point shall be chosen so that B-phase is the system high-leg. That is, the voltage B-to-ground will be 208V. The voltages A-to-ground and C-to-ground will each be 120V. The A-B, B-C, and C-A voltage will each be 240V.

In the past, Xcel Energy North's standard was to make C-phase the high leg. However, the current standard is to follow NEC requirements. Therefore, for three-phase systems, B-phase shall be the high leg. In all panels, the center phase shall be the high leg, and this shall correspond to B-phase. That is, left to right, the bars in the panel will be A-B-C phase, and correspondingly, X-Y-Z. Single phase, 120V loads will be connected X-to-Gnd or Z-to Gnd. The 240V single-phase loads can be connected across A-B, B-C, or C-A. This should be done so as to balance the loading on the panels.

4. Auxiliary Transformer Ratings

4.1. kVA Rating

To determine the correct sizing of the auxiliary transformers, the substation AC loads need to be calculated. The loads should be calculated at winter peak loading to see the worst case heating loading requirements. When calculating the winter peak loading, the transformer cooling load would normally not be included, but this should be verified. Some substations may have transformer cooling loads in the winter. Summer loading requirements should include all transformer auxiliary requirements, as well as any air conditioning loads at the substation. Special needs, such as maintenance and construction requirements, also need to be taken into account. Future expansion/growth needs should also be addressed.

Welders and other equipment used by construction forces require up to 50 kVA, single-phase of load capacity. Since this equipment can be used at any time of the year, calculation of normal winter peak substation load requirements should be made to ensure that the transformer sizing is adequate for both the substation loading and construction and maintenance equipment.

Note that the large oil processing units (OPU) use either large portable generators or a portable transformer to supply the required 200A of 480V three-phase power. (The transformer is temporarily connected to a feeder when the noise level of the generators is a concern.) Thus, the OPUs always have their own power source and are not powered from the substation auxiliary source.

The minimum auxiliary transformer rating to be used is 25kVA. This is large enough to handle most construction and maintenance loads, and the cost is only slightly more than for a lower rated transformer.

The standard auxiliary transformer rating for typical two-transformer distribution substations (in which the power transformers are protected by relays, not fuses) is 75 kVA, single-phase. This rating is usually sufficient for maintenance and construction requirements, as well as, normal station loading. This must be verified as adequate for each particular situation before proceeding with the design.

For small, rural substations, a minimum size of 25kVA is standard. Again, this rating must be verified as adequate for the specific application.

For substations having a preferred and an emergency station auxiliary, the loads to be connected downstream of the ATS need to be determined so the ATS can be properly sized. Such critical loads include: battery chargers; heat for breakers and other equipment, AC to power circuit breakers and controls; LTC controls; station and security lighting and receptacles; and control house heaters.

For substations with large loading requirements, the use of a three-phase auxiliary system should be considered. The normal configuration for three-phase auxiliary systems is two-legged, open-delta secondary. When using this connection, the auxiliary cannot be loaded to the sum of the nameplate ratings of the two transformers. For example, two 75kVA transformers connected with a two-legged, open-delta secondary connection generally cannot supply 150kVA of auxiliary load without being overloaded. A reference for information on the loading of two-legged, open-delta connected transformers is the "ABB Distribution Transformer Guide", ABB publication 3A49299H01, Revised October, 1991.

4.2. Voltage Ratings

The primary voltage rating of the transformer is selected based on the voltage of the source bus. The secondary voltage rating shall be 120/240V. The following table defines the various transformer voltage designations:

Designation of Voltage Ratings of Single-Phase Windings

Nomenclature	Nameplate Marking	Condensed Usage Guide
E/E_1Y	2400/4160Y	E/E_1Y shall indicate a winding of E volts that is suitable for Δ connection on an E volt system or for Y connection on an E_1 volt system.
E/E_1GrdY	2400/4160GrdY	E/E_1GrdY shall indicate a winding of E volts having reduced insulation which is suitable for Δ connection on an E volt system or Y connection on an E_1 volt system, transformer neutral effectively grounded.
E_1GrdY/E	12470GrdY/7200	E_1GrdY/E shall indicate a winding of E volts with reduced insulation at the neutral end. The neutral end may be connected directly to the tank for Y or for single-phase operation on an E_1 volt system, provided the neutral end of the winding is effectively grounded.
E/2E	120/240	E/2E shall indicate a winding, the sections of which can be connected in parallel for operation at E volts, or which can be connected in series for operation at 2E volts, or connected in series with a center terminal for three wire operation at 2E volts between the extreme terminals and E volts between the center terminal and each of the extreme terminals.
2E/E	240/120	2E/E shall indicate a winding for 2E volts, two-wire full kVA between extreme terminals, or 2E/E volts three-wire service with ½ kVA available only, from midpoint to each extreme terminal.

$Key: E_1 = \sqrt{3}E$ Source: IEEE Std C57.12.01-1989.

Care must be taken to select a transformer with proper voltage ratings for the application. For a line-ground or wye primary connection, either a single-bushing transformer or a two-bushing transformer may be used. For a line-line or delta primary connection, a two-bushing transformer must be used. For all applications, the voltage rating of the transformer winding must be matched to the voltage being applied to the winding, i.e. between the two bushings (two-bushing transformers) or between the bushing and ground (single-bushing transformers).

Example 1: A transformer rated "13800/23900Y" has a winding rated for 13,800V. It is suitable for line-line or delta connection on a 13.8kV system. It is also suitable for line-ground or wye connection on a 23.9kV system. Since it can be used on a delta connection, it must have two bushings. However, it must not be line-line or delta connected on a 23.9kV system, since that would apply 23,900V to a winding only rated for 13,800V.

Example 2: A transformer rated "13800GrdY/7970" has a winding rated for 7,970V, with reduced insulation at the neutral end. It is suitable for line-ground or wye connection on a 13.8kV system. It is not suitable for any line-line or wye connections, as it only has one bushing. The neutral end must be grounded.

5. Primary Fusing and Switching

5.1. Fused Disconnects

Substation auxiliary power transformers shall be fused on the high side using fused disconnects as shown in the following tables. The fuse sizes were selected by choosing the smallest rating, which is at least 150% of the high-side full load ampere current (FLA). In order to promote standardization of fuse sizes used in the system, sizes 3E and 7E are not used.

High-Side Fusing for
Single-Phase Systems Connected Line-Ground
and
Three-Phase Systems with Two-Legged, Open-Wye to Open-Delta, Closed-Wye to Delta or Closed-Delta to Delta Connection*

TR kVA	34.5/19.9 kV		23.90/13.80kV		13.8/7.97 kV		12.5/7.2 kV	
	Line FLA	Fuse Rating	Line FLA	Fuse Rating	Line FLA	Fuse Rating	Line FLA	Fuse Rating
10	0.50	5E	0.72	5E	1.26	5E	1.39	5E
15	0.75	5E	1.09	5E	1.88	5E	2.08	5E
25	1.26	5E	1.81	5E	3.14	5E	3.46	10E
37.5	1.88	5E	2.72	5E	4.71	10E	5.20	10E
50	2.51	5E	3.62	10E	6.28	10E	6.93	15E
75	3.77	10E	5.44	10E	9.41	15E	10.39	20E
100	5.02	10E	7.25	15E	12.55	20E	13.86	25E

* For 3-Phase systems, TR kVA in the tables refers to the size of one of the single-phase transformers in a matched bank of two or three transformers. For example, a bank of two 75kVA, 34.5/19.9kV transformers connected two-legged, open-wye to open-delta would be fused with two 10E rated fuses.

High-Side Fusing for
Single-Phase Systems Connected Line-Line
and
Three-Phase Auxiliary Systems with Two-Legged-Open-Delta to Open-Delta Connection*

	34.5/19.9 kV		23.90/13.80kV		13.8/7.97 kV		12.5/7.2 kV	
TR kVA	**Line FLA**	**Fuse Rating**	**Line FLA**	**Fuse Rating**	**Line FLA**	**Fuse Rating**	**Line FLA**	**Fuse Rating**
10	0.29	5E	0.42	5E	0.72	5E	0.80	5E
15	0.43	5E	0.63	5E	1.09	5E	1.20	5E
25	0.72	5E	1.05	5E	1.81	5E	2.00	5E
37.5	1.09	5E	1.57	5E	2.72	5E	3.00	5E
50	1.45	5E	2.09	5E	3.62	10E	4.00	10E
75	2.17	5E	3.14	5E	5.43	10E	6.00	10E
100	2.90	5E	4.18	10E	7.25	15E	8.00	15E

* For 3-Phase systems, TR kVA in the tables refers to the size of one of the single-phase transformers in a matched bank of two or three transformers. See previous Table note for an example.

The fuse sizes shown in the tables above are based on the use of S&C SM5 fuses. The S&C SM5 is the standard fuse to be used in the system. In the past, both SM4 and SM5 type fuses were used. However, to promote standardization of fuse types, the SM4 type should not be used for new applications. The SM5 fused disconnects have a significantly higher fault interrupting rating and a slightly higher cost than the SM4 type.

When purchasing fused disconnects, one replacement element should be purchased for each element to be installed. These spares should be kept in the substation as replacement parts.

The standard time-rated fuse should be used (rather than the slow or very-slow rating).

5.2. Current-limiting Back-up Fuses

Some substations may have available fault currents greater than the interrupt rating of the fused disconnect. In these cases, current-limiting back-up fuses should be used in series with the fused disconnect. The current-limiting back-up fuse will limit the fault current and also provide for clearing of faults up to its interrupt rating.

Note that the interrupt rating of the current-limiting back-up fuse must be greater than the available fault current. If it is not, then this approach is not sufficient and further engineering will be necessary. For instance, current-limiting reactors could be used to reduce the fault current, or a high-rated current-limiting fuse could be employed.

The back-up fuse should be placed downstream of the fused disconnect; in this way, the back-up fuse can be replaced by opening the fused disconnect, and without deenergizing the source. The design should make sure, to the greatest extent possible, that there is adequate clearance to replace the back-up fuse without deenergizing the source.

With this configuration, there is an accepted risk of a fault occurring in the lead between the two fuses which could not be cleared by the fused-disconnect. This would be a bus fault, and would have to be cleared by the station relaying.

The back-up fuse is meant to be used in series with another fuse. For low current level faults, the primary fuse will clear the fault. For high current level faults, the current-limiting back-up fuse will clear the fault. The time-current characteristics of the two fuses do not coordinate; therefore, if the element of either fuse blows, both elements should be replaced at the same time.

When installing back-up fuses in a substation, spare fuses should also be ordered and kept in the substation as replacement parts.

Xcel stocks the following current-limiting back-up fuse: Cooper NX Companion II, 25A, 23kV fuse (Stock #09-2663). This fuse can be applied on systems up to 36.5kV. (See Cooper bulletin 240-64, which is available at www.cooperpower.com, for product information and ratings). The interrupting rating of this fuse at various system voltages is shown in the following table:

Interrupt Rating of 23kV Cooper NX Companion II Fuse
(Xcel Energy Stock #09-2663)*

Applied System Voltage (Line-Line)	Interrupting Rating
System Voltage ≤ 15.2kV	50kA
15.2kV < System Voltage ≤ 26.4kV	43kA
26.4kV < System Voltage ≤ 36.5kV	31kA

*Note: The application of the 23kV NX fuse at lower system voltages was discussed with Cooper. The 23kV NX fuse has the same element as the 8.3kV and the 15.5/17.2kV NX fuses, the ratings of which are shown in the table below. Therefore, it was established that the interrupt rating of the 23kV fuse, when applied at lower voltages, would be as shown in the table above.

Interrupt Rating of Cooper NX Companion II Fuses

Fuse Voltage Rating	For Application at	Interrupting Rating
8.3kV	System Voltage ≤ 15.2kV	50kA
15.5/17.2kV	15.2kV < System Voltage ≤ 26.4kV	43kA
23kV	26.4kV < System Voltage ≤ 36.5kV	31kA

6. Secondary Fusing and Switching

For new installations (and retrofits when appropriate), a 120/240V, 600 Ampere outdoor main panelboard is to be installed at the station auxiliary transformer(s) (1000A panels are generally used because that is what is available at the best price). For single-phase systems, the panelboard shall be 600A single-phase three-wire. For three–phase systems, the panelboard shall be rated 600A, three-phase, four-wire. One panelboard shall be installed at the preferred auxiliary source and another shall be installed at the emergency auxiliary source. If the emergency source is supplied from outside of the substation, then the installation of an outdoor fused disconnect panelboard may not be reasonable.

The panelboard shall contain three sets of current-limiting, fused disconnects and space for at least one additional set of fused disconnects (See table below). One set of fused disconnects will be for protection of the AC panels in the control house, one set will be for the transformer cooling requirements, and a third set will be for maintenance/construction connections. The fused disconnects protecting the circuit to the control house will also protect the automatic transfer switch when applicable. To comply with the NEC, the panelboard shall not have more than six disconnects.

For single-phase systems, three standard, outdoor, fused disconnect panelboards have been set up as follows:

Standard Outdoor Fused Disconnect Panelboards for Single-Phase Auxiliary Systems

Description:	Stock No.
Single-phase, three-wire, 60 Hz, 120/240V, 100kAIC minimum, 600A main lug, copper bus in a NEMA 3R enclosure, 44" minimum width, top feed, rejection type fuses and with:	
• two 200A/2P fused disconnects (normally for ATS and maintenance source) • one 60A/2P fused disconnect (normally for transformer cooling loads) • two 200A/2P spaces only • two 100A/2P spaces only • one 60A/2P space only	S5-1012
• one 400A/2P fused disconnect w/ 2 #2-600 MCM Lugs (normally for ATS) • one 200A/2P fused disconnect (normally for maintenance source) • one 60A/2P fused disconnect (normally for transformer cooling loads) • one 200A/2P space only • one 60A/2P space only	S5-1013
• one 400A/2P fused disconnect w/ 2 #2-600 MCM Lugs (normally for ATS) • one 200A/2P fused disconnect (normally for maintenance source) • one 100A/2P fused disconnect (normally for transformer cooling loads) • one 200A/2P space only • one 100A/2P space only	S5-1014

Sizing of the individual fuse elements for the fused disconnect modules needs to be determined for each specific application. The individual fuses *are not* included in the above stock numbers.

For stations with auxiliary transformers of 25kVA or less, the standard 600A panel is not required. For these sites, a 100A, single-phase, three-wire panelboard with a 100A main breaker shall be installed in the substation yard. It is not necessary to use a separate fused safety switch upstream from the panelboard. If there is a panelboard mounted in the control house and an outdoor panelboard is not required for any other outdoor branch circuits, then a 100A fused safety switch mounted at the auxiliary transformer will suffice.

Conduits with weatherheads are to be used to route the secondary conductors to the outdoor main panelboard.

Xcel Energy stock transformers come equipped with eyebolt-type secondary bushing terminals. In some cases, the size or number of the secondary conductors may be larger than the bushing terminals can accommodate. In these cases, transformer adapter connectors should be used, rather than purchasing a non-stock transformer with a different type of terminal. One terminal adapter, which may be used, is the Burndy FCB64-4N, which consists of a stud connected to a NEMA standard 4-hole flat pad. Stock transformers are to be used whenever possible, as it makes replacements easier.

7. Grounding and Neutral Connections

The grounded neutral conductor shall be sized in accordance with the NEC-1999, Article 250-24.

The station auxiliary neutral is to be grounded in three places:

1. At the neutral bushing of the auxiliary transformer.
2. In the fused panel located in the yard.
3. In the transfer switch in the control house. (Note: This is a deviation from the NEC. See explanation below for details.)

<u>**Explanation of Deviation from the NEC**</u>

Re-grounding the neutral at the transfer switch in the control house, when there is also continuous metallic ground path between the panel in the yard and control house, is a deviation from the NEC-1999 Article 250-32(b)(2). The NEC is written to cover typical electrical installations outside of utility substations and does not consider the unique situation where the primary system is in close proximity to the secondary system. In a substation, it is possible for disturbances on the primary system to have a greater effect on the secondary system than what is experienced on systems outside of the substation. Therefore, exceptions are taken to the NEC because of these special conditions.

When a line to ground fault occurs on the primary system within a substation, the ground grid in the area of the fault can rise to a much higher potential than a part of the grid located some distance away from the fault. If this primary fault was to occur near the fused panel in the yard and the neutral were not regrounded in the control house there could be a significant difference in potential between the neutral and the ground grid in the control house. This voltage difference could present a hazard to anyone that happened to be in the control house when the fault occurred. It could also subject the equipment to line-to-ground potentials outside of their ratings. When the auxiliary system neutral is bonded to ground in the control house, any potential difference between the ground grid and neutral in the control house is kept to a minimum and below levels that would put people or equipment at risk.

The NEC prohibits this connection in order to prevent normal load current from using the metallic ground as a return path. Whenever current flows through a conductor, the resistance of the conductor generates a voltage drop. In the case of current through a ground conductor, this voltage drop causes a voltage difference between the conductor and what is considered "true earth". This voltage difference could put a person at risk should they come in contact with the grounded system and "true earth". Since our substations have a ground grid with all equipment and structures bonded together, the risk of coming in contact with the substation ground system and "true earth" is considered insignificant. Therefore, this deviation is made to the NEC to protect substation personnel and equipment from what we consider to be the more significant risk.

8. ATS and Indoor Panels

For new installations (and retrofits when appropriate), the preferred and emergency supplies to the control house will be brought into the automatic transfer switch and then into a control house main breaker panelboard. This standard does not require service disconnects to be installed inside the control house on the supply side of the ATS. Instead, the service disconnects are located at the fused panelboard in the yard. This is allowed by the NEC as there is a hold-card system in place to ensure that the service is not inadvertently energized.

The main panel in the control house shall be 120/240V, 600 Ampere main lug only. For single-phase systems, the main panelboard shall be 600A, single-phase, three-wire. For three–phase systems, the panelboard shall be 600A, three-phase, four-wire.

For new installations, 200 Ampere, single-phase, AC power and lighting panels should be installed, which would each require 200 Ampere feeder breakers on the main panelboard. For existing substations, the feeder breakers need to be matched to the AC panels.

For three-phase systems, a 225A, three-phase, AC power panel may be installed in addition to the single-phase power and lighting panels. This panel would be used to power 240V loads such as heaters, as well as, any three-phase loads. It is recommended that no 120V loads be supplied from this panel.

The standard indoor main breaker panelboards are listed below:

Standard Indoor Main Breaker Panelboards
for Single-Phase Auxiliary Systems

Description:	**Stock No.**
Single-phase, three-wire, 60 Hz, 120/240V, 22kAIC minimum, 600A main lug, copper bus in a NEMA 1 enclosure, 36" minimum width, top feed and with: • four 200A/2P breakers • two 200A/2P breaker spaces • two 125A/2P breaker spaces	S5-1010
• two 200A/2P breakers • two 200A/2P breaker spaces • two 125A/2P breaker spaces	S5-1011

9. Secondary Available Fault Currents

The available fault currents and ratings of equipment must be taken into consideration when designing the auxiliary system. A reference for further information on this subject is:

> IEEE Std 242, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).

The available fault current at the secondary terminals of the auxiliary transformers according to auxiliary transformer kVA sizing is as follows:

Available Fault Current
Single-Phase Auxiliary Systems
With 120/240V secondary

TR kVA	Approx. Fault Duty (kA) *	Assumed $Z_{\%}$ Impedance (%)
25	4.5	2.3
37.5	7.4	2.1
50	9.5	2.2
75	19.5	1.6
75	17.4	1.8
75	15.6	2.0
100	14.4	2.9

* Assumes infinite source

$$Z_B = \frac{V^2}{VA} \qquad Z_{act} = Z_B \times \frac{Z_\%}{100} \qquad I_F = \frac{V}{Z_{act}}$$

V = Line-to-Line Voltage (i.e. 240V)
Z_B = Transformer Base Impedance
Z_{act} = Transformer Actual Impedance
I_F = Fault Current

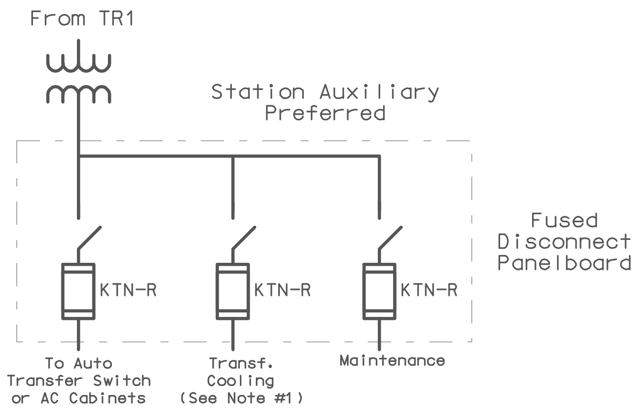
Available (3-Phase) Fault Current
for Closed-Delta or Two-Legged, Open-Delta Secondary
Three-Phase Auxiliary Systems with 120/240V secondary

Single TR kVA	3-Phase Total kVA**	Approx. Fault Duty (kA) *	Assumed $Z_\%$ Impedance of each transformer (%)
25	75	7.8	2.3
37.5	112.5	12.9	2.1
50	150	16.4	2.2
75	225	33.8	1.6
75	225	30.1	1.8
75	225	27.1	2.0
100	300	24.9	2.9

* Assumes infinite source
** Choose the row of the table based on the kVA of the individual transformers used. Using the value in this column for both two-legged-open-delta and closed-delta systems will provide the correct worst-case three-phase fault current.

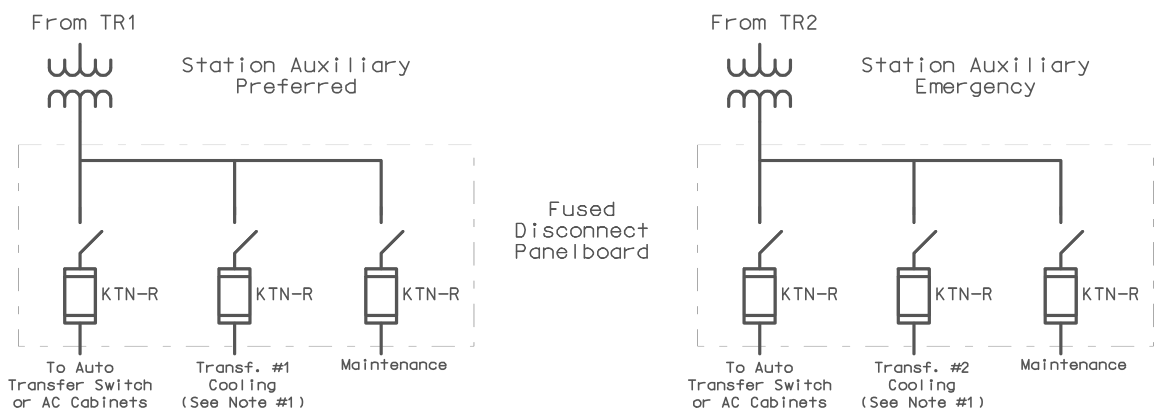
$$Z_B = \frac{V^2}{VA_{3-Phase}} \qquad Z_{act} = Z_B \times \frac{Z_\%}{100} \qquad I_F = \frac{V}{\sqrt{3} \times Z_{act}}$$

V = Line-to-Line Voltage (i.e. 240V)
Z_B = Transformer Base Impedance
Z_{act} = Transformer Actual Impedance
I_F = Fault Current

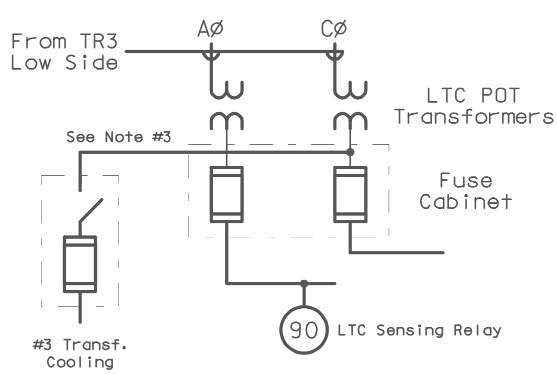


Notes:
1. Fuse size to be determined when transformer manufacturer's drawings are received.
2. For Transformer #1 & #2 supplies, see Two Transformer scheme.
3. The 3rd transformer cooling is not to be taken from the LTC POT used for LTC sensing. Where only one POT exists, the transformer cooling should be taken from the AC cabinet.

One Transformer

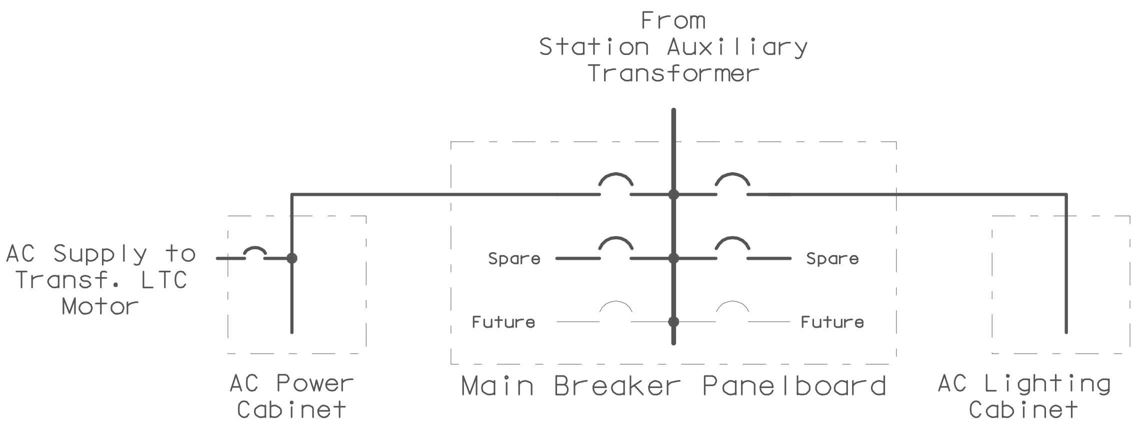


Two Transformer

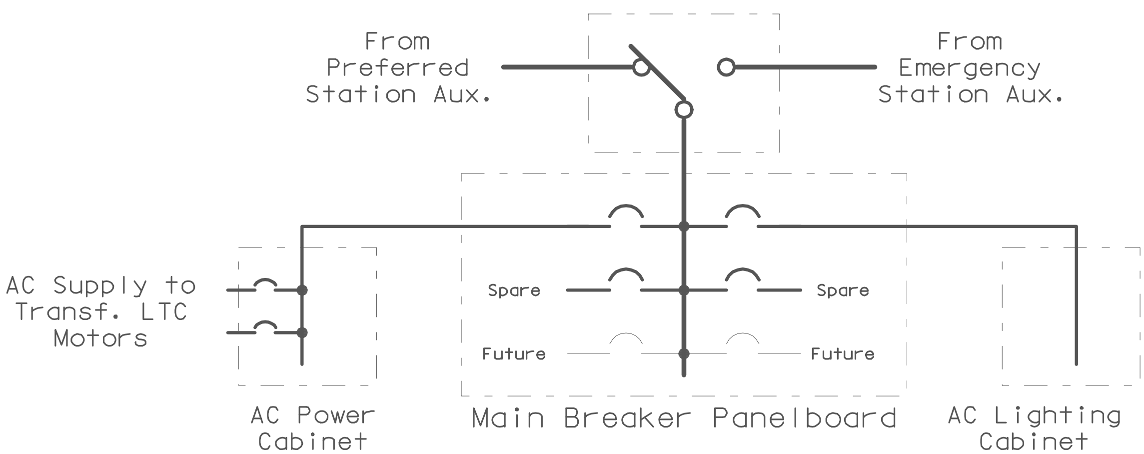


Third Transformer
(See Note #2)

Substation AC Auxiliary Systems



Control House Load Center - No Emergency Source



Control House Load Center
With Preferred & Emergency Sources

Nameplates for Substation Equipment and Cabinets

1. General

All outdoor equipment and cabinets shall be identified with 1" x 2", 1 ½" x 6", 1 ½" x 7", 5" x 8", 6" x 10" or 6" x 14" on 0.080 aluminum plate covered with 3M high intensity yellow Scotchlite, code 3871, and one inch high letters (except CCVT grd, carrier, potential, and norm which shall have 1/2" letters). The letters shall be silk screened with 3M #845 black paint.

1.01. Outdoor nameplates shall be mounted either by the use of pop-rivet or 3M Adhesive No. 847 when drilling is not feasible.

1.02. Three-line equipment identification shall be on a 5" x 8" plate. Four-line equipment identification shall be on a 6" x 10" or 6" x 14" plate. All power transformers shall be identified with a 6" x 10" plate. The word "Transformer" shall not be abbreviated on the power transformer nameplate. Transformer may be abbreviated on other equipment nameplates. Use "TR" as the identification for a transformer. The identification "bank" shall not be used for the identification of a transformer.

1.03. Transformers, breakers, reclosers and motor-operated disconnect switches shall have the nameplate located on the equipment cabinet at approximately 5 to 6 feet above grade, when possible, and near the center of the cabinet. Transformers, also require 1 UTC # nameplate (1½"x7" adhesive nameplate). Reclosers require 2 nameplates located on each side of the control cabinet. See examples in Sections 4.01, 4.01, 4.04, and 4.04.

1.04. Manual group operated disconnect switches shall have the nameplate located in such a way that it is clearly visible when operating the disconnect switch. See the examples in Section 4.05.

1.05. When multiple manual disconnect switches are mounted on one column, install nameplates as shown in Section 4.06.

1.06. Hook-stick disconnect switches shall be identified as shown in examples in Sections 4.07, 4.08, and 4.09. When identifying the phasing, the information shall appear on the third line of the nameplate. As you face the switch, the right phase shall be on the right side, the center phase shall be in the center, and the left phase shall be on the left side of the nameplate.

1.07. Coupling capacitor voltage transformers (CCVT), potential transformers (PT), and metering units shall be identified as shown in the example in Section 4.10.

1.08. Coupling capacitor voltage transformers (CCVT) with/without carrier shall be identified as shown in the example in Section 4.11.

1.09. Secondary fuse cabinets shall be identified as shown in the example in Section 4.12.

1.10. Capacitor banks shall have (1) nameplate on each phase and shall be identified as shown in the example in Section 4.13.

1.11. Station auxiliary transformers shall be identified as shown in the example in Section 4.14.

1.12. Control test receptacles shall have a 6" x 10" nameplate and shall identify both receptacles. The nameplate shall be identified as shown in the example in Section 4.15.

1.13. Foreign utility substation equipment maintained and operated by Xcel Energy shall have equipment nameplates. All other foreign substations maintained and operated by Xcel Energy shall have equipment nameplates when approved by the foreign company.

1.14. Feeder reactors, wave traps, and current transformers do not require nameplates.

1.15. Nameplates should label operating voltage, not designed voltage.

2. N/A

3. Nameplate Layout

The following tables contain a list of examples of the different variations of equipment nameplates that are required.

3.01. 345 KV Substation

8N4 345KV BKR	8N4A 345KV DISC	8N4A1 345KV DISC	BUS 1 PT 345KV DISC
BUS 1 345KV PT A PHASE	BUS 1 345KV PT SEC FUSES	BUS 2 345KV CCVT SEC FUSES	BLL LINE 345KV CCVT SEC FUSES
BLL LINE 345KV CCVT A PHASE	BLL LINE TUNING UNIT	TRANSFORMER 8 GENERATOR 345-20KV	TRANSFORMER 8 345-115-13.8KV
TR8 345KV MOD	FRA LINE 345KV METERING UNIT A PHASE	FRA LINE 345KV METERING UNIT SEC FUSES	MTC LINE 345KV REACTOR A PHASE

3.02. 230 KV Substation

TR7 230KV MOD	7N2 230KV MOD	7N2A 230KV DISC	FRA LINE 230KV METERING UNIT SEC FUSES
BEN LINE 230KV CCVT B PHASE	BEN LINE 230KV CCVT SEC FUSES	TRANSFORMER 7 230-69KV	FRA LINE 230KV METERING UNIT A PHASE

3.03. 161 KV Substation

WBG LINE 161KV CCVT A PHASE	WBG LINE 161KV CCVT SEC FUSES	WBG LINE TUNING UNIT	FRA LINE 161KV METERING UNIT A PHASE
FRA LINE 161KV METERING UNIT SEC FUSES	TR6 161KV DISC	TRANSFORMER 6 161-69KV	

3.04. 115 KV Substation

TR5 115KV DISC	5M193A 115KV DISC	5N6 115KV BKR	CAP1 115KV A PHASE BANK
5N6A 115KV DISC	FRA LINE 115KV CCVT A PHASE	FRA LINE 115KV CCVT SEC FUSES	FRA LINE TUNING UNIT
FRA LINE 115KV METERING UNIT A PHASE	FRA LINE 115KV METERING UNIT SEC FUSES	BUS 1 115KV PT SEC FUSES	BUS 1 115KV PT A PHASE
TRANSFORMER 5 115-69KV	TR5 115KV MOD	TR5 115KV CKT SW	

3.05. 69 KV Substation

TR3 69KV PT A PHASE	TR3 69KV PT SEC FUSES	TR3 69KV BKR	TRANSFORMER 3 69-13.8KV
BUS 1 69KV PT A PHASE	BUS 1 69KV PT SEC FUSES	BUS 1 69KV CCVT A PHASE	BUS 1 69KV CCVT SEC FUSES
4E61A 69KV DISC A B C	4X40A1 69KV DISC	4X40 69KV BKR	FRA LINE 69KV METERING UNIT A PHASE
FRA LINE 69KV METERING UNIT SEC FUSES	4E256B 69KV PT A PHASE	KLS LINE 69KV PT A PHASE	
	This PT is located between the breaker and the “B” disc.	This PT is located on the transmission line	

3.06. 34.5 KV Substation (23 KV Similar)

3P1 34.5KV BKR	3P1A 34.5KV DISC	HUG311-HUG321 34.5KV MOD	HUG311-HUG321 34.5KV DISC
FRA LINE 34.5KV METERING UNIT A-PHASE	FRA LINE 34.5KV METERING UNIT SEC FUSES	YNK311 34.5KV DISC	
TR9 GRD DET TR A PHASE	TR9 GRD DET TR 34.5KV DISC	TR9 GRD DET TR 34.5KV SEC FUSES	TR9 GRD DET TR 34.5KV RES CAB
REACTOR 9 34.5KV A PHASE	REACTOR 9 34.5KV PT A PHASE	REACTOR 9 34.5KV PT SEC FUSES	

3.07. 13.8 KV Substation

TR9 13.8KV-240V AUX TR	BLM61 13.8KV BKR (2 REQUIRED)	BLM61A 13.8KV DISC	WLM62TB 13.8KV DISC
STA AUX TR 13.8KV FUSED DISC A B C	GRD TR 13.8KV A PHASE	WLM62B 13.8KV DISC A B C	RRK62A 13.8KV DISC
STM21C 12.5KV FUSED DISC C B A	BUS 1 13.8KV CAPACITOR GRD SW	BUS 1 13.8KV PT A B C	BUS 1 13.8KV PT SEC FUSES
DBL43 13.8KV DISC GRD SW C B A	BUS 1 13.8KV FUSED DISC A B C	BUS 1 13.8KV METERING UNIT A B C	BUS 1 13.8KV METERING UNIT SEC FUSES
TRANSFORMER 1 115-13.8KV	TR1 13.8KV BKR	TR1 13.8KV MOD	WAT81 13.8KV REGULATOR A PHASE
BT1-2A1 13.8KV DISC	BT1-2TA1 13.8KV DISC		

3.08. Pad Mounted Cap Bank

WIL66 13.8KV CAP BANK (2 REQUIRED)	FUSES	RADIO NO

3.09. By-Pass Switch

BUS 1 13.8KV REG BY-PASS SW A B C	L *(LOAD)* *(TO BE MOUNTED ON SW BLADES)*	S *(SOURCE)* *(TO BE MOUNTED ON SW BLADES)*	BP *(BY-PASS)* *(TO BE MOUNTED ON SW BLADES)*

3.10. Switch Fuse Combination

WLM62B 13.8KV DISC A B C	WLM62C 13.8KV FUSED DISC A B C

3.11. CCVT with Carrier

NOTE: CCVTs without carrier require only 1 nameplate each for POTENTIAL, NORM AND GRD. No CARRIER nameplate is required. These are all ordered using assigned Cat. ID's, see Physical Material List items: 723A, 723B, 723C & 723D.

CARRIER	POTENTIAL	NORM	GRD
		(2 required)	(2 required)

3.12. Switchgear

BLC61 13.8KV CUBICLE	SWGR CHASKA BLC 81,82,83	SWGR BLC 81,82,83 BUS 2-SEC 1
(2 required)	(2 required)	(Xcel Energy SWGR doors only) (2 required)

3.13. Outdoor Substation Power & Light

345KV AC LTG CAB M	115KV YARD AC LOAD CENTER	AUTO TRANSFER SWITCH 1	1 DIST. TR 480-120/240V
DISTR PANEL A	LTG CAB L 120/240V FUSED DISC	LTG TERM CAB C3	AC PWR CAB M
1 STA AUX 120/240V JUNCTION BOX	345KV SUB PWR CAB L	EMERGENCY STA AUX 120/240V FUSED DISC	PREFERRED STA AUX 120/240V FUSED DISC
PREFERRED STA AUX TR 13.8KV-120/240V B & C PHASE	EMERGENCY STA AUX TR 13.8KV-120/240V B & C PHASE	PREFERRED STA AUX TR 120/240V FUSED SAF SW	EMERGENCY STA AUX TR 120/240V FUSED SAF SW
345KV SUB LOAD CTR 3 AUTO TRANSFER SW	345KV SUB LOAD CTR 3 FUSED SAF SW PREFERRED	PREFERRED STA AUX TR 120/240V PANELBOARD	MAINTENANCE AC SUPPLY 120/240V

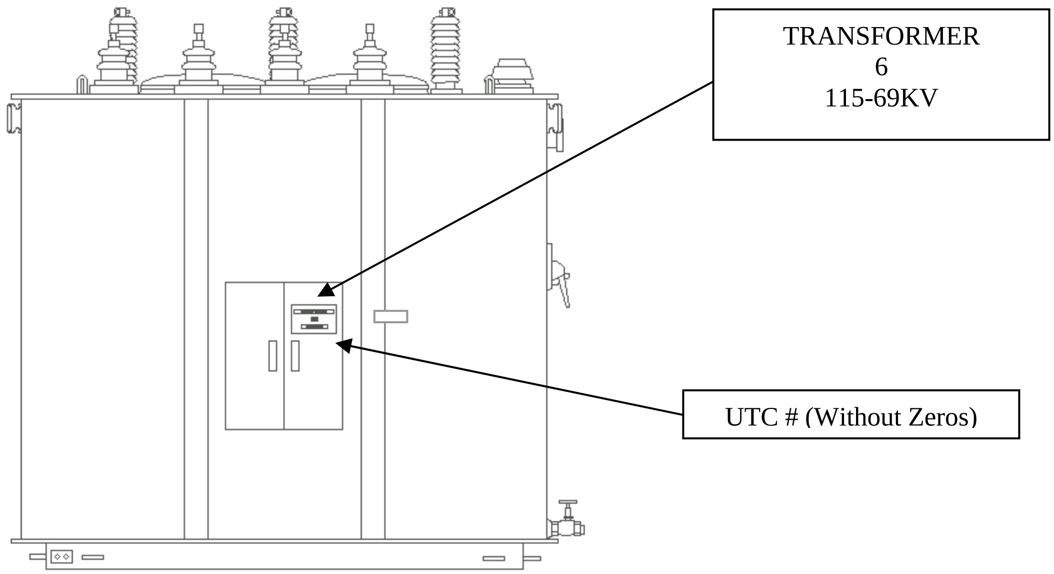
3.14. Miscellaneous

TR1 8400V SPOT TRW B PHASE	MOBILE TR CONTROL CABLE CONNECTION CABINET	EBL64-EBL65 VCR RECEPTICAL	UTC #1686665
TR1 CABLE TERM CAB			

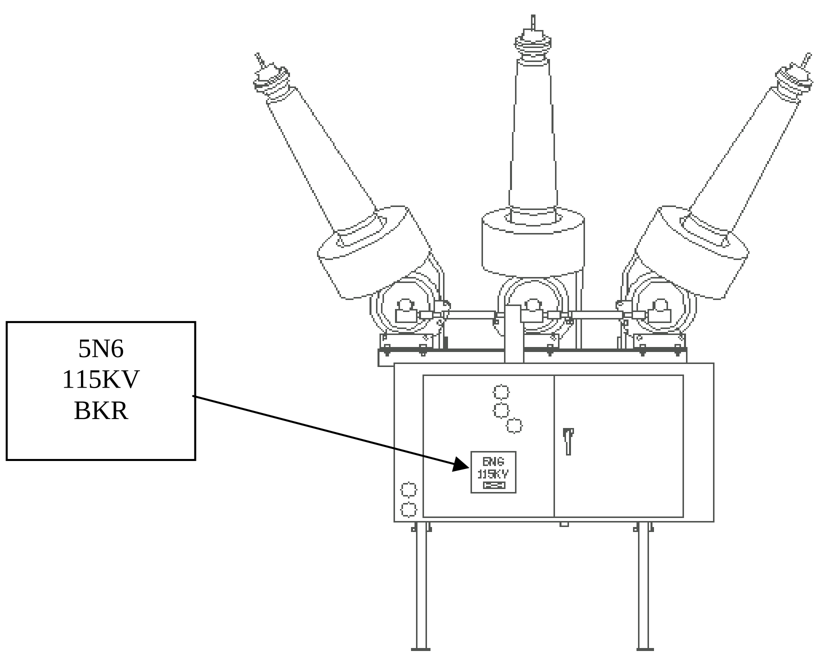
4. Location of Nameplates

The following is a list of examples indicating the location of nameplates.

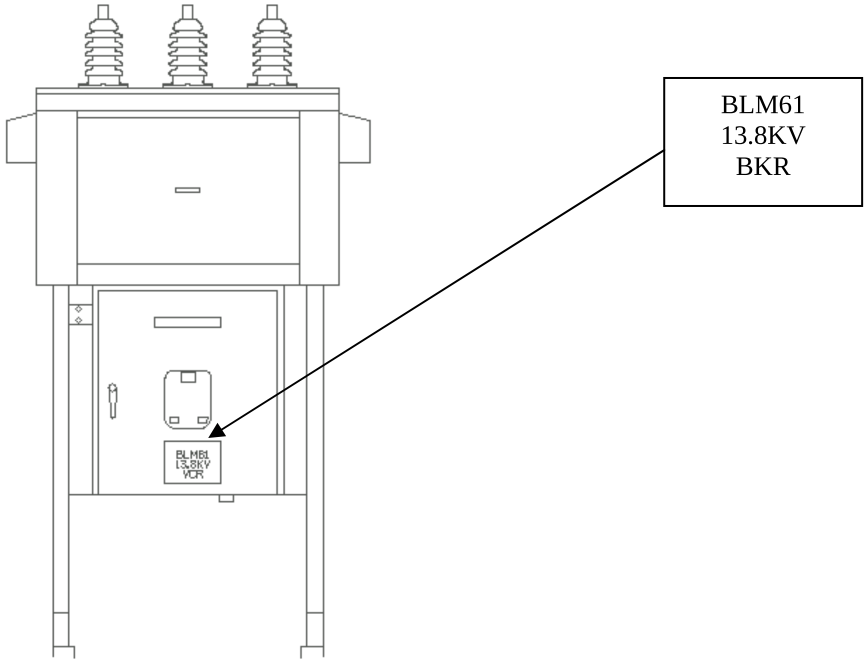
4.01. Power Transformers (UTC # Nameplate)



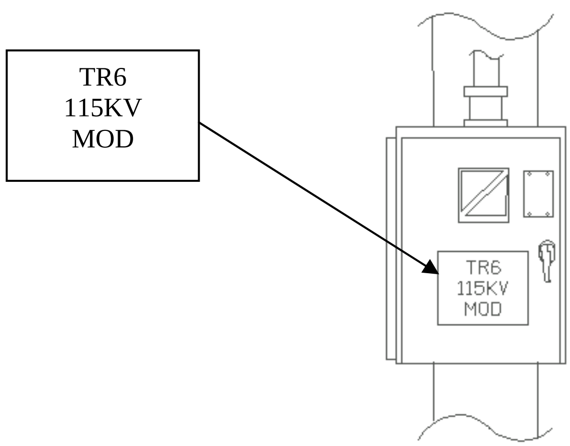
4.02. Breakers



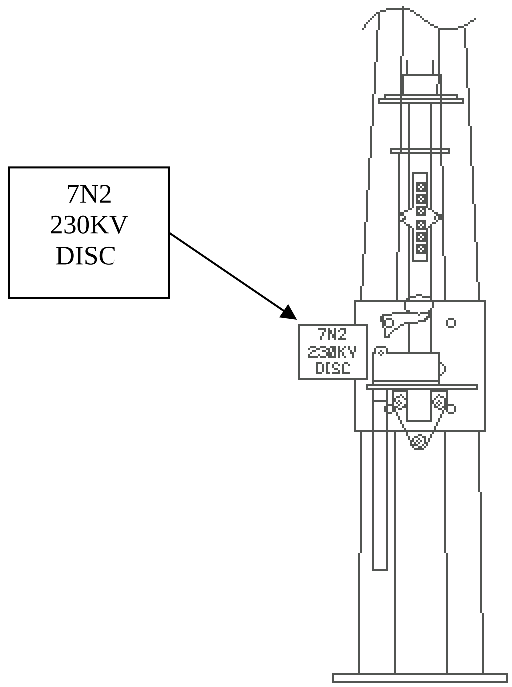
4.03. Reclosers (2 Nameplates Required – one on each side of the control cabinet)



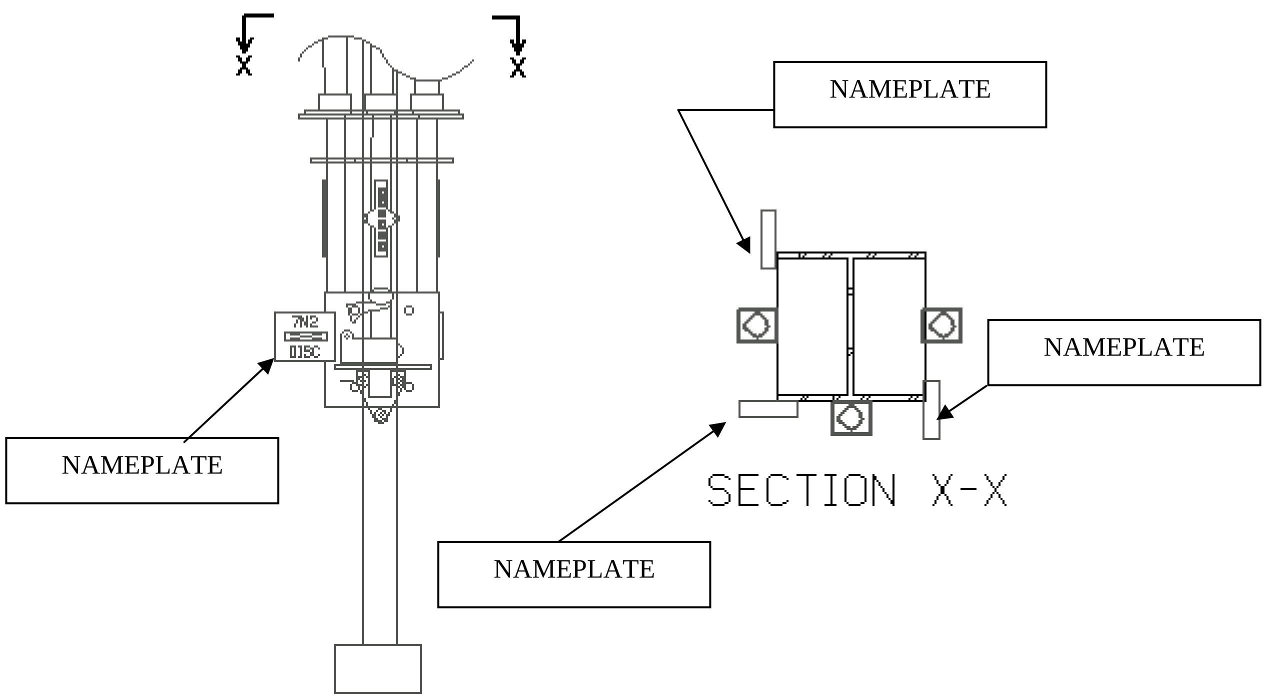
4.04. Motor Operated Disconnect Switch



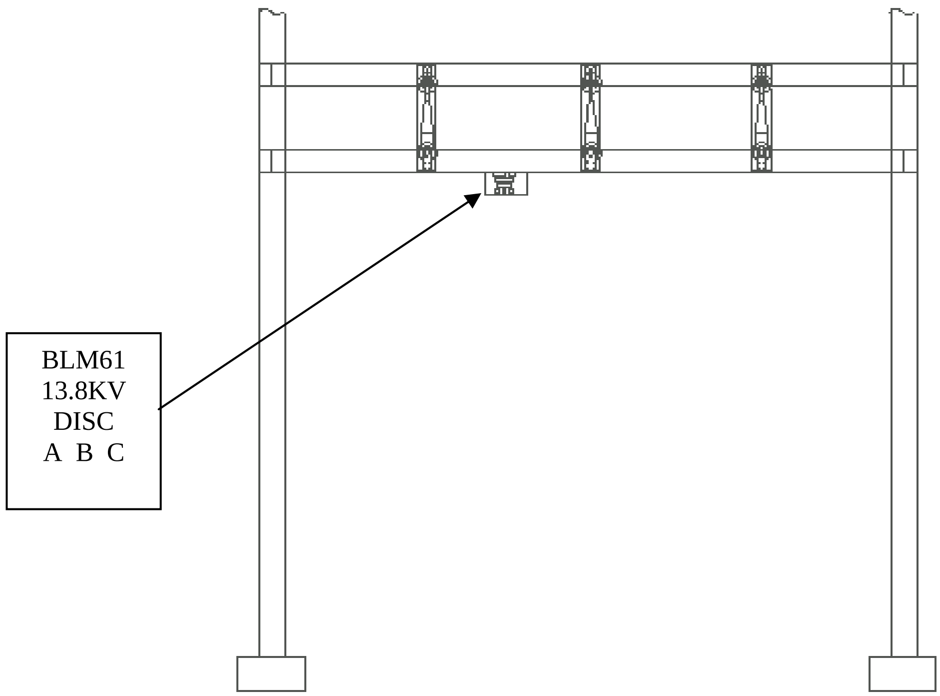
4.05. Disconnect Switch – Crank Operated



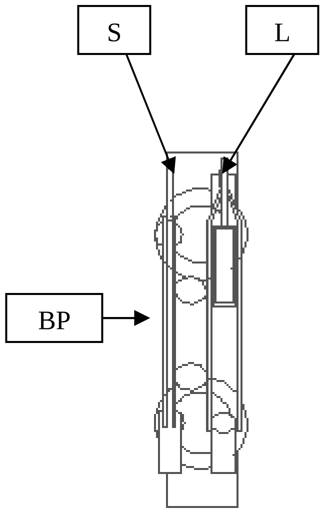
4.06. Multiple Manual Disconnect Switches



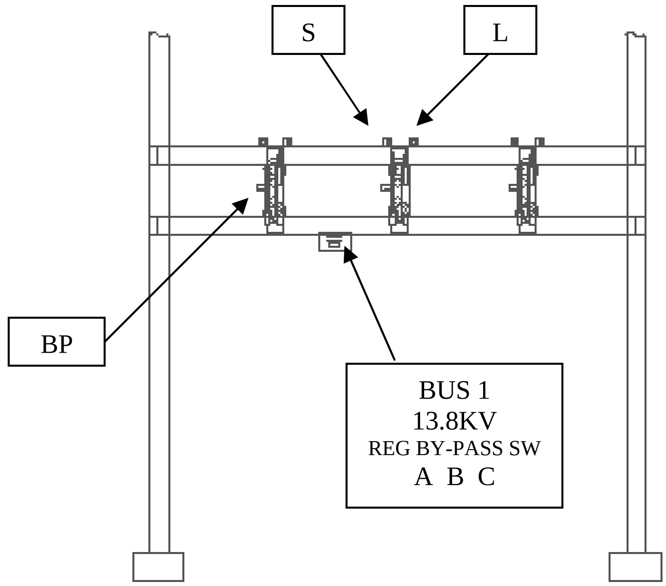
4.07. Hook-Stick Disconnect Switches

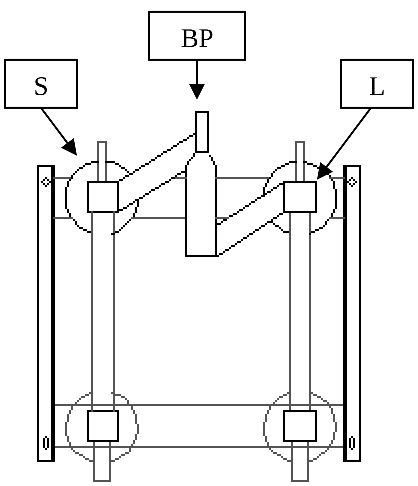


4.08. By-Pass Switches

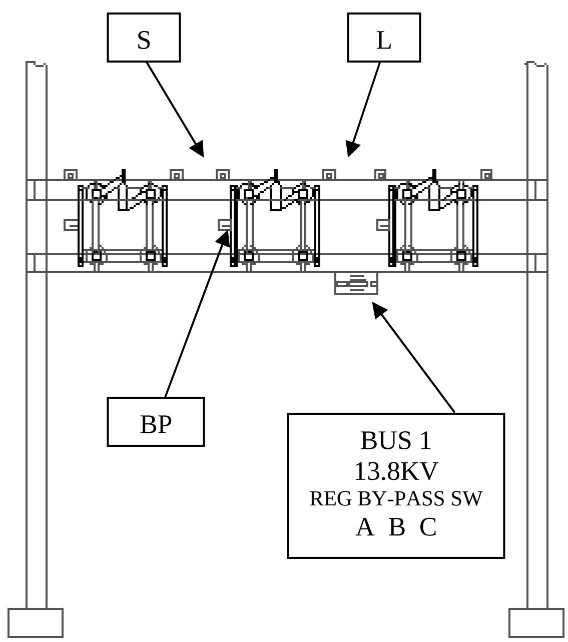


FOR 600AMPS
AND BELOW

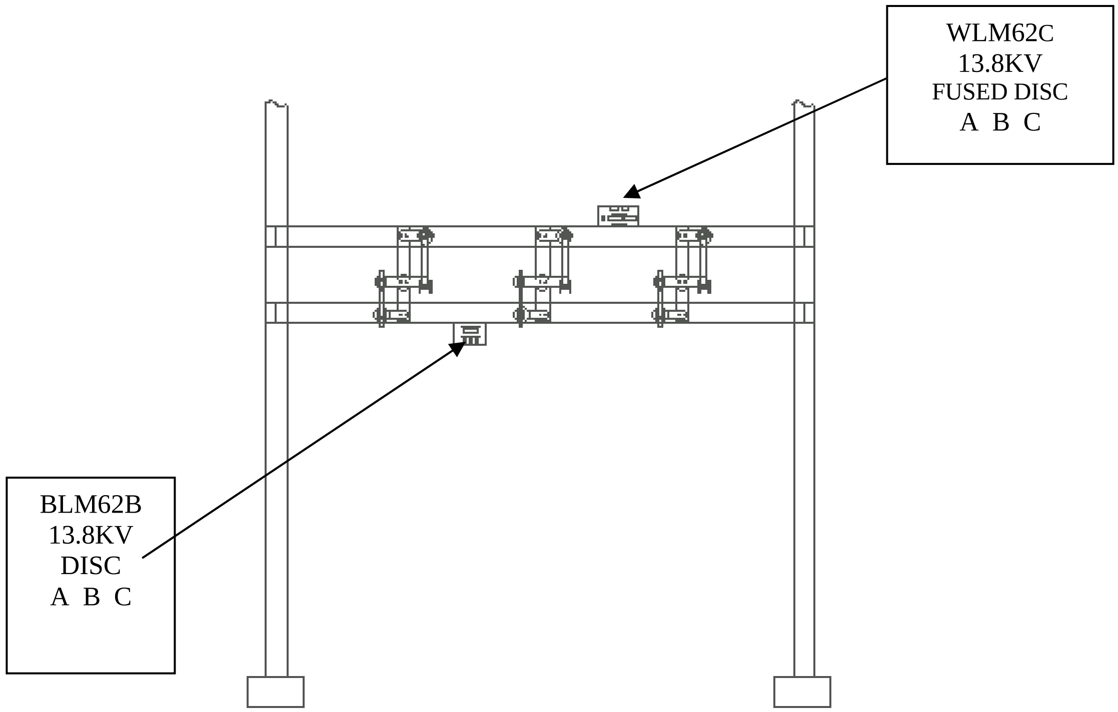




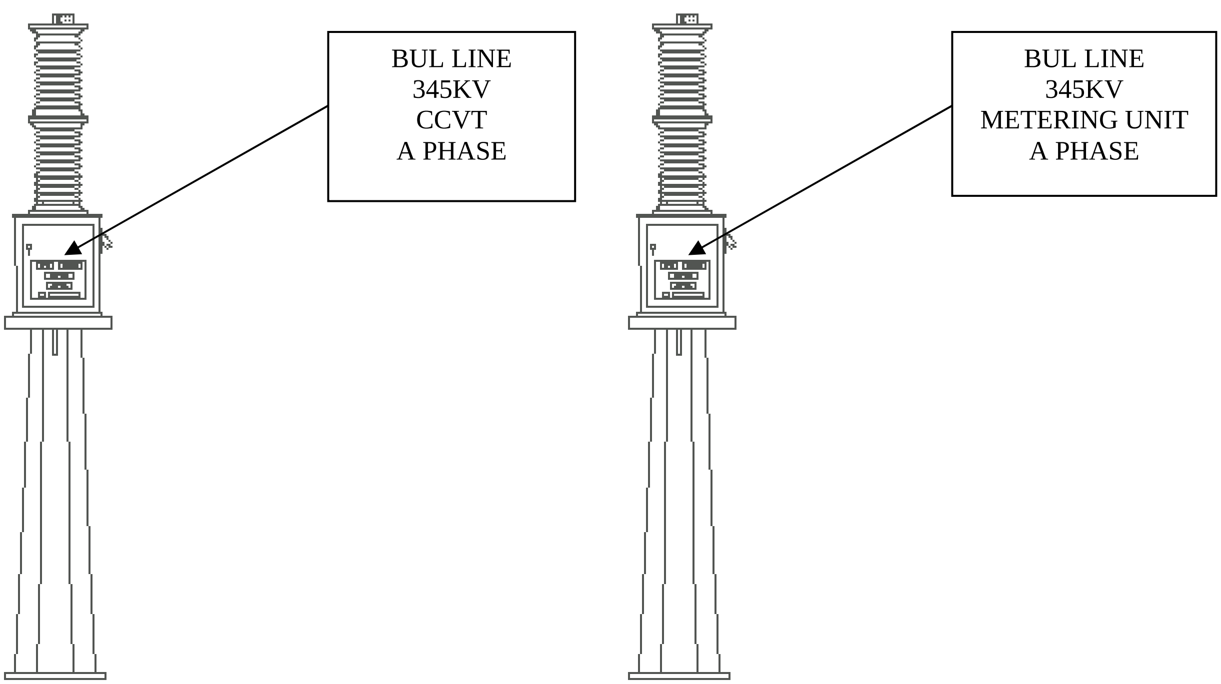
OVER 600
AMPS



4.09. Switch Fuse Combination



4.10. Coupling Capacitor Voltage Transformer (CCVT), Potential Transformer (PT), and Metering Unit. Mount using 3M adhesive #847

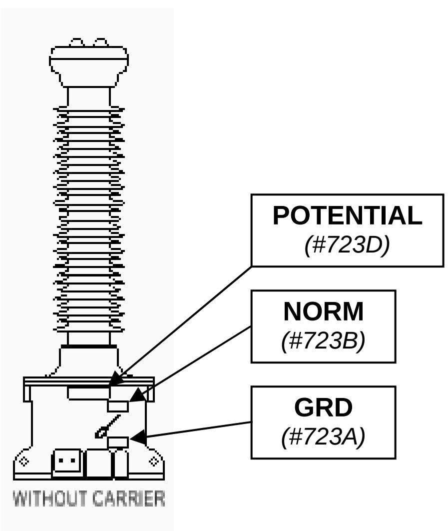


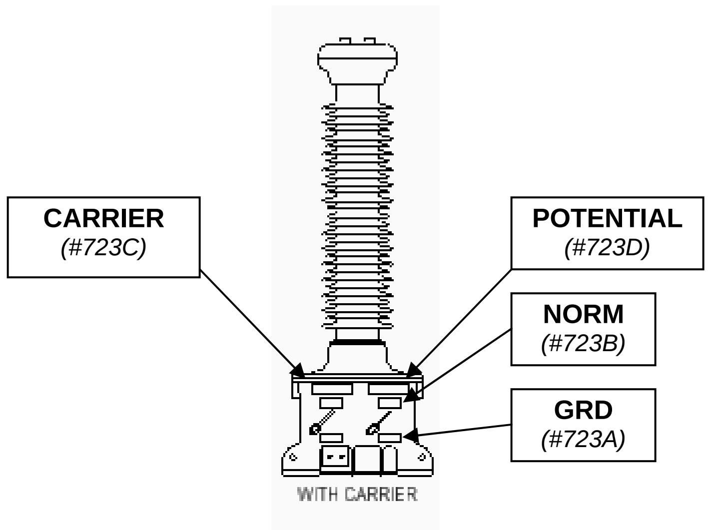
4.11. Coupling Capacitor Voltage Transformer (CCVT)

NOTE: CCVT's without carrier require only 1 nameplate each for POTENTIAL, NORM and GRD. No CARRIER nameplate is required. These are all assigned using assigned Cat. ID's, see Physical Material List items: 723A, 723B, 723C & 723D.

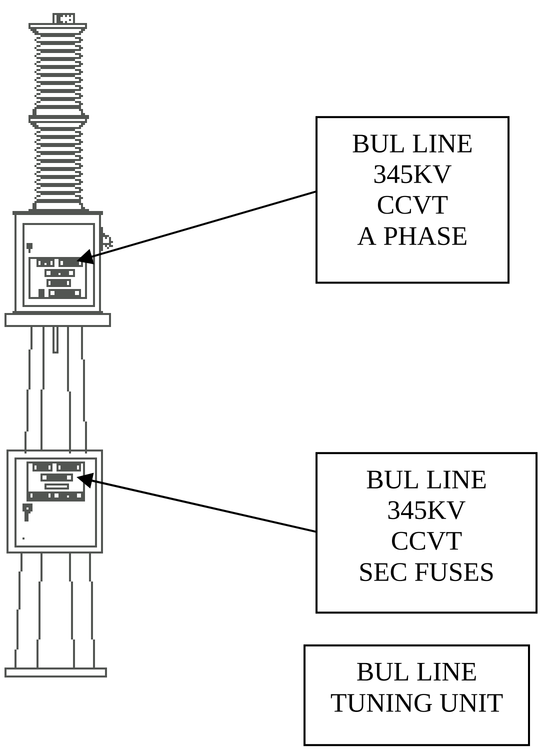
Potential Transformers with grounding switch require NORM and GRD nameplates.

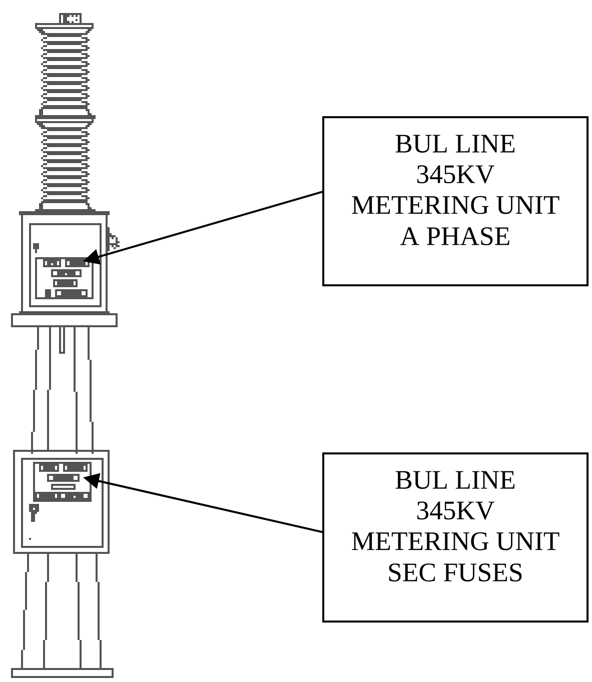
Mount using 3M adhesive #847





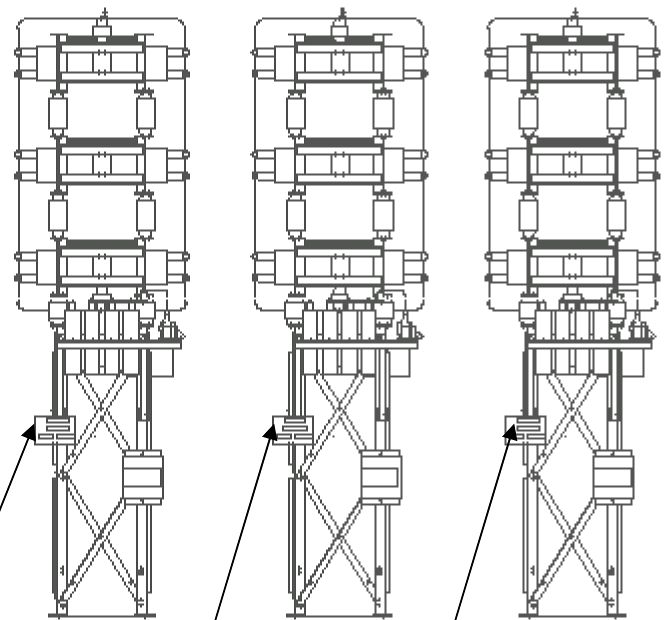
4.12. Secondary Fuse Cabinets. Mount using 3M adhesive #847





4.13. Capacitor Bank

ONE
NAMEPLATE
EACH PHASE ON
FRONT SIDE OF CAP
BANK

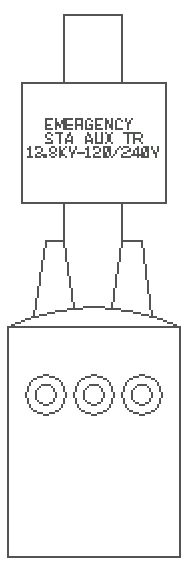


CAP1
115KV
A PHASE BANK

CAP1
115KV
B PHASE BANK

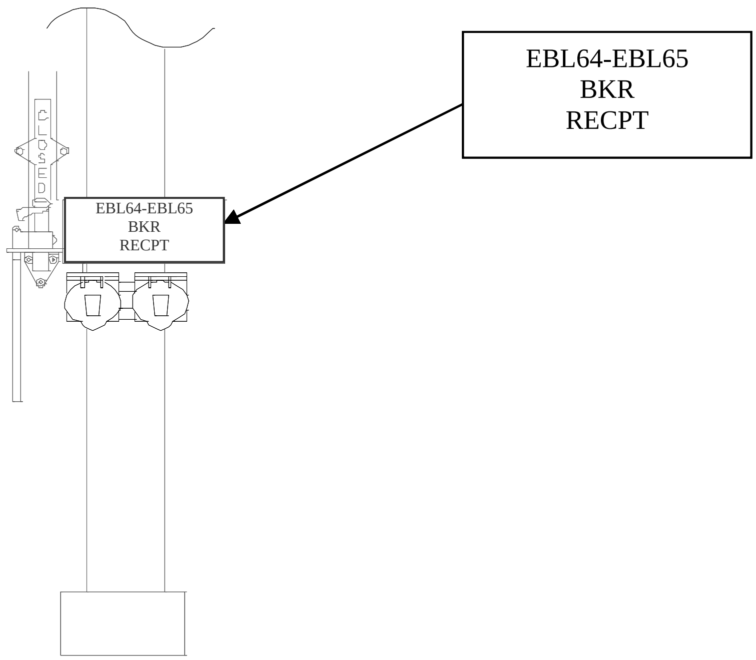
CAP1
115KV
C PHASE BANK

4.14. Station Auxiliary Transformers



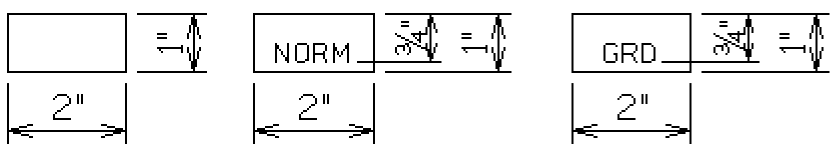
EMERGENCY
STA AUX TR
13.8KV-120/240V

4.15. Receptacles (These receptacles are no longer installed)

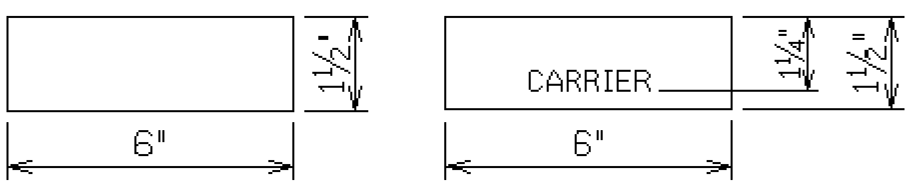


5. Nameplate Size and Use

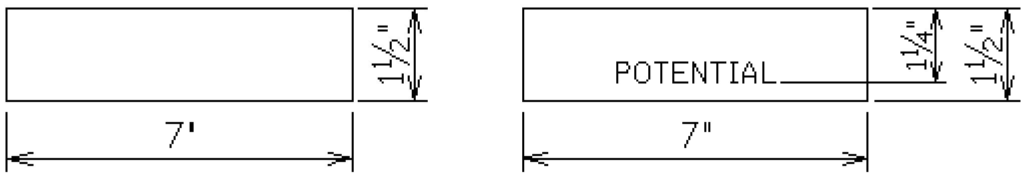
5.01. Size 1" x 2" – Used for regulator by-pass switch letters "L", "S" and "BP" or other signs with a maximum of four ½" tall characters.



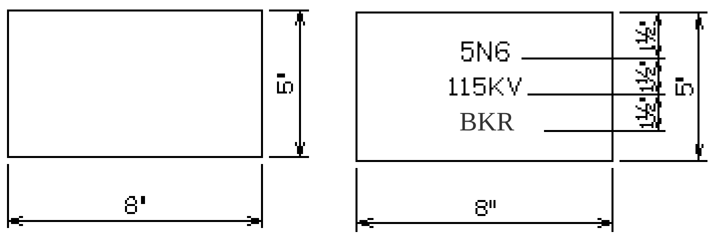
5.02. Size 1½" x 6" – Used for signs with from five to nine ½" tall characters.



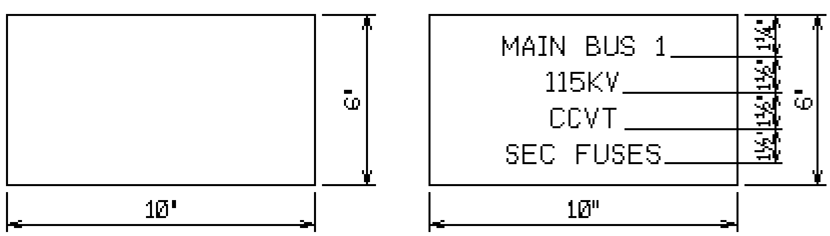
5.03. Size 1 ½" x 7" – Used for signs with from ten to thirteen ½" tall characters.



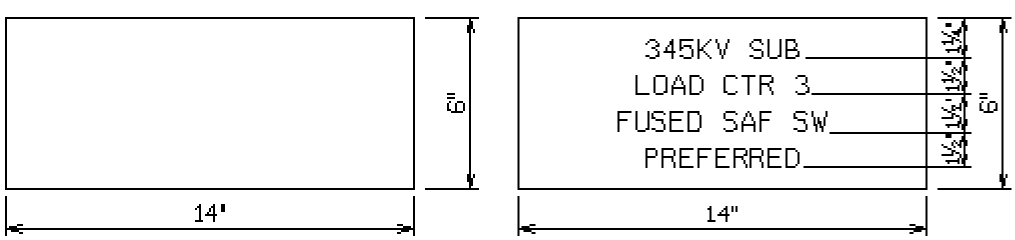
5.04. Size 5" x 8" – Used for three text lines; maximum of twelve 1" tall characters per line.

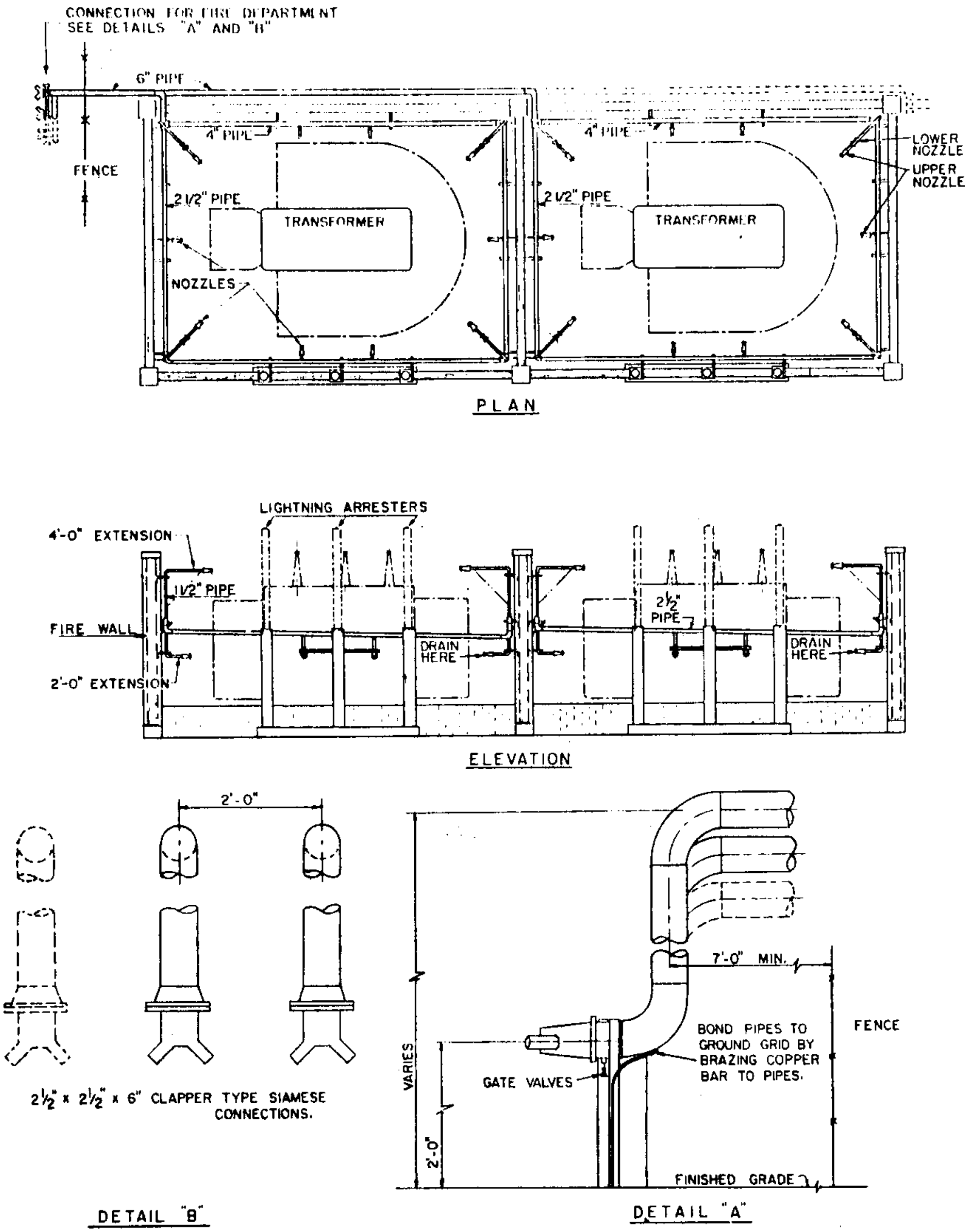


5.05. Size 6" x 10" – Used for TRANSFORMER and signs with four text lines; maximum of fifteen 1" tall characters per line.



5.06. Size 6" x 14" – Used for long identification signs with a maximum of twenty 1" tall characters per line.

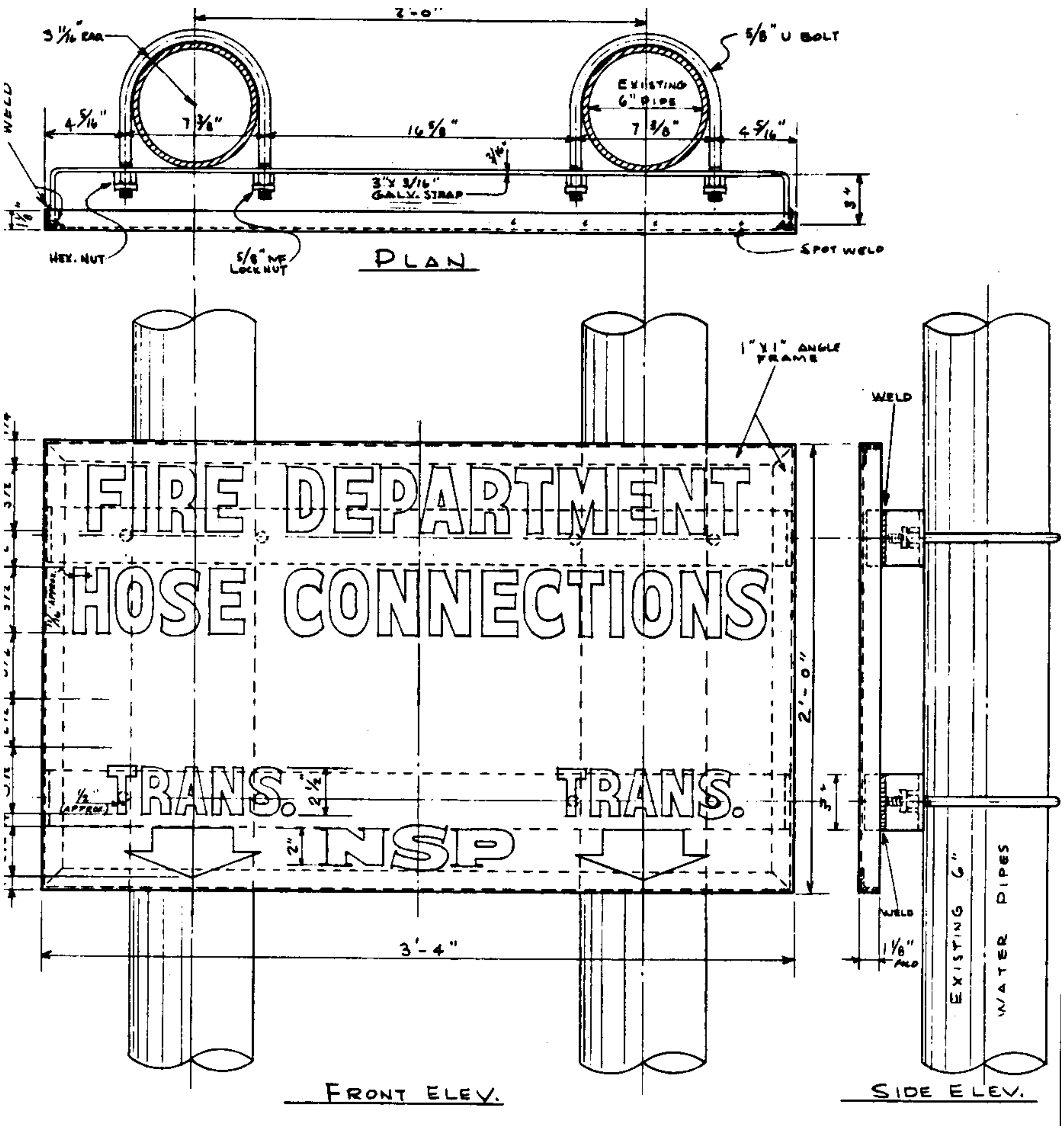




NOTES
1 1/2" MARINE TYPE FOG NOZZLES WITH I.P.T. THREADS

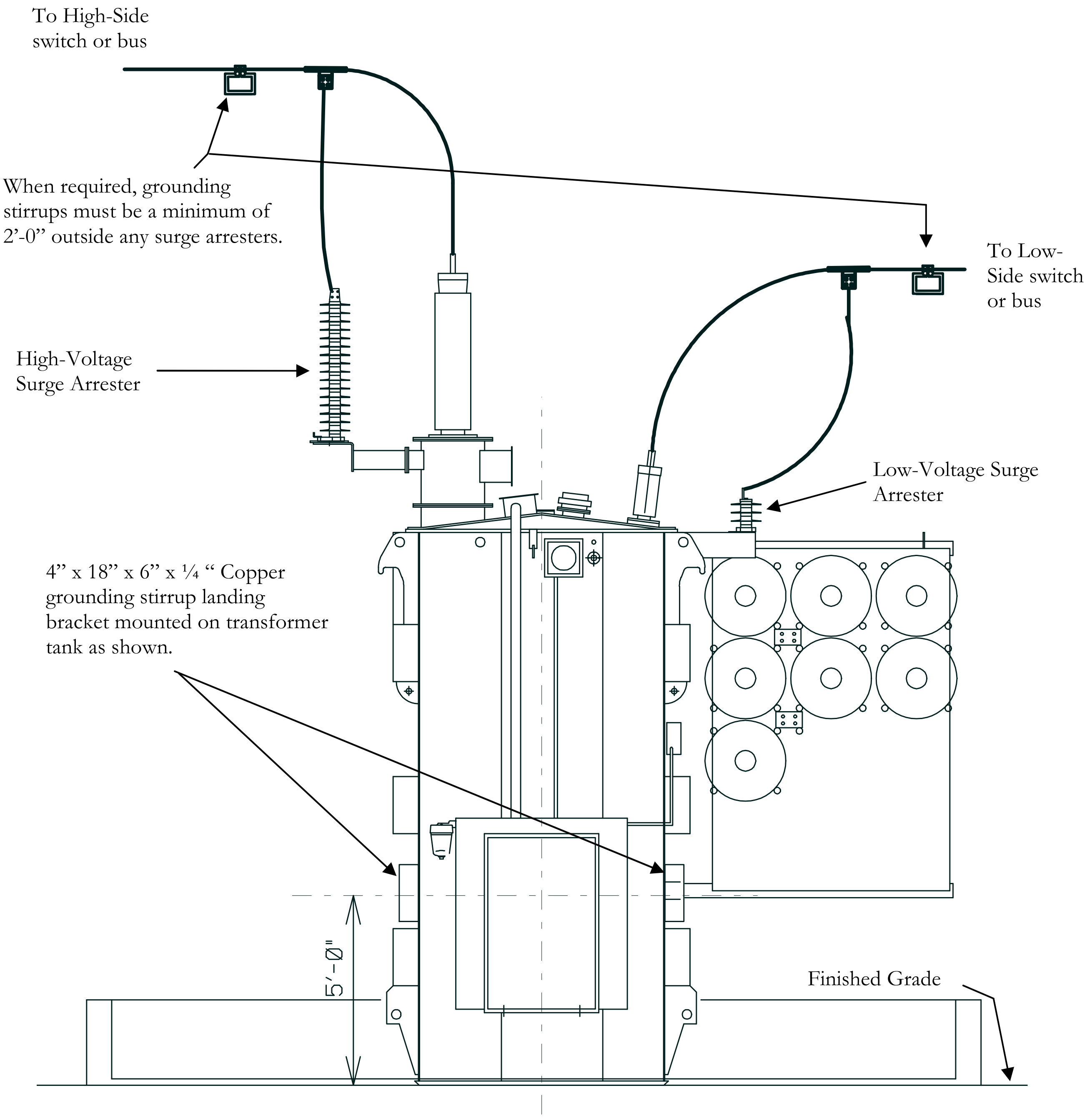
Typical Fire Protection System For Major Bulk Power Stations

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 12/7/56		0	SHEET 1	ED 4.09.04



SIGN FOR FIRE PROTECTION SYSTEM FOR MAJOR BULK POWER STATIONS

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED	0	SHEET 2	ED 4.09.04
	DATE 8/20/2013				



1. Provisions must be made for attachment of personal grounds. Transformers shall have a 4" x 18" x 6" x ¼" copper, galvanized, or stainless steel bracket mounted 5'-0" from the bottom side of the tank to the centerline of the bracket.

2. Connections to transformer bushings should be installed to provide a ground attachment point which is parallel to grade. If transformer connections can't be made to provide an easy ground attachment point due to vertical bus or bundled conductor, an approved stirrup should be installed. The stirrup should be installed on the conductor 2'-0" or more outside the bushing/surge arresters to provide an easily accessible grounding point.

Operating and Maintenance – Ground Stirrups for Transformers

Xcel Energy - North	Date: 03/27/2003	Approved:	Rev. 3	Substation Engineering & Design Standards	
				Sheet 1 of 1	ED 4.09.05.01

1.0 Purpose

The purpose of this standard is to provide direction for application of new personal protective grounding attachment point devices on the Xcel Energy system. This standard will also address the handling and limitations of the previously used ground stirrups and studs. Background information regarding some of the history of these devices is provided in a power point presentation complete with notes, located in **DSC\LIBRARY\REFERENC\Presentations\Grounding.ppt**. There is also a supporting paper written for the 2000 Minnesota Power Systems Conference located in **DSC\ Library\ Referenc\ Presentations\Papers\Substation Ground Testing.doc**.

2.0 Retired or Superseded Devices

The devices listed in Table 1 and shown in Figure 1 were tested and found to no longer be acceptable for new installation in Substations on the Xcel Energy system (see note "a" below Table 1 and Figure 1). These devices are still safe for use at fault currents of 24 kA or less. However, even though the devices have been tested and are safe at this limited fault level, projects in substations where these devices already exist, should request funding to remove and/or replace the devices with those listed in Section 3.0 of this standard.

In substations where the fault is below the 24 kA level, these devices shall be removed/replaced on any bus section or portion of the substation that will be outaged during a construction or maintenance project. In substations where the fault levels already exceed the 24 kA level and a project has been identified at that location, the project funding authority should be consulted to determine whether all ground attachment devices at the substation not presently approved are to be removed and/or replaced.

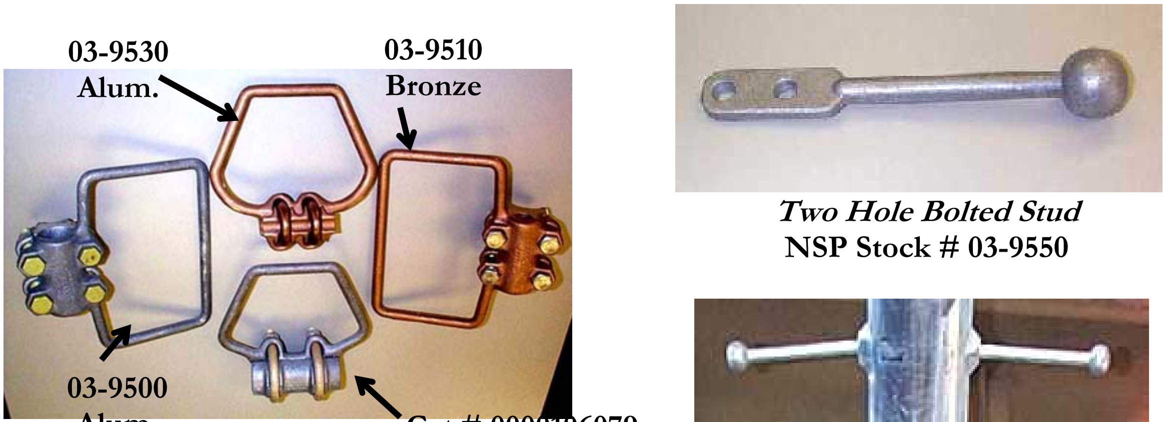
In no circumstance where the fault level exceeds 24 kA are the devices listed in Table 1 to be used for personal protective ground attachment points. <u>Safety grounds will be attached directly to the bus conductor</u>. If this is not possible due to bus configurations, additional outages will be required to obtain a point that can be safely grounded.

Table 1
Superseded Ground Attachment Devices (Studs and Stirrups)

Stock #	PassPort Catalog #	Description	Cat. #
03-9500		Aluminum rectangular ground stirrup (Anderson)	C14995
03-9530		Aluminum ground stirrup (Anderson)	ACT-13A
03-9510		Bronze rectangular ground stirrup (Anderson)	C14995-1
03-9540 [a]	0000106079	Bronze ground stirrup (Anderson)	BCT-6
03-9550		Aluminum stud, 2-hole (Anderson)	CC5806
11-2004 11-2006 S1-0002		Aluminum stud, welded (Anderson)	WTESR-10-24 WTESR-30-60

[a] Stock # 03-9540 **will be retained** for use in low fault (less than 24kA) areas where copper conductor is in use.

Under **no** circumstances at **any** fault level are devices **not** listed in Table 1 or Table 2 to be used for personal grounding attachment points. Any such devices shown on drawings or found in the field shall be removed on maintenance or construction projects done for that substation.



Stirrups

Cat # 0000106079
NSP Stock #03-9540
Bronze [a]

Two Hole Bolted Stud
NSP Stock # 03-9550

Welded Stud
NSP Stock # 11-2004, 11-2006, & S1-0002

[a] PassPort Cat # 0000106079 (Old NSP Stock # 03-9540) will be retained for use in low fault (less than 24kA) areas where copper conductor is in use.

Figure 1 - Superseded Ground Attachment Devices

3.0 Installation of Approved Attachment Devices

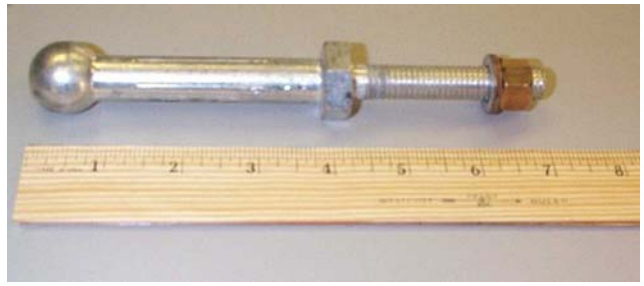
The devices listed in Table 2 and shown in Figure 2 have been approved by the Xcel Energy North Grounding Committee for use on the Xcel Energy System. These devices are safe and acceptable for use when the available fault current is less than or equal to 50kA. At locations where the fault level may exceed 50 kA, steps must be taken to reduce the available fault to a maximum of 50 kA before the work site may be safely grounded. In locations where the fault levels are known to be close to or exceeding the maximum 50 kA fault level, the project engineer shall perform fault studies to determine the fault levels at the substation and whether additional outages to lower the fault are required.

The grounding attachment devices will also be used as a connection point for devices that are connected to the bus with hot line clamps, i.e. mobile transformers. The **hot line clamp, NSP Stock # 03-6441** (Passport Cat. # 0000106010), has been chosen because it will fit over the larger stirrup and welded stud. Installation of any new equipment requiring a hot line clamp shall utilize this clamp along with the stirrup or stud for connection to the bus.

Table 2
Approved Ground Attachment Devices (Studs and Stirrups)

Old NSP Stock #	Passport Catalog #	Description	Approved Manf. Cat. #
03-9555	0000106081	Aluminum rectangular 1" ground stirrup (Anderson)	C16125
03-9595	0000106082	Aluminum stud, bolted (AB Chance)	T600-2364
03-9597	0000106083	Aluminum stud, welded (Electrical Builders)	EBIGS6-W

1" Aluminum Stirrup
PassPort Cat # 0000106081



Bolted Stud
PassPort Cat # 0000106082

Welded Stud
PassPort Cat # 0000106083

Figure 2 - Approved Ground Attachment Devices

4.0 Design Application Guidelines

The following sections provide guidelines for the consistent installation of ground attachment devices. The spacing of the devices is based on spacing used during tests of the devices and the adequacy of the devices cannot be assured if they are applied differently in the field.

4.1 Stirrups

Ground stirrups are to be applied only as necessary. Ground stirrups should be considered necessary when bus sections that need to be grounded are vertical and/or bundled conductor. When bus conductor is a single conductor with an adequate horizontal expanse for attachment of ground clamps, no grounding attachment devices are required. In those instances, grounding should be done directly to the conductor.

Horizontal bundled conductors - One stirrup shall be installed for every *two* ground cables required for the station fault level. If more than one stirrup per phase is required, they shall be installed on different conductors of the bundled set. The stirrup spacing shall be such that from the outside edge of one stirrup to the next is approximately **six (6) inches**. See Figure 3 for an example of a horizontal bundled conductor application.

Vertical conductors (bundled or single) - One stirrup shall be installed for *every* ground cable required for the station fault level. If more than one stirrup is required per phase, they shall be installed on different conductors of bundled sets as much as possible considering the number of stirrups and the number of conductors in a bundle. The stirrup spacing shall be such that from the outside edge of one stirrup to the next is approximately **six (6) inches**. The stirrups may be turned so that they are not in the same plane so that multiple ground cables do not interfere with each other (See Figure 4a). See Figure 4a and Figure 4b for examples of a vertical bundled and unbundled conductor applications.

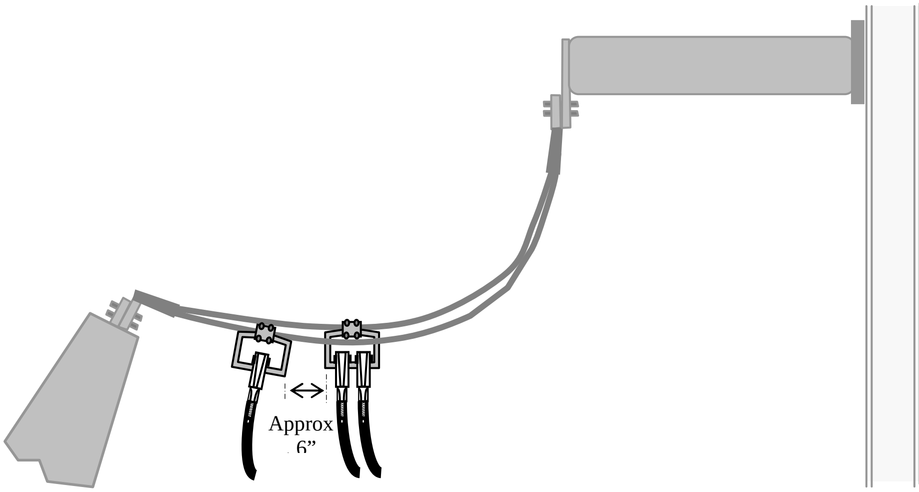


Figure 3 – Horizontal Bundled Conductor - Example

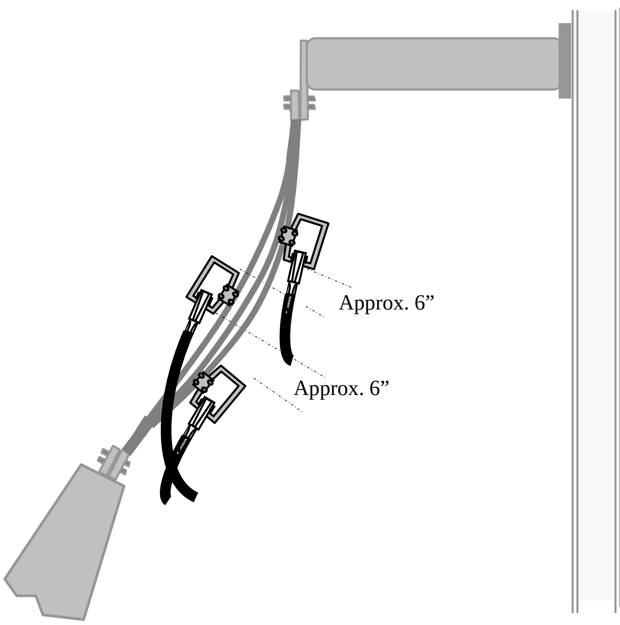


Figure 4a – Vertical Bundled Conductor – Example

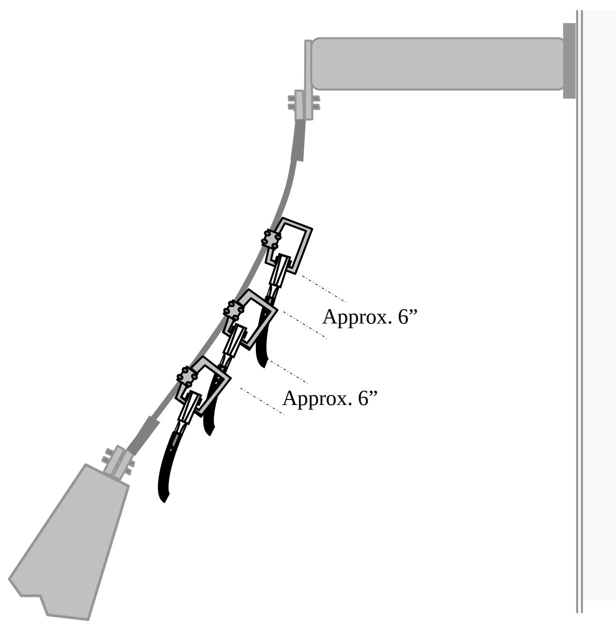


Figure 4b – Vertical Single Conductor - Example

4.2 Studs

Ground studs are to be applied only as necessary. Ground studs should be considered necessary when bus sections that need to be grounded are tubular bus larger than 2.5" in diameter or integral web channel bus (IWCB) which the standard ground clamps cannot fit around.

Welded Stud - One welded stud shall be installed for every *two* ground cables required for the station fault level. If more than one stud is required per phase, they shall be installed such that they are directly opposite from each other or spaced **one (1) foot** apart on the same side of the bus conductor. See Figure 5 for examples.

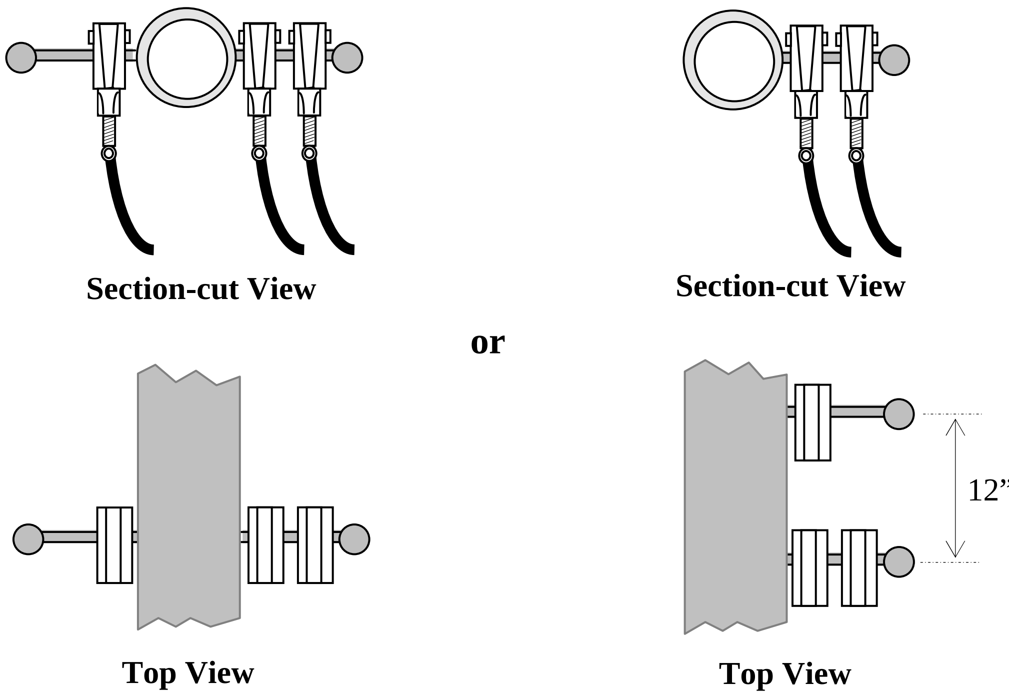


Figure 5 – Welded Stud - Example

Bolted Stud - One bolted stud shall be installed for *every* ground cable required for the station fault level. If more than one stud is required per phase, they shall be installed such that they are opposite from each other (spaced slightly apart to avoid installation problems with bolts) or spaced **one (1) foot** apart on the same side of the bus conductor. See Figure 6 for examples.

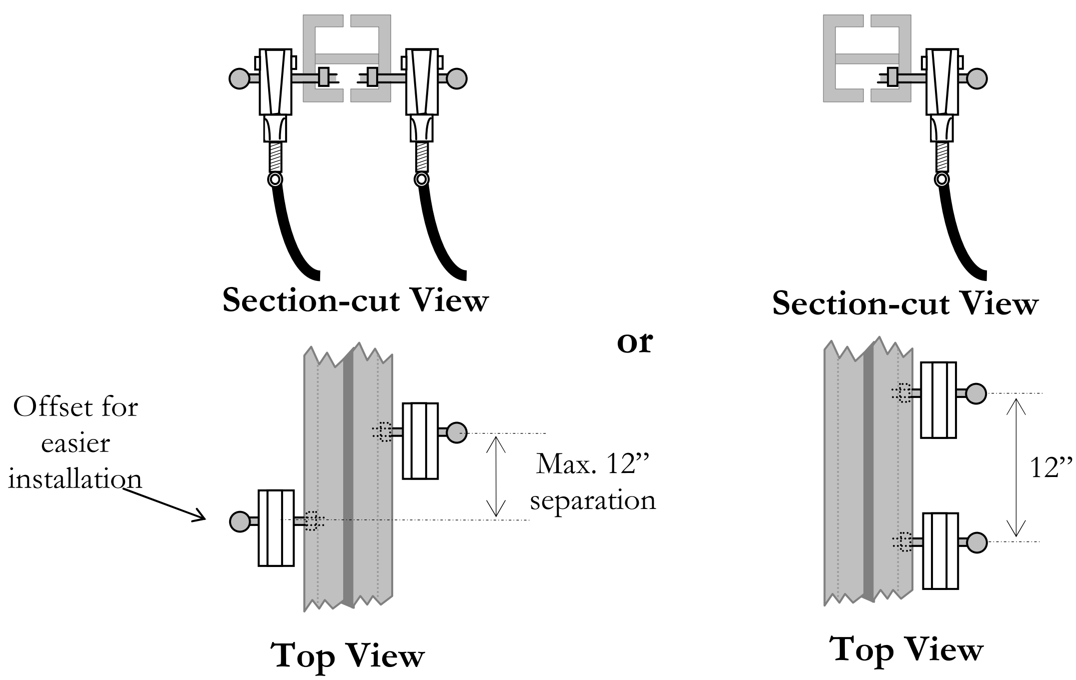


Figure 6 – Bolted Stud - Example

5.0 Retrofit Guidelines

Devices listed in Table 1 and shown in Figure 1 should be replaced or removed whenever possible on projects. The installation guidelines in Section 3.0 should be followed when retrofitting a substation. There are three situations that will be present in existing substations:

1. **Substations with fault levels exceeding 24 kA.**
At these locations, replacement/removal of all unacceptable devices should be done when practical on the next capital project at that location. Superseded stirrups or studs used for attachment of hot-line clamp connections for PTs, arresters, etc. should be left in place **only** if they are not in a position where they could be used as a personal grounding point or when it is not practical to remove them. When it is not practical to replace or remove unacceptable devices, the Project Engineer should verify that suitable ground clamps, when necessary, for large tubular or integral web channel bus are available at the site.

2. **Substations with fault levels at or slightly less than 24 kA.**
At these locations, replacement/removal of unacceptable devices shall be done in areas directly affected by, or within equipment outage areas, on the next capital project at that site. Superseded stirrups or studs, in these areas, used for attachment of hot-line clamp connections for PTs, arresters, etc. may be left in place **only** if they are not in a position where they could be used as a personal grounding point.

3. **Substations with significantly less than 24 kA (12 kA or less).**
At these locations, devices that are safe up to 24 kA may be replaced or left in place at the discretion of the Project Engineer. At a minimum, devices in locations where grounding could be easily connected directly to bus conductor should be removed when the opportunity arises.

6.0 Ground Clamps

When grounding to devices listed in **either** Table 1 or Table 2, it is also important to use an appropriately sized ground clamp. For these devices, the clamp should be designed for no larger than 2 inch IPS conductor. If only larger clamps are available in the substation, a set of appropriately sized ground sets should be ordered.

Substation Safety Sign

12" x 14" sign

1. General

1.1. Signs should be placed on all substation enclosure types unless this conflicts with local laws and ordinances.

1.2. The signs should be placed 2 to 3 times the readability distance of the message text (Table 1, ANSI Z535.2-1998 section B3.3.14 "Minimum Letter Height Calculations"). In this case, 30 to 45 feet apart and no more than 15 feet from the corners of the enclosure.

1.3. Two signs should be placed on each drive gate, one on the inside and one on the outside (back to back). This is done so you can read the inside sign if the gate is open.

1.4. One sign should be placed on the outside of each walk gate.

1.5. The signs should be placed approximately 5'-0" form grade to top of sign.

1.6. Mount using a copper or aluminum wire tie in each hole.

1.7. The Xcel Energy stock number is 16-0092, manufactured by Electromark # XCE999-W-FG-Z32. The material is embedded fiberglass.

2. Sign specifications:

2.1. Wherever possible use ANSI Z535.1, 2, 3 (1998) for safety signs placed on the outside of facility enclosures. Specific laws and ordinances pertaining to facility safety signs supersede the ANSI standards in those locations specified only.

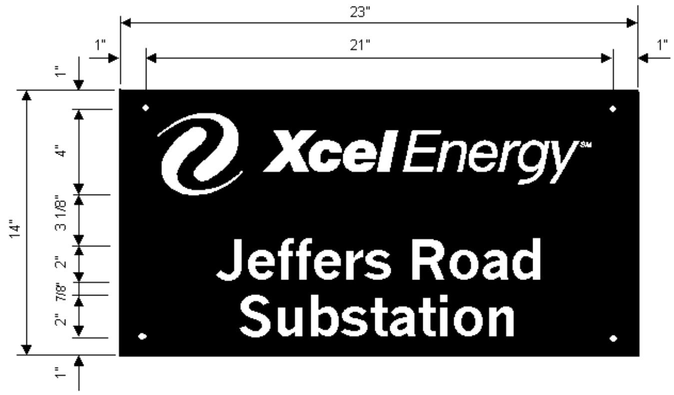
2.2. The word "WARNING" should be placed at the top most portion of the sign. Black text with safety orange background as specified in Table 1 of ANSI Z535.1-1998. The word should be all caps and a height of 1.2 inches. There should be a "safety alert symbol" included to the left of the word "WARNING" (arrangement ANSI Z535.2 section B2). It should be a safety orange exclamation mark inside a black equilateral triangle within the safety orange background which includes the word "WARNING".

2.3. The symbol portion should be designed with the proportions shown in Figure 2 of ANSI Z535.3-1998 following section A9. The example symbol in section 8.1 of ANSI Z535.3 of the falling body with electrical wire near arm is the preferred symbol. No height is specified in the standard, so a reasonable height that does not completely dominate the sign should be used. The symbol should be black with white background.

2.4. The message text portion should consist of the words "Keep Out!," "Hazardous voltage inside,." "Will shock, burn or cause death.". Each phrase should have its own line for easier readability. The first phrase ("Keep Out!") should be a text height of 0.8 inches. The rest of the message text should be 0.6 inches. Text should be black with a white background. It should be of a sans serif font with 120% leading between lines of text (ANSI Z535.2-1998 section B3.3.11 "Choice of type spacing"). The text should all be left justified. The text should be mixed capitals and lower case letters as typed above.

2.5. Section 4.7 "Panel" of ANSI Z535.2 dictates that there should be a "clearly delineated" line between sections of the panel that do not have "distinctive background color". There should be a line bordering the symbol.

Substation Identification Sign



14" x 23" sign

1. General

1.1. The sign should be placed on all substations unless this conflicts with local laws and ordinances.

1.2. The signs should be 6'-0" from grade to top of sign, placed adjacent to substation walk or drive gate and above the address sign.

1.3. Mount using a copper or aluminum wire tie in each hole.

1.4. To order the sign use file located at \\BLACK\TEAM\DSC\FORMS\GEN\NAMEPLATE & SIGNS.XLS.

2. Sign specifications:

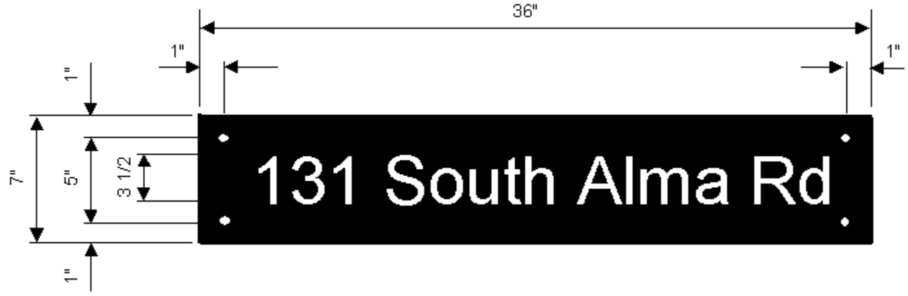
2.1. Size: 14" x 23"

2.2. Material: 0.080 aluminum plate with 3M High Intensity Silver Scotchlite code #3870. Background to be silk-screened with 3M #845 black paint.

2.3. Text shall be 2" Helvetica Medium Upper and Lower Case. (example: Jeffers Road Substation)

2.4. Xcel Energy logo must be per company guidelines as approved by Betsy Brown, Brand/Advertising Director, on 2-14-2001.

Substation Address Sign



1. General

1.1. The sign should be placed on all substations unless this conflicts with local laws and ordinances.

1.2. The signs should be placed adjacent to substation walk or drive gate and under the Substation Identification Sign.

1.3. Mount using a copper or aluminum wire tie in each hole.

2. Sign specifications:

2.1. Size: 36" x 7" (vendor can make sign longer for longer addresses).

2.2. Material: 0.080 aluminum plate with 3M High Intensity Silver Scotchlite code #3870. Background to be silk-screened with 3M #845 black paint.

2.3. Text shall be 3 ½" Helvetica Medium Upper and Lower Case.

Battery Warning Sign

10" x 14"

General

1. Signs should be placed on the outside of all substation control house doors.

2. Sign is to be mounted to the door using sheet metal screws.

3. The signs should be placed approximately 5'-0" from the bottom of door to the top of the sign and centered on the door.

4. These signs are now required per the National Electrical Safety Code, Section 14, Part 146B.

5. The Xcel Energy stock number is S7-5454, manufactured by Electromark # IPCO14-W-FQ-AM3. The material is rigid fiberglass.

Substation Buried Cable Sign

10" x 7" Sign

General

1. The sign should be placed at substations where cables are in the area and need to be marked to prevent accidental digging.

2. The signs should be mounted on each side of the substation fence fabric, back to back, at the location where cables pass under the fence.

3. Mount to fence using a copper or aluminum wire tie in each hole.

4. Outside of the substation fence this sign can be mounted to a steel channel post (stock number 16-0095)

5. The Xcel Energy stock number is 16-0088, manufactured by Electromark # XCE170-G-FG-A71. The material is embedded fiberglass.

Substation Danger Sign

10" x 12" Sign

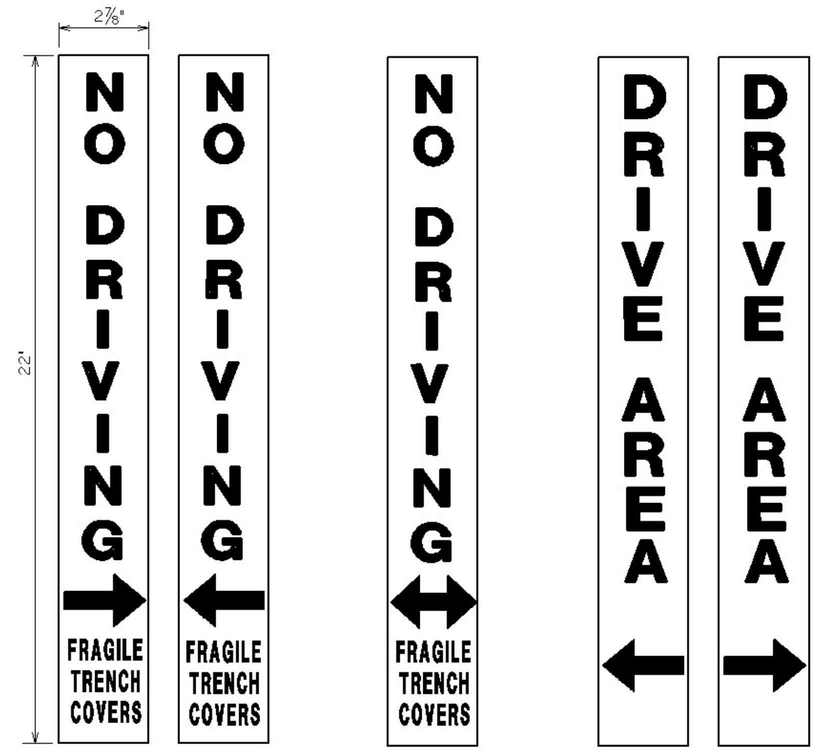
General

1. This sign is used to remind field people of a danger they may need to be aware of. (example: Low profile bus)

2. This sign is intended to be used **only** inside the substation fence.

3. The Xcel Energy stock number is 16-0056, manufactured by Electromark # XCE167-W-FG-BC2. The material is embedded fiberglass.

Substation Precast Cable Trench Signs



<u>Sign #1 Decals</u>
Mounted
Back-to-Back

<u>Sign #2 Decals</u>
Mounted
Back-to-Back

<u>Sign #3 Decals</u>
Mounted
Back-to-Back

1. General

1.1. Vehicles cannot drive over precast cable trench without breaking covers. The warning signs shown above will be driven into the ground at strategic locations where vehicles could mistakenly drive over the precast cable trench.

1.2. Drive post into ground using an installation tool made for this post.

1.3. The Xcel Energy Catalog ID for the signs are:

Sign #1 – 211428   Sign #2 - 211429   Sign #3 - 211430

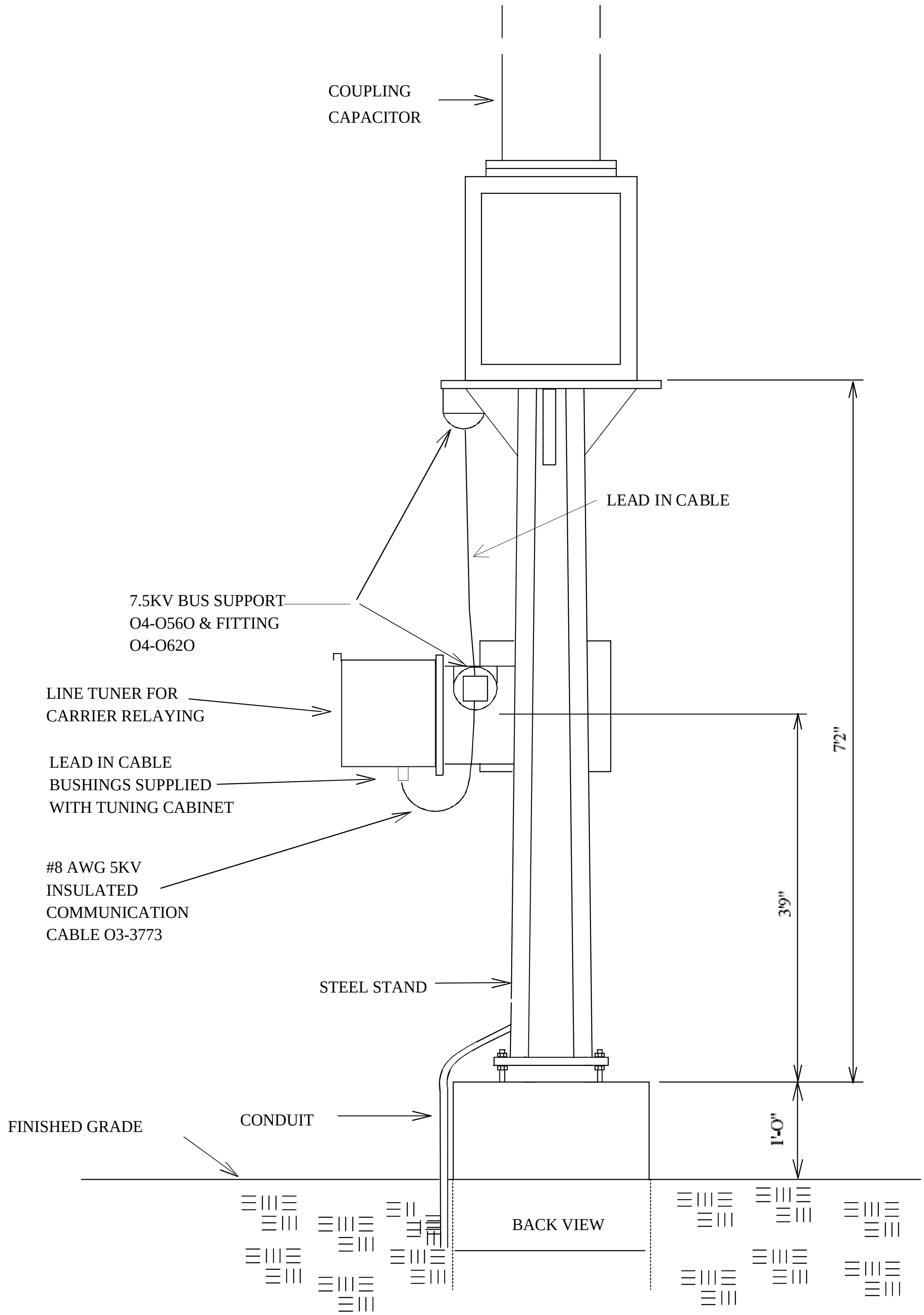
2. Sign specifications:

2.1. Post: 3.8” x 78” yellow fiberglass reinforced composite.

2.2. Decal: 2 7/8” x 22” with solid black letters and yellow background.

2.3. The “NO DRIVING” and “ DRIVE AREA” text is 1” or larger if space allows.

2.4. The “FRAGILE TRENCH COVERS” text is 5/8” or larger if space allows.

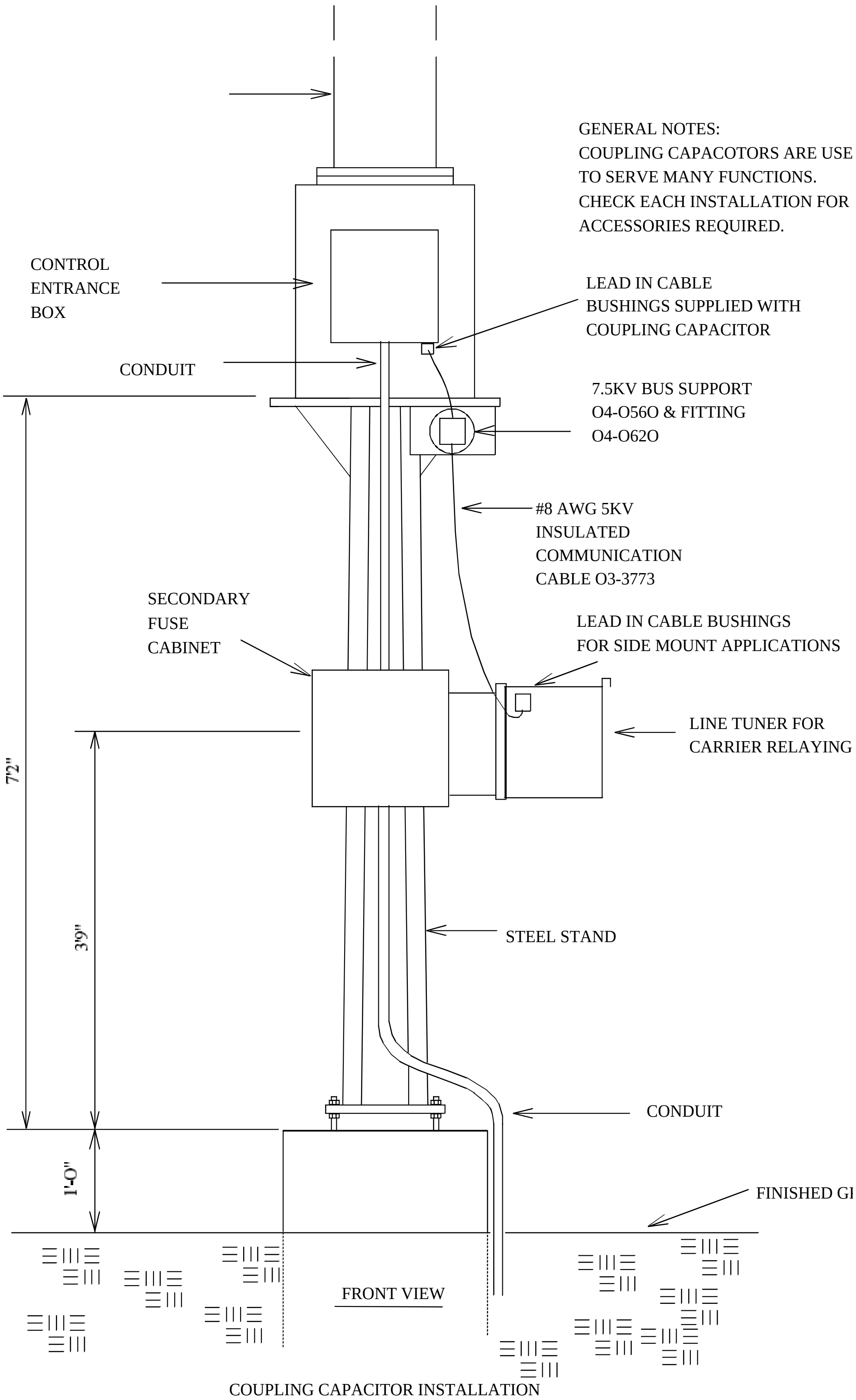


COUPLING CAPACITOR INSTALLATION
WITH LEAD IN CABLE BUSHING ON BOTTOM OF TUNER

L:\MASTERS\PHYSICAL\G1070301

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN CHECKED DATE 9/15/95	FILMED APPROVED	REV 1	SUBSTATION ENGINEERING & DESIGN STANDARDS **SHEET 1** **ED 5.05.04.01**

GENERAL NOTES:
COUPLING CAPACOTORS ARE USE TO SERVE MANY FUNCTIONS. CHECK EACH INSTALLATION FOR ACCESSORIES REQUIRED.



COUPLING CAPACITOR INSTALLATION

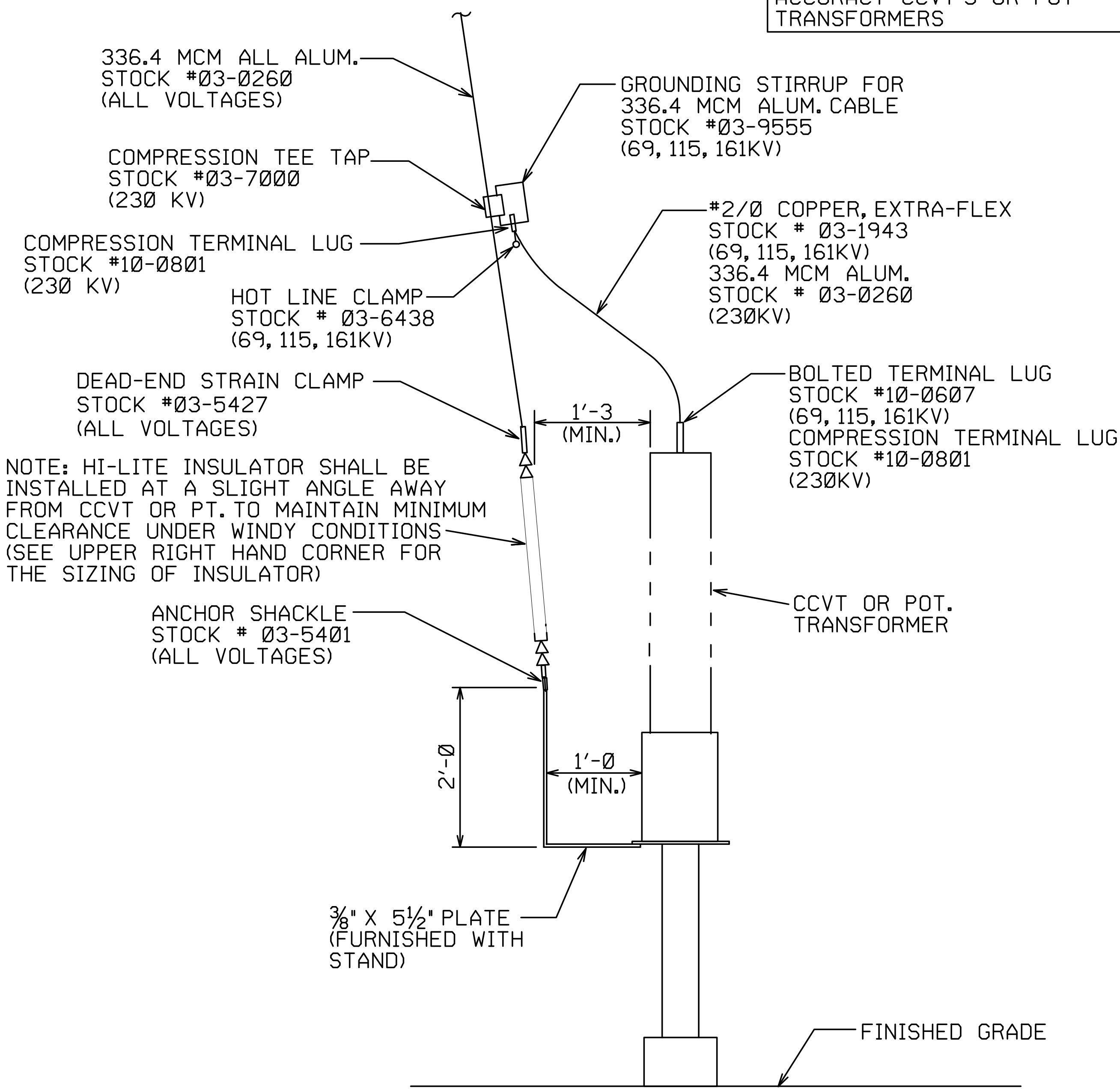
WITH LEAD IN CABLE BUSHING ON SIDE OF TUNER

L:\MASTERS\PHYSICAL\G1070301

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS
	CHECKED	APPROVED		
	DATE 9/15/95		1	SHEET 1 — ED 5.05.04.02

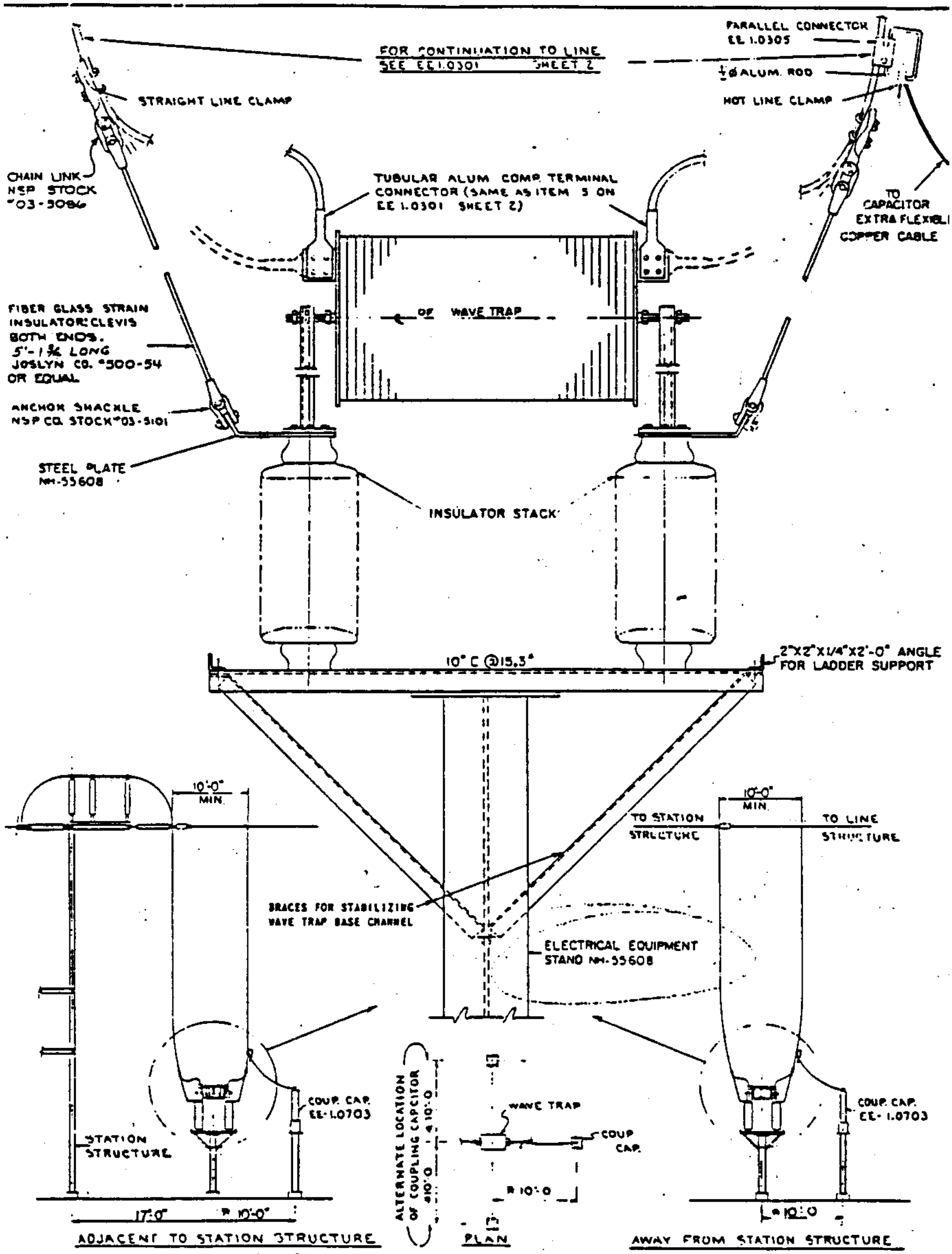
OHIO BRASS CO. HI-LITE INSULATOR	
69KV	CAT. #511005-1000
115KV	CAT. #511207-1000
161KV	CAT. #511011-1000
230KV	CAT. #511212-1000

CHECK WITH PROJECT ENGINEER FOR SPECIFIC LENGTH OF HI-LITE INSULATORS WHEN USING METERING ACCURACY CCVT'S OR POT TRANSFORMERS



Single-Phase CCVT or Pot Transformer Connection to Overhead Line

Xcel Energy - North	Date: 09/18/2001	Approved:	Rev. 5	Substation Engineering & Design Standards Sheet 1 of 1 — ED 5.05.04



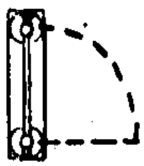
Wave Trap Installation - Pedestal Mounted

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 1/3/74		4	SHEET 1	ED 5.07.04

Switches - Switch Type - Definitions

A. Hookstick - 7.2 - 69kV 600-.4000 Amp.

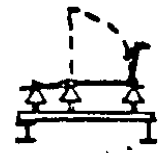
B. Side Break - 7.2 - 115kV 600-1200 Amp. - Normally not used at 115kV



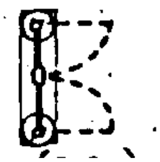
1. Horn Gap, Quick Break Quick Whip - Normally used for line dropping - to break line charging current

2. Load Break - Separate attachments-Normally used for parallel

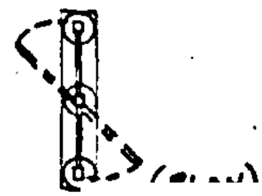
C. Vertical Break - 7.2 - 345kV 600-4000 Amp. Not used at 345kV by NSP
B 1 and B 2 above also apply



D. Center Break - 7.2 - 345kV. 600-2000 Amp.
B I and B 2 above also apply



E. Double Bids Break - 7.2 - 345kV 600-200 Amp

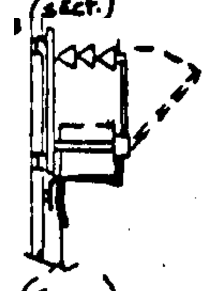


F. Circuit switches - used to interrupt higher magnitude" line charging currents.

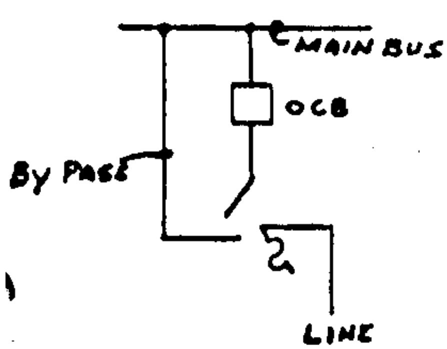
G. Vacuum Switches - load currents or for capacitor switching 7.2 - 115kV

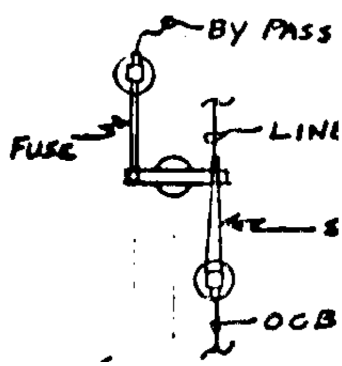
H. Indoor switches - Can be hookstick or group operating'- Switches are available SP ST, SP, DT, front or back connected or combination front or back on same switch to simply connections in cramped space.

I Ground Switches - Up to 115kV - High speed ground apply to line to open remote breakers quicker to remove fault - usually applied where system Z is high and fault current is low. Normal used for clearing of remote breakers which could allow fault to hang on longer.



J. Switch/Fuse Combination - Used on 4 thru 13.8kV installations and only when there to no transfer





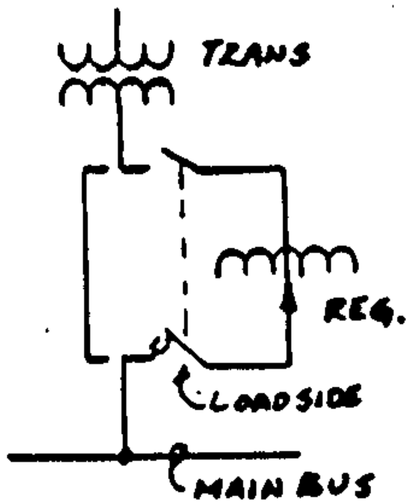
Front Elevation

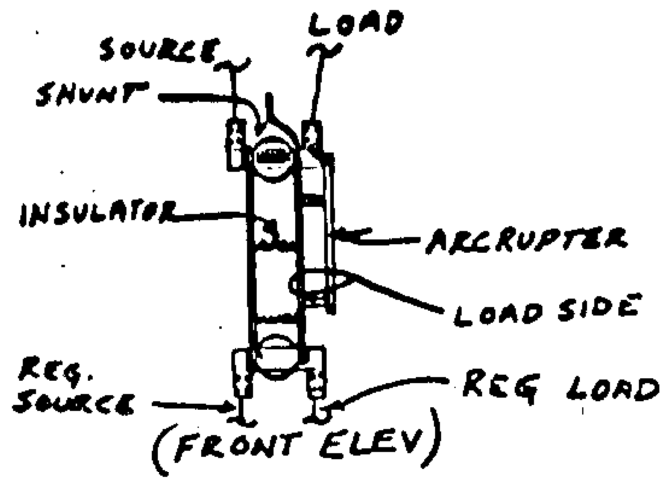
SWITCHES - SWITCH TYPE - DEFINITIONS

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 5/15/86		0	SHEET 1	ED 5.13.03.01

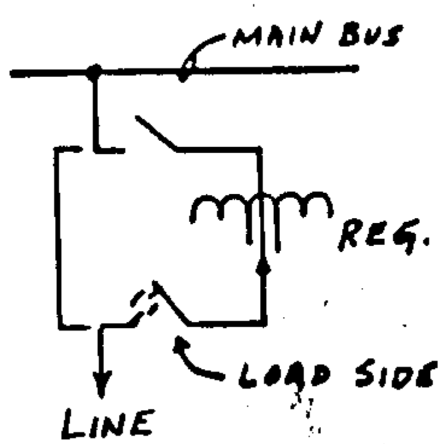
Regulator By pass Switch 4 - 7.2 - 23kV

Hookstick - Normally used with bus regulator





Feeder Position - When used in feeder position normally no breaker in feeder



L. Fuse

M. Motor Mechs Electric operated AC or DC - one MM Switch Hydraulic - one hydraulic system can operate up to 5 - 6 switches

Manual operated swing handle - thru 69KV or 2000 Amp. switch
Crank Gear box - all 115KV or

a. Worm gear -lower voltage
b. Reduction gear high amps

Switching Equipment Capabilities

The following switching device capabilities are intended only as a general guide and may be affected by system conditions and other factors, such as weather, conductor spacing, number of circuits, conductor size, etc. In addition, these switching devices should be operated remotely, whenever possible to provide additional protection for the operator. Exceeding the limitations of these switching devices could result in damage to the equipment and/or inadvertent tripping with possible service interruption.

I. Air Break (with horn gap)

1. De-energize a maximum of approximately 3 amps of line charging current on a single circuit line.
   a. 161 kVApproximately 5 miles
   b. 115 kVApproximately 8 miles
   c. 69 kV Approximately 20 miles
2. Energize and de-energize all -transformers except 500 kV.
3. Open and close most parallel circuits of 115 kV and below. The actual capabilities will depend on the length of the parallel circuits and the megawatt and megavar load.
4. Re-energize a maximum of 50 miles of 161 KV line and 50 miles of 115 KV line and 40 miles of 69 KV line.

II. Air Break Switch With Quick Break Device QB

1. De-energize a maximum of approximately 15 amps of line charging current on a single circuit line.
   a. 161 KV Approximately 20 miles
   b. 115 KV Approximately 50 miles
   c. 69 kV Approximately 100 miles
2. Energize and de-energize all transformers except 500 KV.
3. This device should not be used to open parallel circuits because the full load current will flow through the quick break attachment for several seconds. The quick break attachment has minimum current carrying capability.
4. Close most parallel circuits on 115 KV and below. The actual capability will depend on the length of the parallel circuit and the megawatt and megavar load.
5. Re-energize a maximum of 50 miles of 161 KV line and 50 miles of 115 KV line and 40 mils of 69 KV line.

III. Circuit Switcher

Note: This device will appear as an MOD on the CRT.

1. De-energize charging current for any length line of 345 KV and below.
2. De-energize any transformer.
3. Open and close any parallel circuit of 345 KV and below.

4. De-energize load up to steady state amperage rating of switch.
5. Energize and de-energize Capacitor banks and reactors.
6. Re -energize any line of 345 KV or below or any transformer except 500 KV..

Examples: Panther #7Nl6
S & C
MFG
Type - Mark IV

IV. Transrupter

This device is similar to a circuit switcher except the associated disconnect switch is external to the interrupting device and may or' may not be motor operated. This device will appear as a breaker on the CRT.

1. De-energize charging current for any length line of 345 KV and below.
2. De-energize any transformer.
3. Open and close any parallel circuit of 345 KV and below.
4. De-energize load up to steady state amperage rating of switch.
5. Energize and de-energize Capacitor banks and reactors.
6. Re-energize any line of 345 KV or below on any transformer, except 500 KV.

Examples: Westgate #3 and #4 TR
MFG Joslyn Mfg. Co.
Type VBU 4 Transrupter

V. Loop Break Switch

1. De-energize a maximum of approximately 3 amps of line charging current on a single circuit line.
   a. 161 KV Approximately 5 miles
   b. 115 KV Approximately 8 miles
   c. 69 kV Approximately 20 miles
2. De-energize all transformers except 500 KV.
3. Open or close any parallel circuit of 115 KV or below.
4. Re-energize a maximum of 50 miles of 161 KV line and 50 miles of 115 KV line and 40 miles of 69 KV line.

Examples: Avon #4N65 & #4N64 MFG - Joslyn Mfg. Co. Type - Vac-Rupter Interrupter

VI. Loop Break with Quick Break Attachment

1. De-energize a maximum of approximately 15 amps of line charging current on a single circuit line.
   a. 161 KV Approximately 20 miles
   b. 115 KV Approximately 50 miles
   c. 69 kV Approximately 100 miles
2. De-energize any transformer.
3. Open & close any parallel circuit of 115 KV or below.
4. Re-energize a maximum of 50 miles of 161 KV line and 50 miles of 115 KV line and 40 miles of 69 KV line..

   Example: Crossroads 5N44 & SN46
   MFG Joslyn Mfg. Co
   Type Load Sectionalized Interrupter

VII. Load Interrupter

1. De-energize charging current for any length line of 115 KV or below.
2. De-energize any transformer except 500 KV.
3. Open or close any parallel circuit of 115 KV or below.
4. De-energize load up to amperage rating of switch.
5. Re-energize a maximum of 50 miles of 161 KV line and 50 miles of 115kV line and 40 miles of 69 KV line..'

Manual Operation Mechs for Switches

Crank 115kV and above regardless of amps
Crank 69kV 2000 amps and above
Crank below 69kV 2000 amps and above

All others are switch handles.

There are exceptions to this but for doing sketches this guide should be close.

ALUMINUM CONDUCTOR STANDARDS - BUS AND CONNECTIONS

1.0 INTRODUCTION

The use of aluminum conductor has become standard practice in all NSP Company substations. When adding to existing installations having copper conductors, consideration should be given to the feasibility of converting to aluminum in the new portion. Aluminum conductors in the forms of cable, tubing, bar, angle, integral web channel bus (IWCB) and solid rod are carried in NSP Company stock for this purpose. All respective conductor sizes, shapes and specifications are tabulated in Engineering and Design Standards. The following information describes aluminum conductors most commonly used in NSP substations.

2.0 CONDUCTOR APPLICATION

Standard conductor sizes should be used wherever possible. The selection of aluminum conductor for a particular purpose depends upon the following electrical and physical (mechanical) requirements:

2.1 CABLE

All aluminum cable is used for substation strain bus and connections where flexibility is required or rigid bus is not feasible. ACSR conductor can also be used where practical to gain rigidity in some special cable connections. The following cables are commonly used in substations:

CABLE - ALL ALUMINUM E.C. ALLOY

Size	Strands	Dia.	Weight 1000 FT	Ampere Capacity				Stock No.
				30/40°C	40/40°C	50/40°C	60/40°C	
*3/0	19	.470	157.5	270	310	340	375	03-0280
336,400cm	19	.666	315.8	430	490	545	590	03-0260
556,500cm	19	.856	522.4	595	680	755	810	03-0236
954,000cm	37	1.124	895.5	845	965	1075	1160	03-0221
1,590,000cm	61	1.454	1493.0	1200	1320	1460	1590	03-0217

Used for substation grounding conductor above ground.

2.2 TUBING

Tubing is used primarily to obtain structural rigidity in long unsupported spans of bus, usually in high voltage structures, and over design in current carrying requirements is disregarded. Welding is used to form tubing joints and electrical connections.

The following tubing sizes are commonly used in substations:

SEAMLESS TUBING SCHEDULE 40 (20 and 40 ft Lengths) 6063-T6 ALLOY

IPS Size	Weight lbs/ft	Ampere Capacity 30/40°C	40/40°C	50/40°C	Stock No.
1”	.58	650	767	878	03-2901
1 1/2”	.94	925	1092	1249	03-2902
2”	1.26	1150	1357	1553	03-2903
2 1/2”	2.00	1550	1829	2093	03-2904
3”	2.62	1890	2230	2552	03-2905
3 1/2"	3.15	2170	2561	2930	03-2906
4”	3.73	2460	2903	3321	03-2907
5”	5.06	3080	3634	4158	03-2909

2.3 ANGLE

Universal angle provides the convenience of bolted connections. It is used in small installations where ultimate bus capacity will not exceed that of a single angle. The installation of double angle bus has been discontinued in favor of integral web channel bus (see 2.5) for higher capacities. Extensions to existing double angle bus shall be made with IWCB where practical.

The following angle bus conductor is used in substations:

UNIVERSAL ANGLE BUS CONDUCTOR (UABC) 2EC-T6 ALLOY

3 1/4" x 31/2" x 1/4" Angle Stock No. 03-2964 (25 ft. Lengths)	Weight Lbs/Ft	Ampere Capacity 30/40°C	40/40°C	50/40°C
Single Angle-ALCOA No. 88286	1.85	1800	2124	2430
Two Angles-Back to Back No Spacing	3.70	2400	2800	3200
Two Angles-Back to Back 1/4" Spacing	3.70	2900	3422	3915

2.4 BAR

Bar is used for making joints and electrical connections. The radius of bends shall be no less than two times the bar thickness.

The following sizes are commonly used in substations:

BAR - #2EC-T61 (Slightly rounded edges) 20 Ft. LENGTHS

Sizes	Weight lbs/ft.	Ampere Capacity (flat) 30/40°C	40/40°C	Stock No.
1/4” x 1”	0.29	300		03-2945
1/4” x 2”	0.58	530	640	03-2944
1/4” x 3”	0.80	735	890	03-2943
1/4” x 4”	1.17	900	1120	03-2942
1/4” x 5”	1.47	1120	1360	03-2941
1/4” x 6”	1.76	1270		03-2940
1/2” x 5”	2.94	1520		03-2948

2.5 INTEGRAL WEB CHANNEL BUS (IWCB)

Integral web channel bus is installed where high current carrying capacity is required and to provide rigidity in long unsupported spans. It is used extensively in both low voltage and high voltage buswork. The following sizes are used in substations:

Integral Web Channel Conductor 2EC-T61 Alloy	Weight Lbs/Ft	Ampere Capacity 30/40°C	40/40°C	50/40°C	Stock No.
4" x 4" ALCOA No. 88960	5.36	3400	4000	4600	03-2970
4" x 6" ALCOA No. 250011	8.27	4400	5200	5900	
6" x 6" ALCOA No. 86498	13.47	5800	6800	7800	

2.6 RODS

Solid rod is most commonly used to form low current carrying connections, such as those made with hot line clamps. They are most frequently used for surge arrester and coupling capacitor connections. The rod is 1/2" diameter solid aluminum 6061-T6 alloy, NSP Stock Number 03-2984. (12 foot lengths)

3.0 CONNECTIONS

3.1 GENERAL

All current carrying aluminum connections shall be thoroughly cleaned, coated and sealed with an oxide inhibiting agent. Aluminum oxide, which is a poor electrical conductor, forms rapidly on the surface of drawn or rolled aluminum. It must be removed and prevented from reforming after the connection is completed. This applies to all connections, whether bolted, clamp or compression type. Three approved inhibitors are NO-OX-ID A, PENETROX A and ALCOA NO. 2.

Caution - Aluminum expands 30% (1.33 times) more than copper. Every connection involving a combination of aluminum and copper must be planned to avoid gradual loosening caused by large temperature changes. Unequal expansion of aluminum, copper and steel can cause extremely high pressure during hot conditions which stretches one or more of the metals leaving a loose connection when cold conditions occur.

3.2 FLAT SURFACE BOLTED CONNECTIONS

Bolted electrical connections shall be made on flat contact surfaces, completely cleaned with an oxidation inhibitor. This must be done by thoroughly scratch-brushing the contact surfaces through the inhibitor, leaving enough of it on the surface to control reformation of oxides. After the connection is completed, additional compound shall be applied and forced into every irregularity and opening in order to completely seal the joint against moisture and corrosion.

3.21 **Aluminum to Aluminum** connections shall be fastened with aluminum bolts, 2024-T4 alloy with No. 205 alumalite finish and preferably NO-OX-ID coated. Nuts shall be of the same alloy and finish. Heavy series bolts and nuts (7/8" across flats) are preferred.

3.22 **Aluminum to Copper** connections shall be made only with flat contact surfaces. Dressing and sealing the connection with inhibitor is especially important where unlike metals are in contact. Care must be taken to place the aluminum above copper when in a horizontal plane so that corrosive copper salts do not flow onto the aluminum.

The type of bolt used is also important because extreme temperature changes can cause a loose joint due to the expansion differential between copper and aluminum. Aluminum or bronze bolts will be used as specified below:

(a) Use aluminum bolts if thickness of the aluminum conductor is the same or greater than the copper conductor.

(b) Use bronze bolts (Everdur) if the copper conductor is thicker than the aluminum.

3.3 CABLE CONNECTIONS

Cable terminations can be made with clamp, compression and welded type fittings; preferably welded or compression types. Welded fittings should be used only when there is enough other bus welding on the project to make it economical.

3.31 **Compression Type Terminal Lugs** shall be used for 336.4, 556.5, 954 and 1590 MCM all aluminum and ACSR conductors. There must be enough inhibitor in the barrel of each terminal lug so that it squeezes out around the wire when inserted and compressed. The various lugs are stocked by NSP Co.

3.32 **Compression Type Tee Connectors** with a flat pad tap terminal shall be used for full current carrying tee connections on 336.4, 556,5, 954.0 and 1590 MCM all aluminum cable bus.

3.33 **Conductors for Non Current Carrying Connections**, such as for potential transformers, surge arresters, coupling capacitors, etc., may be joined with special wide range parallel groove clamps of approved design. This type of connection frequently involves a solid rod conductor looped through one side of the parallel clamp, to which a hot line clamp is attached. Seal the grooves as completely as possible with inhibitor.

3.34 **Equipment Terminals** should provide a flat pad for attaching terminal lugs or direct bolting of rigid bus. Where bronze clamp type or aerial lugs are furnished, do not place aluminum conductor in bronze terminals. Expansion differential and chemical reaction between the two metals can cause faulty connections. Install copper conductor to the first point at which a conversion to aluminum can be made on a flat surface or equipment terminal such as a switch.

3.35 **Clamp Type Terminal Lugs** should be avoided for use on aluminum cable whenever possible. Due to the open design of the clamps, it is difficult to completely seal the cable contact area.

3.4 WELDED CONNECTIONS

The inert gas shielded arc electric welder is preferred in making welded bus connections. This method shall be employed for aluminum tubing and integral web channel bus (IWCB), including welded type cable terminal lugs where practical. See ED 6.01.04 for tubing and cable welding details and for IWCB details.

4.0 MASTER DRAWINGS

The following Master Drawings of bus connection details described in these Standards are reproduced for project construction drawings:

NH-25532	Angle Bus Connections
NH-48651	Misc. Elect. Connections
NH-48652	IWCB Connections
NH-48850	Tubing Connections
NH-51505	Misc. 345 kV Connections

Bus & Connections -Safety Identification Markings Specifications And Application

INTRODUCTION

Aluminum bus conductor consisting of bar, angle, integral web channel and tubing are being used In Northern States Power Company Substations.

The similarity In appearance of aluminum shapes and galvanized structural steel has created a need for identifying aluminum bus; also energized structural members.

Aluminum tubing bus normally need not be marked unless It can be mistaken for nearby galvanized pipe or conduit.

METHOD OF IDENTIFICATION

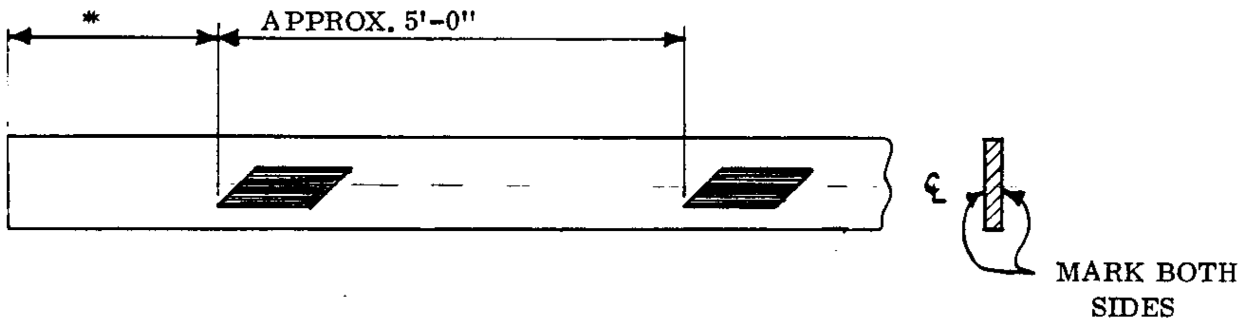
The use of a red colored reflecting tape with an adhesive back is the preferred method of Identification. A 45°parallelogram 2" wide by 4" long shall be placed' at approximately 60" Intervals along the most visible side(s) of the bus conductor or structural member. See sheet 2 for details of marking aluminum and sheet 3 for energized steel.

MATERIAL

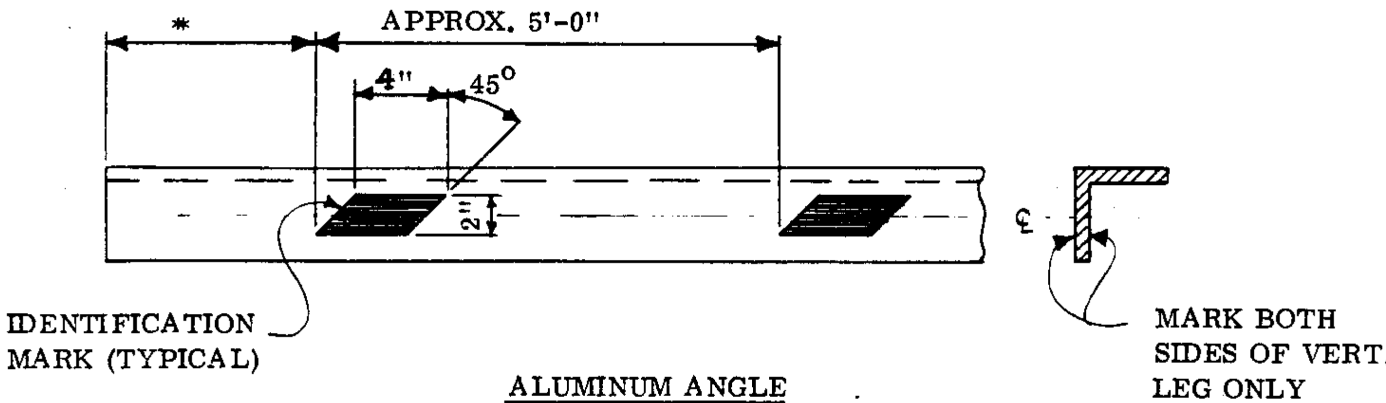
Minnesota Mining and Manufacturing Company adhesive tape, 2 inch x 50 yards of No. 3272 Scotchlite Reflective Sheeting. shall be used. (NSP Co. Stock No 14-3457)

APPLICATION

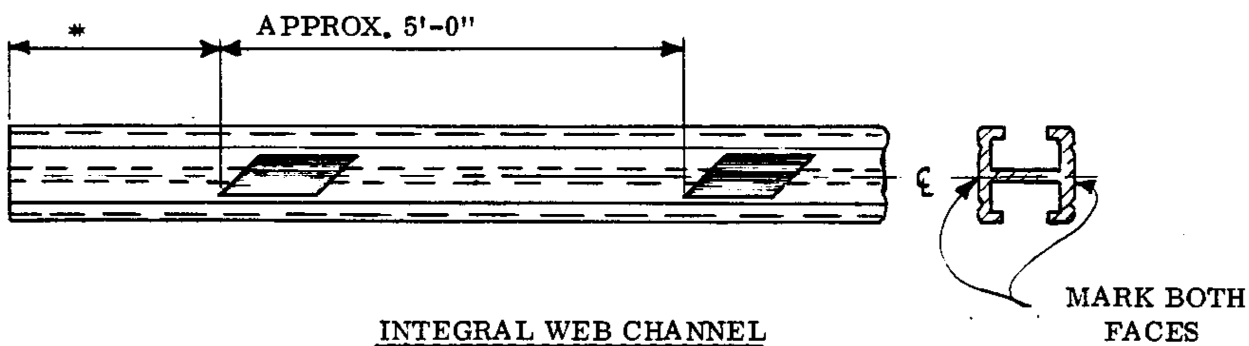
Clean the surface of the conductor with a rag and attach the adhesive backed tape directly to the metal. If the tape is applied at temperatures of 50°F or below, Scotchlite A-3 adhesive activator, for use on Scotchlite reflective sheeting type 3 adhesive coated 3270 series only, should be first applied sparingly to the adhesive on the back of the tape.



ALUMINUM BAR



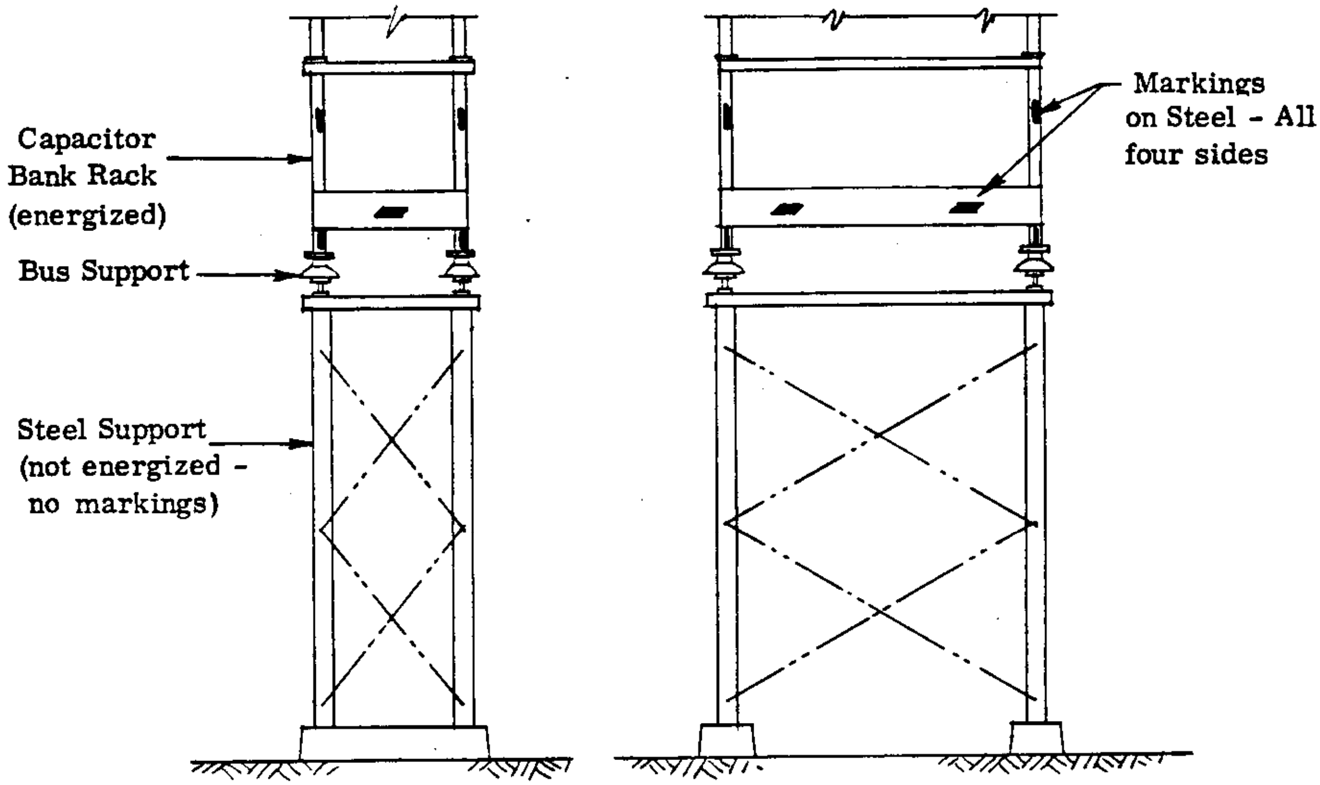
ALUMINUM ANGLE



INTEGRAL WEB CHANNEL

BUS & CONNECTIONS -SAFETY IDENTIFICATION MARKINGS

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 1/14/77		2	SHEET 2	ED 6.01.03



CAPACITOR BANK

Energized structural members shall be marked similar to the aluminum busses shown on Sheet 2.

BUS & CONNECTIONS -SAFETY IDENTIFICATION MARKINGS

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 1/14/77		2	SHEET 3	ED 6.01.03

BUS CONNECTIONS STANDARD

1. Introduction

This document describes standard connection methods for bus conductors in Xcel Energy substations. All connections shall be made in accordance with this standard. If an existing connection is taken apart and put back together, it shall be treated as a new connection and shall be made in accordance with this standard.

It is recognized that there may be situations where this standard cannot or should not be followed. In these cases, substation engineering and/or the worker's supervisor should be consulted.

This document is intended for use in the portion of Xcel Energy formerly known as NSP. It has not yet been considered for company-wide application.

2. Detail Drawings of Bus Connections

For detail drawings of bus connections, refer to Master Drawings NH-25532 (Aluminum Angle Bus Connections), NH-48652 (Aluminum IWCB Bus Connections), NH-48850 (Aluminum Tubing Bus Connections), NH-48651 (Miscellaneous Electrical Connections). Current copies of these drawings may be obtained from substation engineering. Note that equipment vendors may provide their own connection details and these should be used as specified by the vendor.

3. Bus Materials

3.1. Aluminum

Aluminum is the standard bus conductor material used in Xcel Energy substations.

Aluminum oxide, which is a poor electrical conductor, forms rapidly on the surface of drawn or rolled aluminum. The aluminum oxide must be removed before a connection is made and prevented from reforming after the connection is completed. Therefore, all current carrying aluminum connections must be thoroughly cleaned, coated, and sealed with an oxide-inhibiting agent (see section 5.1). This applies to all aluminum connections, whether bolted, clamped, or compression type.

3.2. Copper

Although aluminum is the standard material for bus conductors, copper bus conductors are often found in existing substations. Additionally, copper bus is frequently used in enclosed switchgear.

Copper is the standard material used for grounding conductors in Xcel Energy substations. Cadweld connections are standard for both above and below grade grounding connections. Many existing ground connections in substations are bolted. If cadweld material is not available for a reworked connection, a bolted connection may be used. See section 6.1.2 for details.

Connections between aluminum and copper require that special care be taken. For changes in temperature, aluminum expands 36% more than copper does. Therefore, aluminum-to-copper connections must be carried out so as to avoid gradual loosening caused by temperature changes. The unequal expansion of aluminum and copper can cause extremely high pressure during high temperatures, which deforms one or more of the metals, leaving a loose connection when low temperatures occur. Additionally, because of the electrochemical relationship between the two metals, aluminum is anodic to copper. Therefore, the aluminum will be susceptible to galvanic corrosion. The accumulation of films or corrosion products on the contact surfaces will increase the electrical resistance of the joint. See section 6.1.3 for details on making the connection.

3.3. Bronze

Bronze is not to be used as a bus material in Xcel Energy substations.

Where bronze clamp type or aerial lugs (as on cable potheads) are furnished, do not place aluminum conductor in bronze terminals. Expansion differential and chemical reaction between the two metals can cause faulty connections. Install copper conductor to the first point at which a conversion to aluminum can be made on a flat surface or equipment terminal such as a switch.

4. Bolting Hardware Materials

4.1. Aluminum

Aluminum bolting hardware is to be used for aluminum-to-aluminum connections.

Aluminum bolting hardware is also used in certain cases for aluminum-to-copper connections. See the bolted connections section below for further information on aluminum-to-copper connections.

Aluminum bolts and nuts must not be reused. The stresses of the previous bolted connection, age, and exposure can all change the mechanical properties of the hardware and prevent a good connection from being made. Therefore, new bolting hardware must be used for each bolted connection.

Aluminum bolts should be 2024-T4 alloy with No. 205 Alumalite finish, with a no-oxide coating. Nuts shall be of the same alloy and finish. Aluminum washers should be 3003 series alloy.

Standard aluminum hardware and stock numbers are shown in the following tables. Note that aluminum washers are not stock items.

Standard Aluminum Bolts Hex Head – Anodized - No-Ox-Id Coated			
Diameter	**Length**	**Length of Thread**	**Stock No.**
3/8	1	FULL THREAD	01-5978
3/8	1 ½	FULL THREAD	01-5980
½	1 ½	FULL THREAD	01-5990
½	1 ¾	1 ½	01-5991
½	2 ¼	1 ½	01-5992
½	3	1 ½	01-5995
½	4	1 ½	01-5996
½	4 ½	1 ½	01-5997
½	5	1 ½	01-5998

Standard Aluminum Nuts - Hexagon	
Diameter	**Stock No.**
3/8 – 16 Thread	01-8258
½ - 7/8 Across Flats	01-8260

4.2. Bronze

Bronze is commonly known by the trade names Duron and Everdur. It is also referred to as silicon bronze.

Bronze bolting hardware is to be used for copper-to-copper connections.

Bronze bolting hardware is also used in certain cases for aluminum-to-copper connections. See the bolted connections section below for further information on aluminum to copper connections.

In general, bronze bolting hardware is not to be reused. Bronze bolting hardware may be reused with discretion, but only if it is in good condition and the situation warrants it.

Standard bronze hardware and stock numbers are shown in the following tables:

Standard Bronze Bolts Hex Head – Everdur – Bronze			
Diameter	**Length**	**Length of Thread**	**Stock No.**
3/8	1 ¼	FULL THREAD	01-5900
3/8	1 ½	FULL THREAD	01-5901
3/8	1 ¾	FULL THREAD	01-5902
3/8	2	FULL THREAD	01-5903
3/8	2 ½	2	01-5905
3/8	4	2	01-5907
½	1	FULL THREAD	01-5917
½	1 ¼	FULL THREAD	01-5919
½	1 ½	FULL THREAD	01-5920
½	1 ¾	FULL THREAD	01-5921
½	2	1 ¾	01-5922
½	2 ½	2	01-5923
½	3	2	01-5924
½	3 ½	2	01-5925
½	2 ¼		01-5926

Standard Bronze Nuts – Hexagon	
Diameter	**Stock No.**
3/8	01-8341
½	01-8342

Standard Bronze Flat Washers	
Diameter	**Stock No.**
3/8	01-8781
½	01-8782

Standard Bronze Lock Washers	
Diameter	**Stock No.**
3/8	01-8783
½	01-8784

4.3. Stainless Steel

Stainless steel bolting hardware is NOT for standard use in Xcel Energy substations (See exception below). This material was removed from the Xcel Energy warehouse stock and the bolting standard in 1994. After almost four years of trying to establish stainless steel as a universal bolting material that could replace all the other alloys being used, this effort was abandoned for the following reasons:

- Material quality and sizing problems continued to occur too frequently even with intensified specification and warehouse receipting efforts.
- Equipment and material specifications did not include detailed controls on all tapped holes a manufacturer includes with their equipment (such as on station auxiliaries or bus supports) which would have to interact with the stainless steel bolting hardware.
- The predominant industry use of stainless steel bolting hardware was primarily where corrosiveness was a problem such as in the marine or aircraft industry and this was not Xcel's main reason for using this material.
- The cost of the stainless steel material was two and a half to three times that of the other alloys.

Exception:

Although stainless steel bolting hardware is not for standard use, there are a few cases where it may make sense to use it. For instance, stainless steel hardware is sometimes provided by an equipment vendor. Stainless steel bolts, nuts, flat, and Belleville washers can be considered an acceptable material for electrical and mechanical bolting needs when the material meets all the following requirements: AISI 300 series and 302 or 304 as applicable; Bolts, nuts, and flat washers are typically grade 18-8; Belleville washers are required to be 302 stainless steel (cold roll); Bolt threads rolled to class 2A fit and furnished uncoated; Nut threads to be class 2B fit and furnished uncoated. Specific torquing requirements should be followed for each size of bolt. Check for consistent alloy and sizing of all material received.

In general, stainless steel bolting hardware is not to be reused. Stainless steel bolting hardware may be reused with discretion, but only if it is in good condition and the situation warrants it.

5. Connection Accessories

5.1. Oxide Inhibitors

Oxide inhibitors serve several functions in electrical connections. The inhibitor prevents moisture from coming in contact with the connecting surfaces. The inhibitor provides active resistance to oxidation and corrosion. Finally, when applied to stranded conductors, the inhibitor promotes uniform interstrand current distribution, thereby reducing current concentrations and the resulting effect of localized heating.

Note that oxide inhibitors should not be applied to connections which will be submersed in oil (i.e. inside a transformer or oil breaker).

The approved oxide inhibitors are shown in the following table:

Approved Oxide Inhibitors			
Inhibitor	**Stock Number**	**Common Packaging**	**Application**
Alcoa No. 2 EJC	10-1808	Blue Tube	**Preferred for Bolted Connections**
Alcoa Alnox	10-1809	Red Tube (contains nickel grit)	**Preferred for Compression-Type Connections**
Alnox-UG	10-1807	Green Tube	Bolted Connections, Underground Applications
NO-OX-ID “A”	S980A5	Pint Can	Bolted Connections, Battery Applications, Welded Joints
Penetrox A	Not a stock item	--	Bolted Connections (Not Preferred)
Alcoa Filler Compound	10-1806	Caulking Tube	Compression Lugs and Tees (where not factory-filled)

Alcoa No. 2 EJC is the preferred compound for all flat-to-flat surface connections.

Alcoa Alnox is the preferred oxide inhibitor for compression-type connections.

Alnox-UG is preferred where compatibility with rubber products is required, and is particularly suited for underground usage.

NO-OX-ID “A” is often heated and liquefied when used in the substation. It is useful for battery cable connections. It may also be poured into completed welded connections to prevent water penetration; for instance, it may be used to prevent water seeping into voids around a stranded conductor.

Alcoa Filler Compound AFC may be used for lugs and tees that are not factory prefilled. For instance, size 1590 and 2312 lugs are typically not factory-prefilled.

5.2. Wire Brushes

Contact surfaces must be hand brushed with the proper brush so the machined surface is not damaged. There are 2 types of hand wire brushes approved for cleaning aluminum conductors and pads. They may also be used for copper conductors. These brushes can be ordered from the tool warehouse. The approved wire brushes are:

Stock number NS-4804 stainless steel brush.

Stock number NS-4808 2-pronged v-shaped wire brush.

An electric grinder with a wire wheel or abrasive pad should never be used on the face of a lug or on aluminum wire.

6. Making Connections

6.1. Bolted connections

The preferred oxide inhibitor for bolted connections is ALCO EJC No. 2.

6.1.1 Aluminum-to-Aluminum

Aluminum-to-aluminum bolted electrical connections shall only be made on flat contact surfaces.

Connection shall be made as follows:

1) Verify that the materials to be bolted are clean and free of debris. Pay special attention to the area around the backside of the bolt-holes and to the connecting surfaces.
2) Apply oxide inhibitor to the surfaces of the connection.
3) Use a wire brush to thoroughly scratch the contact surface through the inhibitor, leaving enough of it on the surface to control reformation of oxides.
4) Bolt the surfaces together with aluminum bolting hardware. Follow the torquing guidelines below.
5) Wipe off excess oxide inhibitor.

6.1.2 Copper-to-Copper

Copper-to-copper bolted electrical connections shall be made as follows:

1) Verify that the materials to be bolted are clean and free of debris. Pay special attention to the area around the backside of the bolt-holes and to the connecting surfaces.
2) Use a wire brush or other fine abrasive material to thoroughly clean the contact surface.
3) Apply inhibitor to the surfaces of the connection.
4) Bolt the surfaces together with bronze bolting hardware. Follow the torquing guidelines below.
5) Wipe off excess oxide inhibitor.

Note that a wire brush should not be used when making bolted connections of silver or tin-plated copper bus. A fine abrasive material should be used instead.

6.1.3 Aluminum-to-Copper

Aluminum-to-copper connections shall be made only with flat contact surfaces. Dressing and sealing the connection with inhibitor is especially important when dissimilar metals are in contact. Care must be taken to place the aluminum above the copper when in a horizontal or inclined plane so that corrosive copper salts do not flow onto the aluminum. When making a connection in a vertical plane, it is acceptable to place the two materials side-by-side.

The type of bolts used is also important because temperature changes can cause a loose joint due to the expansion differential between copper and aluminum. For instance, if a copper bolt is used, when the temperature increases the aluminum bar will expand more than will the bolt. The bolt will undergo stretching forces. Then, when the temperature is reduced, a loose connection will result. In order to minimize this problem, the following guidelines are to be used:

- Use aluminum bolts if the aluminum bar is as thick as or is thicker than the copper bar.

- Use bronze bolts if the copper bar is thicker than the aluminum bar.

The connection shall be made as follows:

1) Verify that the materials to be bolted are clean and free of debris. Pay special attention to the area around the backside of the bolt-holes and to the connecting surfaces.
2) Prepare the aluminum contact surface as follows:
   a) Apply inhibitor to the surface of the connection.
   b) Use a wire brush to thoroughly scratch the contact surface through the inhibitor, leaving enough of it on the surface to control reformation of oxides.
3) Prepare the copper contact surface as follows:
   a) Use a wire brush or other fine abrasive material to thoroughly clean the contact surface.
   b) Apply inhibitor to the surface of the connection.
4) Bolt the surfaces together. Place the aluminum above the copper when in a horizontal or inclined plane. Follow the torquing guidelines below.
5) Wipe off excess oxide inhibitor.

6.1.4 Tightening Requirements

A torque wrench shall be used on all bolted connections. The torque wrench should be used on the nut, not the bolt.

After the nut is tightened, at least one complete thread of the bolt must extend beyond the end of the nut.

In order to maintain a consistent appearance, the preferred bolt orientation shall be with the bolt-head above the bolted material and the nut below.

Bolts shall be tightened in accordance with the torquing table below:

Tightening Torque for Bolts (Ft-Lbs.)			
	Bolting Hardware Material		
Bolt Dia. (In.)	**Aluminum**	**Bronze**	**Stainless Steel (18-8) ***
5/16	10	12	12
3/8	15	20	20
7/16	20	30	35
½	25	40	45
5/8	40	80	95
¾	60	100	130

(Applies to aluminum bolts with Alumilite 205 finish and lubricant coating.)
Sources: ALCOA Conductor Accessories, Section ACP904, 88-03-15;
Dossert Corporation Internet Site; P.A. Sturtevant Co. Torque Manual.
*** Note**: Stainless steel bolting hardware is NOT for standard use in Xcel Energy substations.

6.1.5 Washer Requirements

The need for flat-washers and split lock-washers is dependent on the type of bolting hardware being used. (Note that washers are always necessary in certain applications; for instance, expansion fittings of angle bus typically require washers.)

<u>For aluminum bolting hardware:</u>

Lock-washers shall NOT be used when using aluminum bolting hardware.

Whether flat-washers are necessary for use with aluminum bolting hardware depends on the diameter of the bolt, the diameter of the bolt-head, and the diameter of the nut. For a given bolt diameter, washers are not needed if the diameter of the bolt-head and nut are great enough. Generally, flat-washers do not need to be used with the aluminum bolts and nuts stocked by Xcel. See the following table:

Flat-Washer Requirements for Aluminum Bolting Hardware			
Bolt Shaft Dia. (In.)	**Hole Dia. (In.)**	**Hex Head Wrench Size (In.)**	**Washer Required?**
3/8	7/16	9/16	Yes
3/8	7/16	11/16	No
½	9/16	¾	Yes
½	9/16	7/8	No

<u>For bronze and stainless steel bolting hardware:</u>

Both flat-washers and split lock-washers should ALWAYS be used when using bronze or stainless steel bolting hardware.

<u>Washer application</u>

Washers must be of the same material as the bolting hardware being used.

The order of washer installation shall be: bolt, flat-washer, material being connected, flat-washer, lock-washer (when used), nut.

6.1.6 Ampacity of Bolted Joints

This section gives a general guideline which can be used to determine the ampacity of bolted joints if no other guidance is given. Note that equipment vendors may provide their own connection details and these should be used as specified by the vendor.

Due to the nature of a bolted joint, it is appropriate to consider amperes per clamping bolt rather than a flat figure based on amperes per square inch. The current rating per bolt will also depend upon the method of preparation of the contact surfaces between the conductors, the size of the bolt and its tightening torque, and proper distribution of the clamping forces. Capacity figures in the following table are suggested current ratings for each fastener in a lapped joint of two rectangular bars where a contact aid such as NO-OX-ID compound is used.

Bolt Diameter	**Amperes per Bolt**
Less than ½ "	225
½ "	300
5/8"	375
¾ "	450

(Source of information: Penn-Union Electric Corporation, Letter dated 10-18-57)

The number of bolts used in a lapped joint will depend upon the current rating of the individual bar. Knowing the current rating, the number of fasteners can easily be determined.

For example, a rectangular bar rated at 1000 amperes will require the following number of 1/2 diameter bolts: 1000/300 = 3.3 or 4 Bolts (1/2" Diameter). Proper design will also make provision for adequate distribution of the applied pressure over the surface on the flats.

The above table may be used for aluminum or bronze bolts.

Detailed engineering may be required for high-current-carrying connections requiring a large number of bolts.

6.2. Welded Connections

A properly welded joint is the most reliable joint from the electrical standpoint because there is no contact resistance. Welded fittings are generally used when there is enough bus welding on the project to make it economical.

The preferred welding method is gas tungsten arc welding (GTAW). The preferred shielding gas is 100% pure argon. The preferred filler metal for welding aluminum is 4043 aluminum alloy.

Care should be taken while welding to prevent sparks from landing on and damaging insulators and bushings. Although metal inert gas welding is generally faster than tungsten inert gas welding, this method is more prone to producing sparks and damaging equipment. Therefore, metal inert gas welding is not recommended.

No inhibitor or sealant is to be applied prior to weld. In cold weather, the surfaces to be welded should be preheated to 200°F or until it is too hot to touch to draw all moisture out of the connection.

Welded connections shall be made as follows:

1) Verify that the materials to be welded are clean and free of debris.
2) In cold weather, preheat the materials to be welded to 200°F.
3) Clean the surfaces to be welded with a stainless steel wire brush to remove oxidation.
4) Tack weld as needed.
5) Wire brush the area around the tack weld.
6) Make final weld. Two welding passes are recommended for 5” bus. One pass is usually sufficient for bus smaller than 5”.

6.3. Compression Fittings for Tubular Bus

Compression fittings for tubular bus are not approved for use in Xcel Energy substations.

6.4. Cable Bus (Stranded Conductor) Connections

6.4.1 Compression-Type Connections

Terminations for aluminum cable bus can be made with compression-type fittings. For compression-type connections, the preferred oxide inhibitor is Alcoa EJC.

Compression-type connections for aluminum cable bus shall be made as follows:

1. Verify that the materials to be used are clean and free of debris.
2. Apply oxide inhibitor to the aluminum cable bus.
3. Use a wire brush to thoroughly scratch the surface of the wire through the inhibitor.
4. Verify that the fitting is factory pre-filled with inhibitor. If not pre-filled, apply inhibitor. Do NOT remove inhibitor as a means to make insertion of conductor easier. Check for foreign particles, and remove if necessary.
5. Insert the conductor into the lug body and crimp.

Compression-type terminal lugs may be used for 336.41, 556.5, 954, and 1590 MCM all-aluminum and 2312 MCM ACSR conductors. There must be enough inhibitor in the barrel of each terminal lug so that it squeezes out around the wire when inserted and compressed. The various lugs stocked by Xcel Energy are listed in this standard (See Section 9).

Compression-type tee connectors with a flat pad tap terminal shall be used for full current carrying tee connections for 336.41, 556.5, 954, and 1590 MCM all-aluminum and 2312 MCM ACSR conductors.

6.4.2 Clamp-Type Connections

Clamp-type terminal lugs should NOT be used on aluminum cable bus. Due to the open design of the clamps, it is difficult to completely seal the cable contact area. An exception to this rule is in the use of clamp-type stirrups for personal grounds or low-current carrying connections.

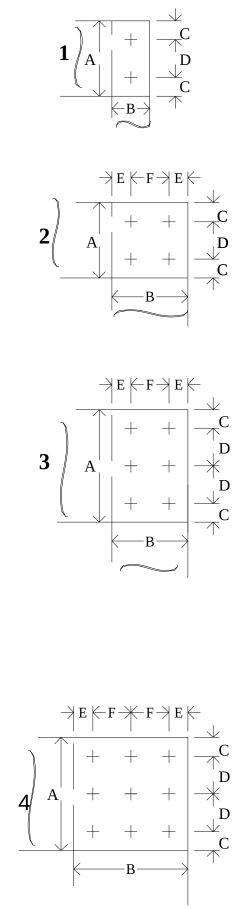
Clamp-type terminal lugs may be used on copper cable.

Low-current-carrying connections (such as for potential transformers, surge arresters, coupling capacitors, etc.) may be made by installing a clamp-type stirrup on the bus, and then connecting a conductor from the equipment to the stirrup with a hot-line clamp. In the past, conductors for low-current-carrying connections were joined with special wide range parallel groove clamps. This type of connection frequently involved a solid rod conductor looped through one side of the parallel clamp, to which a hot line clamp was attached. However, these connections are subject to excessive corrosion and are no longer recommended.

7. Bolting Schedule for Aluminum Bus

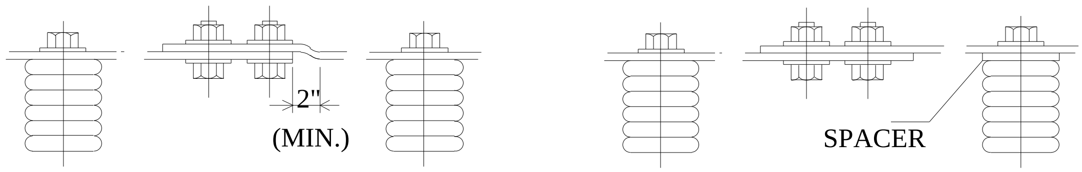
Table 1

Bar Width (In.)			Bolt Spacing (In.)				No. of	Bolt Size		Tangent or Right Angle Joint
A	B	Arrangement	C	D	E	F	Bolts	Alum	Steel	
2	1	1	1/2	1			2	3/8	5/16	
2	1 1/2	1	1/2	1			2	3/8	5/16	
2	2	1	1/2	1			2	3/8	5/16	
3	1	1	3/4	1 1/2			2	3/8	5/16	
3	1 1/2	1	3/4	1 1/2			2	3/8	5/16	
3	2	1	3/4	1 1/2			2	3/8	5/16	
3	3	2	3/4	1 1/2	3/4	1 1/2	4	3/8	5/16	
4	2	1	1	2			2	1/2	1/2	
4	3	2	1	2	3/4	1 1/2	4	3/8	3/8	
4	4	2	1	2	1	2	4	1/2	1/2	
5	2	1	1 1/4	2 1/2			2	1/2	1/2	
5	3	2	1 1/4	2 1/2	3/4	1 1/2	4	3/8	3/8	
5	4	2	1 1/4	2 1/2	1	2	4	1/2	1/2	
5	5	2	1 1/4	2 1/2	1 1/4	2 1/2	4	1/2	1/2	
6	2	1	1 1/2	3				1/2		
6	3	2	1 1/2	3	3/4	1 1/2	4	1/2	3/8	
6	4	2	1 1/2	3	1	2	4	1/2	1/2	
6	5	2	1 1/2	3	1 1/4	2 1/2	4	5/8	1/2	
6	6	2	1 1/2	3	1 1/2	3	4	5/8	5/8	
8	4	3	1 1/4	2 3/4	1	2	6	1/2	3/8	
8	5	3	1 1/4	2 3/4	1 1/4	2 1/2	6	1/2	1/2	
8	6	3	1 1/4	2 3/4	1 1/4	3	6	5/8	1/2	
8	8	4	1 1/4	2 3/4	1 1/4	2 3/4	9	5/8	5/8	



Bus Connections Standard

8. Bolting Schedule for Copper Bus



TYPICAL BUSBAR JOINTS AND MOUNTINGS

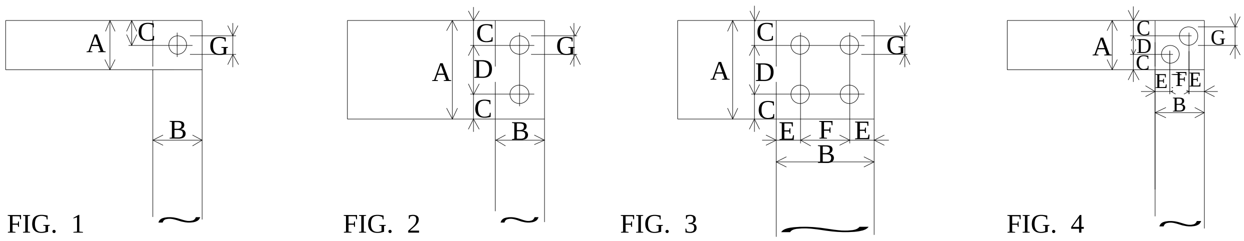


FIG. 1 FIG. 2 FIG. 3 FIG. 4

STANDARD BOLTING FOR BUS AND CONNECTION BARS

Table 2

Bars (In.)		Fig. No.	Bolt Spacing and Hole Dia. (In.)				
A	**B**		**C**	**D**	**E**	**F**	**G**
1	1	1	½	--	--	--	17/32
1 ½	1	1	¾	--	--	--	17/32
1 ½	1 ½	4	7/16	5/8	7/16	5/8	9/16
2	1	1	1	--	--	--	17/32
2	1 ½	4	9/16	7/8	7/16	5/8	9/16
2	2	4	½	1	1/2	1	9/16
2 ½	1	2	½	1 ½	--	--	9/16
2 ½	1 ½	2	½	1 ½	--	--	9/16
2 ½	2	2	½	1 ½	--	--	9/16
2 ½	2 ½	3	½	1 ½	½	½	9/16
3	1	2	5/8	1 ¾	--	--	9/16
3	1 ½	2	5/8	1 ¾	--	--	9/16
3	2	2	5/8	1 ¾	--	--	9/16
3	2 ½	3	5/8	1 ¾	½	1 ½	9/16
3	3	3	5/8	1 ¾	5/8	1 ¾	9/16
4	1	2	1 1/8	1 ¾	--	--	17/32
4	1 ½	2	1 1/8	1 ¾	--	--	9/16
4	2	2	1 1/8	1 ¾	--	--	9/16
4	2 ½	3	1 1/8	1 ¾	½	1 ½	9/16
4	3	3	1 1/8	1 ¾	5/8	1 ¾	9/16
4	4	3	1 1/8	1 ¾	1 1/8	1 ¾	9/16

9. Aluminum Compression Lug Details

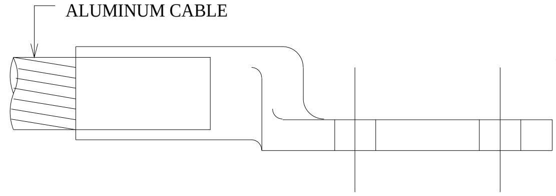
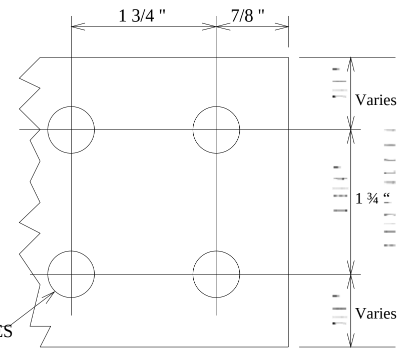


FIG. 4
1590 MCM



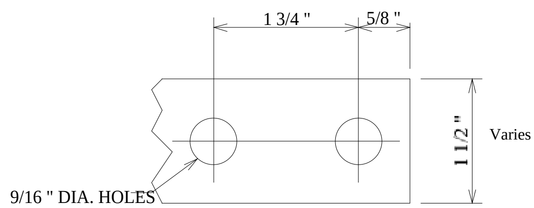


FIG. 1
336.4 MCM 8 #3/0

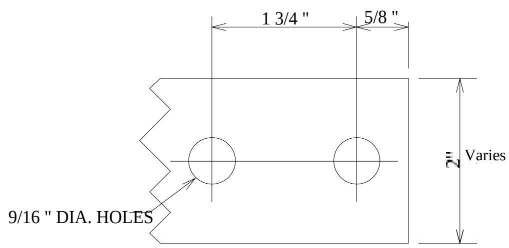


FIG. 2
556.5 MCM

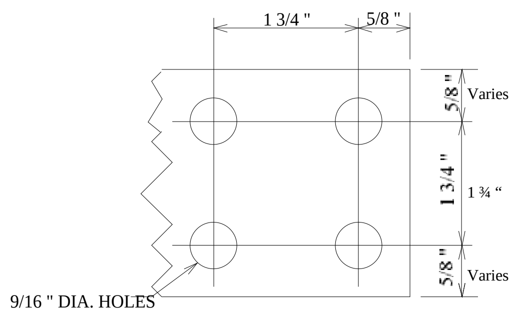


FIG. 3
954 MCM

CONDUCTOR SIZE	NUMBER OF STRANDS	COMPRESSOR MODEL	DIE	NSP STOCK NUMBER
3/0	19	12	74AH	10-0800
336.4 MCM	19	* 12A	* B76AH	10-0801
556.5 MCM	37	60A	6024AH	10-0803
954 MCM	37	60A	6030AH	10-0805
1590 MCM	61	60A	6038AH	10-0808
2312 MCM (ACSR)		* *	* *	

* ALTERNATE COMPRESSOR 60A WITH DIE 6076AH COMPRESSION LUGS COME WITH INHIBITOR
* * USE TRANSMISSION COMPRESSOR AND DIE

ALUMINUM COMPRESSION LUGS
ALUMINUM TERMINAL DETAILS

Bus Connections Standard

Bus Vibration

Bus vibration is caused by low steady winds, less than 15 mph., blowing across a bus span at approximately right angles. Under certain low velocity wind conditions, eddies will break off alternately from the top and bottom surfaces of the bus causing the bus to vibrate in a vertical plane. The bus will vibrate at its natural frequency provided that this frequency is within the range that can be excited by the wind.

Winds over 15 mph are generally too gusty to induce vibration. A span that is "sheltered" from the wind will not be as prone to vibrate as an-exposed span. Shelters may be created by trees planted around the substation, equipment in the substation, or by the surrounding topography of the substation.

Long spans are more prone to vibration than short spans. A long span can have one, two or three (in-the case of extremely long spans) loops of vibration. A loop of vibration is the portion of a vibrating body between two node points. A “node” is the point of a vibrating body that is free of vibration (any point of support would be a node point). The diameter of the bus tube will increase the vibration free span; however, whether a bus tube is Schedule 40 or Schedule 80 has little effect on whether a span will vibrate or not. For maximum vibration free rigid bus lengths, see table for maximum vibration free span.

Support losses are an indeterminable factor, such as support type, insulator type, structure flexibility, and other related factors. In some substations, the support losses are high enough to provide adequate damping but in other substations the support losses are less and the bus will vibrate more.

In general, bus spans greater than a minimum length will vibrate. (See tables for maximum vibration free spans.

In the past, “scrap cable” was installed inside the tubular bus to prevent vibration. Today, external type manufactured dampers are preferred because they are much cheaper and easier to install than scrap cable. The following tables are supplied as bus vibration references:

1. Maximum Vibration Free Span for- Tubular Bus
2. Maximum Vibration Free Span for Universal Angle Bus Conductor (UABC)
3. Maximum Vibration Free Span for Integral Web Channel Bus (IWCB)
4. Damper Spacing for Rigid Bus
5. Recommended Sizes of Cable to be Inserted in Tubular Bus to Prevent Vibration

Table 1
Maximum Vibration Free Span for- Tubular Bus

Nominal Pipe Size	Maximum Safe Span Length
1	5'- 0"
1-1/4	6'- 3"
1-1/2	7'- 0"
2	9'- 0"
2-1/2	10'- 9"
3	13'- 3"
3-1/2	15'- 3"
4	17'- 0"
4-1/2	19'- 0"-
5	21'- 3"
6	25'- 3'

Table 2
Maximum Vibration Free Span for Universal Angle Bus Conductor (UABC)

UABC Size	Maximum Safe Span Length [a, b, c]
3-1/4 x 3-1/4 x 1/4	12'-0
4 x 4 x 1/4	15'-0
4 x 4 x 3/8	14'-9
4-1/2 x 4-1/2 x 3/8	16'-9
5 x 5 x 3/8	18'-6

[a] Lengths based on one span with support at each end
[b] Lengths apply to both Schedule 40 and Schedule 80 tubular bus
[c] Lengths can be increased approximately 20% with reasonable assurance there will be no vibration.

Table 3
Maximum Vibration Free Span for Integral Web Channel Bus (IWCB)

IWCB Size (Inches)	Maximum Safe Span Length [a, b]
4 x 4	14’-6
6 x 4	20’-9
6 x 5	21’-3
6 x 6	21’-9
7 x 7	26’-3
8 x 5	29’-0

a. Spans based on one span with support at each end
b. Lengths can be increased approximately 20% with reasonable assurance there will be no vibration.

Table 4
Damper Spacing for Rigid Bus [a, b]

SPAN	SPACING	SPAN	SPACING	SPAN	SPACING	SPAN	SPACING
15’-0	7’-0	26’-6	10’-10	38’-0	14’-8	49’-6	18’-6
15’-6	7’-2	27’-0	11’-0	38’-6	14’-10	50’-0	18’-8
16’-0	7’-4	27’-6	11’-2	39’-0	15’-0	50’-6	18’-10
16’-6	7’-6	28’-0	11’-4	39’-6	15’-2	51’-0	19’-0
17’-0	7’-8	28’-6	11’-6	40’-0	15’-4	51’-6	19’-2
17’-6	7’-10	29’-0	11’-8	40’-6	15’-6	52’-0	19’-4
18’-0	8’-0	29’-6	11’-10	41’-0	15’-8	52’-6	19’-6
18’-6	8’-2	30’-0	12’-0	41’-6	15’-10	53’-0	19’-8
19’-0	8’-4	30’-6	12’-2	42’-0	16’-0	53’-6	19’-10
19’-6	8’-6	31’-0	12’-4	42’-6	16’-2	54’-0	20’-0
20’-0	8’-8	31’-6	12’-6	43’-0	16’-4	54’-6	20’-2
20’-6	8’-10	32’-0	12’-8	43’-6	16’-6	55’-0	20’-4
21’-0	9’-0	32’-6	12’-10	44’-0	16’-8	55’-6	20’-6
21’-6	9’-2	33’-0	13’-0	44’-6	16’-10	56’-0	20’-8
22’-0	9’-4	33’-6	13’-2	45’-0	17’-0	56’-6	20’-10
22’-6	9’-6	34’-0	13’-4	45’-6	17’-2	57’-0	21’-0
23’-0	9’-8	34’-6	13’-6	46’-0	17’-4	57’-6	21’-2
23’-6	9’-10	35’-0	13’-8	46’-6	17’-6	58’-0	21’-4
24’-0-	10’-0	35’-6	13’-10	47’-0	17’-8	58’-6	21’-6
24’-6	10’-2	36’-0	14’-0	47’-6	17’-10	59’-0	21’-8
25’-0	10’-4	36’-6	14’-2	48’-0	18’-0	59’-6	21’-10
25’-6	10’-6	37’-0	14’-4	48’-6	18’-2	60’-0	22’-0
26’-0	10’-8	37’-6	14’-6	49’-0	18’-4		

Formatted

a Spacing based on 1/3 span length plus two feet
b Damper may be installed from either end of the span

Table 5
Recommended Sizes of Cable to be Inserted in Tubular Bus to Prevent Vibration [a, b, c]

Nominal Bus Size (Inches)	Recommended Min. Size (Circular Mills – CM)
2	266,800
2-1/2	266,800
3	266,800
3-1/2	397,500
4	795,000
5	1,431,000
6	1,590,000

[a] Cable should have a multi-strand core
[b] Based on no energy absorption by supports
[c] Scrap cable is an alternate method of dampening to be used only when manufactured dampers are not available.

Outdoor Bus Supports For Substations Standardization Of Insulation Levels

In 1942 the Electrical Industry adopted as standard, certain Basic Insulation Levels (BIL) for all standard operating voltages. These insulation levels were arrived at only after many years of exhaustive study by various interested groups in the Industry and were approved by the National Electrical Manufacturer's Association (NEMA), later by the American Standards Association (ASA) and presently by the American National Standards Institute, Inc. (ANSI).

By use of these standards it is possible to coordinate the insulation strength of all equipment in a station or substation so surges entering the station will be conducted to ground by protective devices before flashing over or puncturing the insulation of any component part.

Prior to 1942 Delta Star type ZO insulators were used. These insulators were below the present basic insulation levels. Some may yet be in use, particularly at 69kV. The line protective gap for 69kV ZO-7 insulators is 18 3/4 inches. All ZO insulators should be replaced when possible and bring the installation up to standard BIL. This decision will be made by the Sponsor Engineer.

STATION POST INSULATORS

Station post insulators are the insulator of choice for Northern States Power. NSP stocks insulators through 161kV and places all orders for new insulators through the Maple Grove Stores Facility.

Governing Standards

ANSI Standard C 29.9.
NSP Material Standard 4SC6.

Station Post Insulators - Dimension Information

Rating (KV)	BIL (KV)	(5) ANSI TRN	Units Per Stack	Stack Height (In)	† Stack Wt. (Lbs)	(5) Bolt Circle Dia.	Max Dia. (In)	Stock Number
7.5	95	202	1	7.5	15	3(1)	7.5	04-0560
15	110	44 *	1	10	32	5(2)	8.75	04-0561 §
15	110	205	1	10	21	3(1)	7	04-0562
15	110	225 *	1	12	44	5(2)	8.5	04-0563
23	150	208	1	14	30	3(1)	7.25	04-0564
34.5	200	210	1	18	41	3(1)	7.5	04-0566
34.5	200	231 *	1	20	95	5(2)	9.75	None
46 (4)	250	214	1	22	67	3(1)	8	04-0567
69	350	216	1	30	97	3(1)	9.5	04-0568
69	350	278 *	1	30	141	5(2)	10.5	None
115	550	286	1 or 2	45	206	5(2)	11	04-0570
115	550	287 *	1 or 2	45	213	5(2)	10.5	None
161	750	291	2	62	307	5(2)	11	04-0572
230	900	308 *	2 or 3	80	490	5(2)	14	04-0574
345	1300	324	2 or 4	106	654	5(2)	14	04-0576
345	1300	367 *	2 or 4	106	594	Top 5(2) Bot 7(3)	14	None
500	1800	391	3 or 5	152	1007	Top 5(2) Bot 7(3)	14	04-0578
500	1800	**ND** **	3	152	1031	Top 5(2) Bot 14(3)	12	None

Legend:

(1) For 1/2" - 13 Thread Bolts
(2) For 5/8" - 11 Thread Bolts
(3) For 3/4" - 10 Thread Bolts
(4) Used for spacers between capacitor bank series groups
(5) ANSI Standards Publication C-29.9

* High Strength
** Extra High Strength
ND No TRN designation listed
§ For cap and pin replacement.
† Worst Case of approved vendors

High leakage and extra-high leakage insulators are available and have been used to reduce the chance of insulator flashover in substations adjacent to freeways such as at Parkers Lake Substation.

An Excel spreadsheet based on IEEE Standard 605 is available in the Engineering Calcs directory on the Black Server with the file name BUSLOAD.XLS. This spreadsheet can be used to determine when higher strength insulators are required if the criteria for a specific location does not fall within what was used in the Substation Tubular Bus Criteria Standard ED 4.02.01. The IEEE Standard 605 should be reviewed prior to use of this spreadsheet.

Station Post Insulators - Approved Purchasing Supplement

The products of the following manufacturers meet the specifications set forth in the Approved Material Standard #4SC6. These products shall be purchased and stocked under the following NSP Stock Numbers:

NSP Stock #	Rating (kV)	ANSI TRN	Lapp		Victor		NGK-Locke		Newell	
			Cat #	U/S	Cat #	U/S	Cat #	U/S	Cat #	U/S
04-0560	7.5	202	315202-70	1	1750	1	PS00910	1	231001	1
04-0561 §	15	44	315044-70	1	-	-	-	-	-	-
04-0562	15	205	315205-70	1	1751	1	PS01110	1	231002	1
04-0563	15	225 *	315225-70	1	1767	1	PH01110	1	41512	1
04-0564	23	208	315208-70	1	1752	1	PS01510	1	231003	1
04-0566	34.5	210	315210-70	1	1753	1	PS02010	1	231004	1
None	34.5	231 *	315231-70	1	1763	1	PH02010	1	41520	1
04-0567	46	214	315214-70	1	1754	1	PS02510	1	231005	1
04-0568	69	216	315216-70	1	1755	1	PS03510	1	231006	1
None	69	278 *	315278-70	1	1765	1	PH03510	1	41530	1
04-0570	115	286	315286-70	1	1720	2	PS05510	1	47801	2
None	115	287 *	315287-70	1	1725	2	PH05510	1	47821	2
04-0572	161	291	None †	-	1722	2	None †	-	47803	2
04-0574	230	308 *	315308-70	2	1728	3	PH090201	2	47825	3
04-0576	345	324	315324-70	2	16PA00	2	PH130201	2	47831	4
None ‡	345	367 *	315367-70	2	16PA01	2	PH130202	2	47761	4
04-0578	500	391	315391-70	3	1630	5	PE18030	3	47854	5
None	500	**ND** **	314934-70	3	None	-	None	-	None	-

Legend:

*	High Strength
**	Extra High Strength
ND	No TRN designation listed
U/S	Units per stack
§	For cap and pin replacement.
†	Only single piece insulator available at this rating which is not acceptable.
‡	May be less than or equal in cost to the standard strength unit (TRN 324). When requisitioning new switches or just the station post insulator, the requester may wish to have both standard and high strength units quoted for comparison.

Care should be taken when obtaining units from stock that like units from the same manufacturer are obtained as the manufacturers do not all supply the same number of units per stack and sections from different manufacturers are not interchangeable, nor are units from the same manufacturer but of different vintages necessarally interchangeable. Bolt circle dimensions between standard, high strength and extra high strength units differ.

CAP AND PIN INSULATORS

Cap and Pin Substation Insulators are covered by ANSI Standard C 29.8. These insulators are emergency stock items. Cap and Pin Insulators will not be used for new construction. Emergency stock is limited, and the design of these insulators has caused failure problems. Station Post Insulators should be used whenever possible.

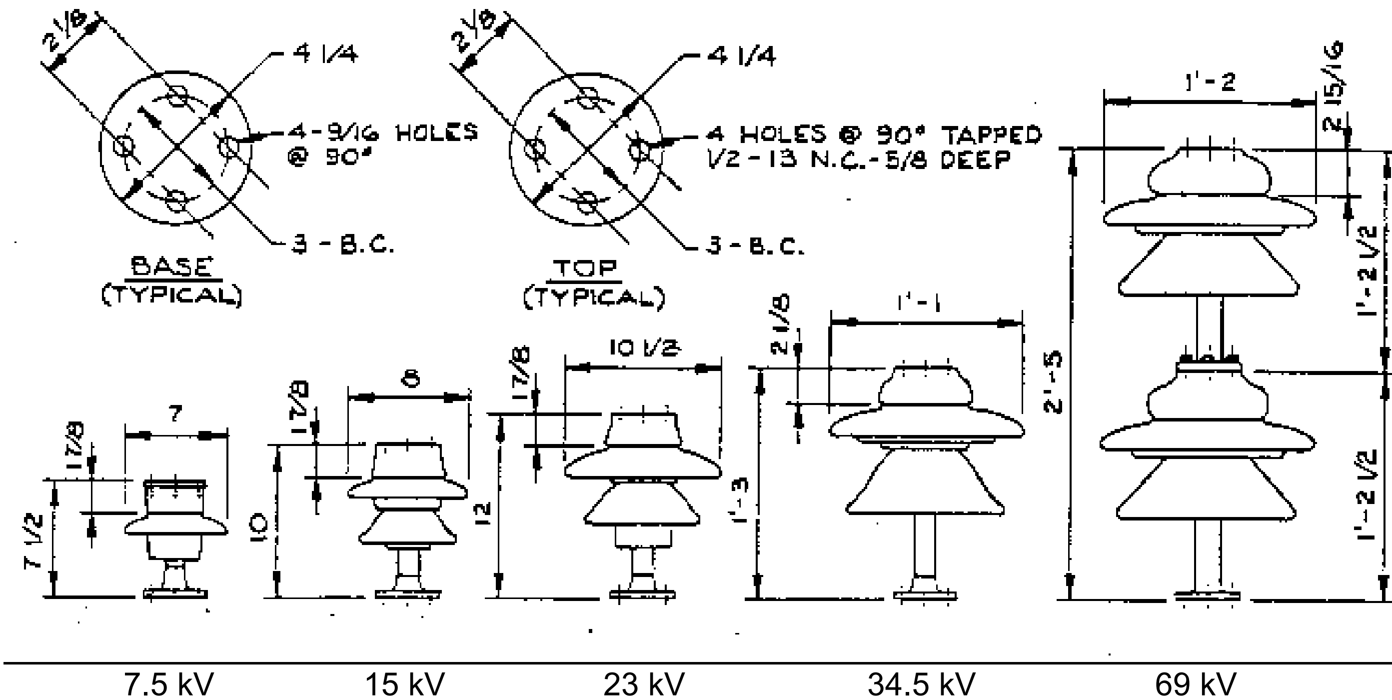
When replacing broken Cap and Pin Insulators, always try to use Station Post Insulators. There may be height differences between Station Posts and the similarly rated Cap and Pins.

Rating (kV)	BIL (kV)	(1)Tech Ref No.	Units per Stack	(1)Tech. Ref. No of Sgl Units	Hgt. of Stack (in)	(5)Bolt Circle Diam.	Max Dia (in)	Stock Number
7.5	95	1	1	1	7 1/2	3	7	04-0521
15	110	4	1	4	10	3	8	04-0527
15(4)	110	44	1	44	10	5	10	
23	150	7	1	7	12	3	10 1/2	04-0534
23(4)	150	46	1	46	12	5	12	
34.5	200	10	1	10	15	3	13	
69	350	16	2	147	29	3	14	04-0548
115	550	19	3	140	431/2	5	17	04-0556
					47(2)			
161(3)	750	26	4	4-140	58	5	17	04-0556
				1-141(4)	61 1/2(2)		18	

Legend:

(1) ANSI Standards Publication C-29.8
(2) Total Height of Bus Support with 3 1/2" Spacer (Required) - Stock No. 04-0942
(3) Station Post Insulators Preferred 161kV and Above - See Sheet 3
(4) High Strength Ins., at Insulator Supporting End, When More Than 1 Unit is Used
(5) 3" Diameter B.C. for 1/2" - 13 Thread Bolts, 5" B.C. for 5/8" - 11 Thread Bolts

Insulators - Outdoor, Cap & Pin Bus Support

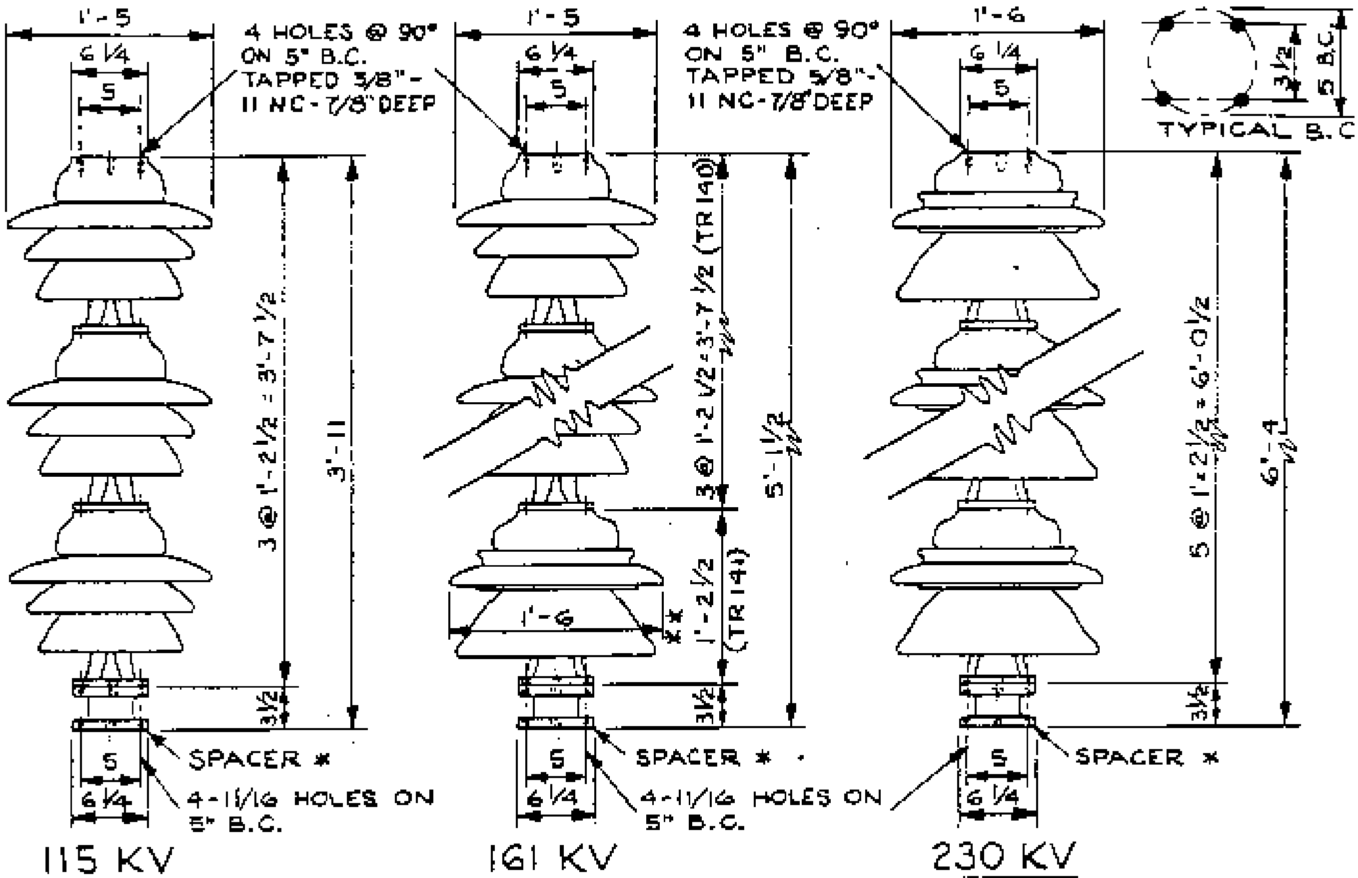


NOMINAL VOLTAGE	7.5 kV	15 kV	23 kV	34.5 kV	69 kV
BIL	95 kV	110 kV	150 kV	200 kV	350 KV
TECH. REF.	1	4	7	10	16 (STACK) 147 (UNIT)
WEIGHT	12 LBS.	16 LBS.	24 LBS.	38 LBS.	100 LBS.(TOTAL

REFERENCE ONLY
Not for design purposes

Insulators - Outdoor, Cap & Pin - 7.5 kV To 69 kV

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 12/18/96		2	SHEET 2	**ED 6.02.01.03**

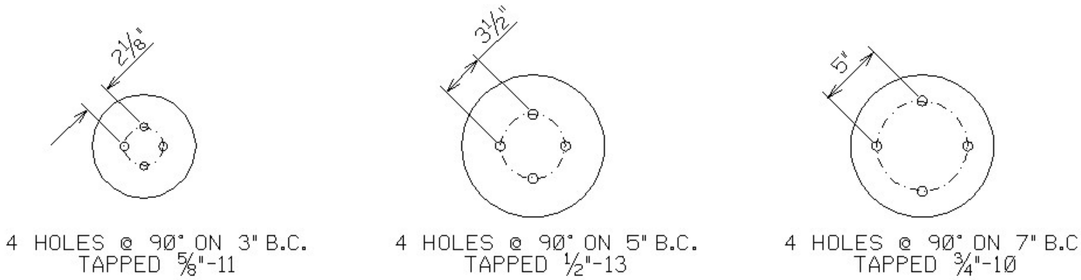


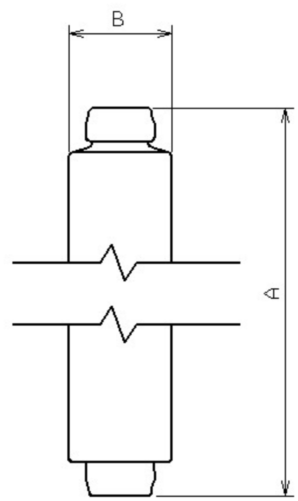
NOMINAL VOLTAGE	115 kV	161 kV	230 kV
BIL	550 kV	750 kV	900 kV
STACK TECH. REF.	19	26	27
UNIT TECH. REF	140 STANDARD STRENGTH	1-END UNIT 141 3- END UNITS140	141 HIGH STRENGTH
STACK WEIGHT	250 LBS.	364 LBS.	580 LBS.

REFERENCE ONLY
Not for design purposes

Insulators - Outdoor, Cap & Pin - 115 kV To 230 kV

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 12/18/96		2	SHEET 3	ED 6.02.01.03





Nominal Voltage kV	Strength	BIL kV	Dimensions A	Dimensions B	B.C. DIA.	WT. LBS	Tech. Ref. Single Unit	PassPort Cat #
7.5	STANDARD	95	7 ½”	6 ¾”	3”	13.5	202	106104
15	STANDARD	110	10”	7”	3”	20	205	86859
15	HIGH	110	1’- 0”	8”	5”	44	225	86861
23	STANDARD	150	1’- 2”	7”	3”	30	208	51517
34.5	STANDARD	200	1’- 6”	7 ½”	3”	41	210	86867
69	STANDARD	350	2’- 6”	8”	3”	85	216	51523
115	STANDARD	550	3’- 9”	11”	5”	206	286	51524
115	EXTRA HIGH	550	3’- 9”	10 ½”	TOP-7” BOT-7”	257	None	
161	STANDARD	750	5’- 2”	11”	5”	331	291	106109
230	HIGH	900	6’- 8”	10”	5”	371	308	86875
345	STANDARD	1300	8’- 10”	9”	5”	388	324	106110
345	EXTRA HIGH	1300	8’- 10”	10 ½”	TOP-5” BOT-7”	675	369	
500	STANDARD	1800	12’- 8”	9 $^{5}/_{8}$”	TOP-5” BOT-7”	705	391	196318

NOTE:

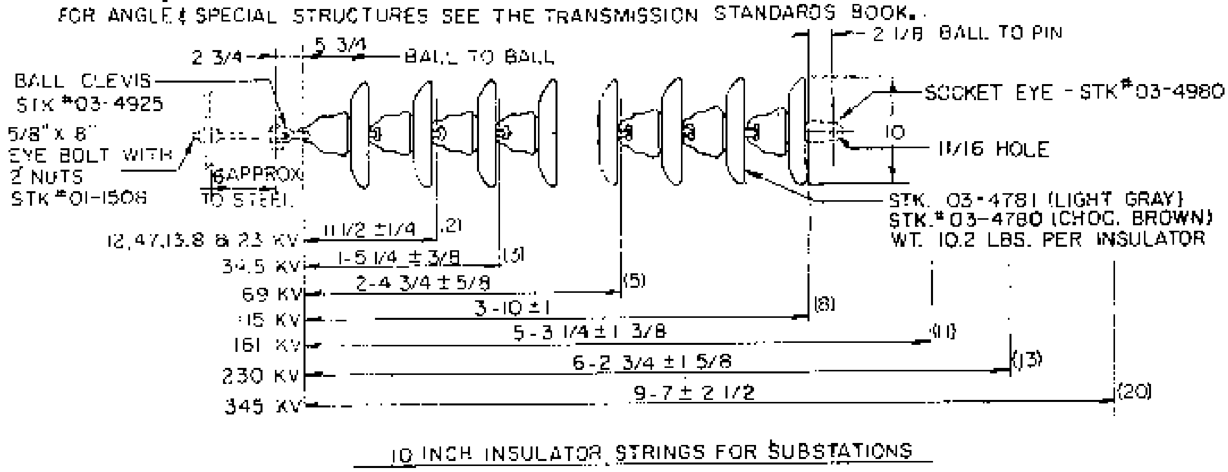
1. All bus supports to be requisitioned as ‘light gray’ unless otherwise notified. (Stock no's are for light gray)
2. The number of stacks determined by manufacturer.
3. Diameter and weight may very by manufacturer.

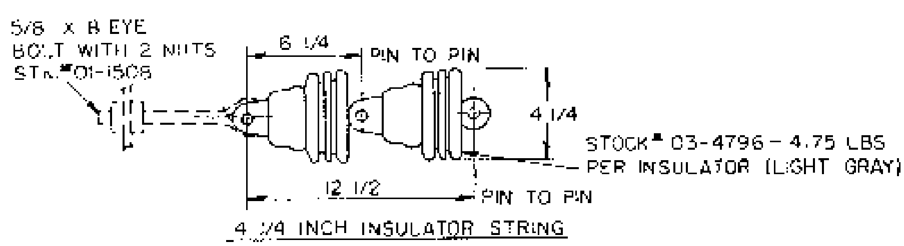
Insulators Station Post Outdoor Bus Support

Xcel Energy - North	Date: 03/19/2006	Approved: SJM/JMT	Rev. 3	Substation Engineering & Design Standards — Sheet 1 of 1	ED 6.02.01.04

SUSPENSION INSULATORS					
	SUBSTATION	TRANSMISSION TANGENT		TRANSMISSION DEAD END	
VOLTAGE	INSULATORS	WOOD	STEEL	WOOD	STEEL
2.4 /4.16 & 11.9 KV	2 - 4 1/4"				
12.47 3 13.8 KV	2 - 10"				
23 KV	2 - 10"	2	3	3	4
34.5 KV	3 - 10"	3	4	4	
69 KV	5 - 10"	4	5	5	6
115 KV	8 - 10"	7	8	8	9
161 K V	11 - 10"	9	10	10	11
230KV	13 - 10"	12	14	14	15
345 KV	20 -10"	18	16	20	20

* SOME EXISTING INSTALLATIONS HAVE 3 INSULATORS. IT IS DESIRABLE TO MAINTAIN THIS INSULATOR LEVEL.
** THIS TABLE COVERS THE GENERALLY ACCEPTED N.S.P. STANDARD FOR TANGENT & DEAD END STRUCTURES. FOR ANGLE & SPECIAL STRUCTURES SEE THE TRANSMISSION STANDARDS BOOK.





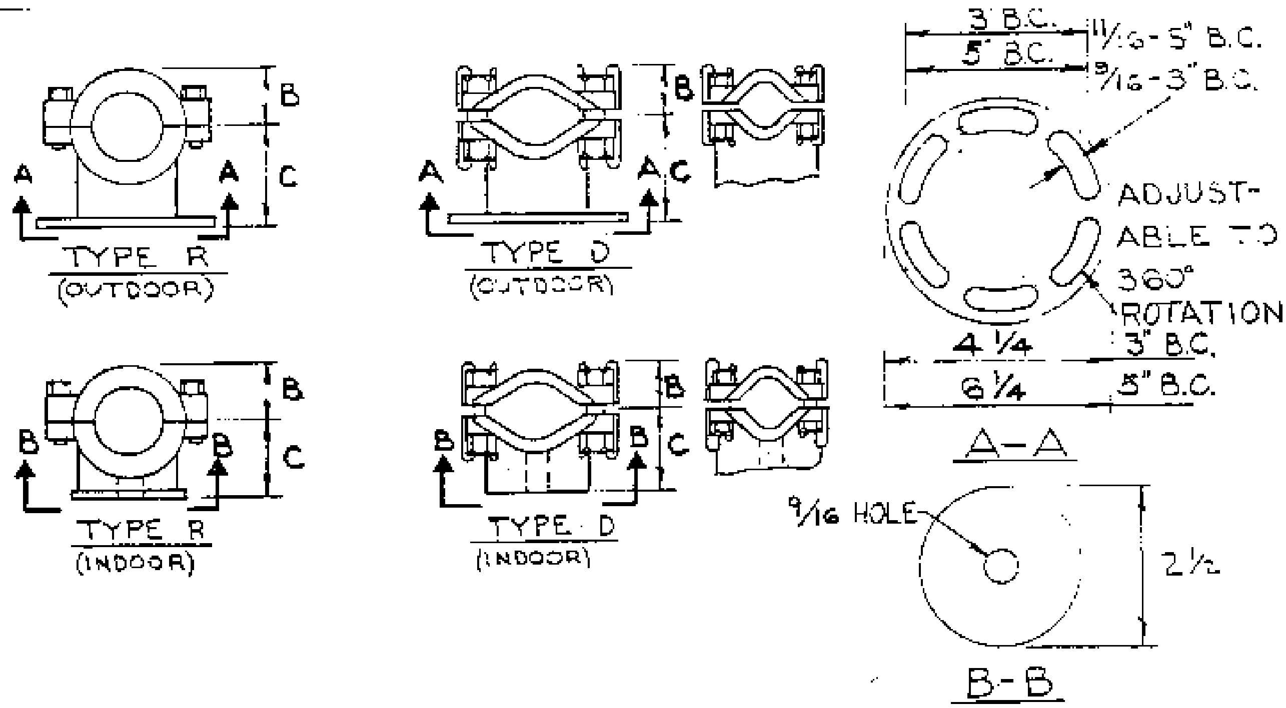
NOTES:

1. ALL SUSPENSION INSULATORS FOR SUBSTATION ARE TO BE REQUISITIONED AS "LIGHT GRAY" UNLESS OTHERWISE SPECIFIED.

2. USA STANDARD SPECS. ALLOW A TOLERANCE OF PLUS OR MINUS 1/8" ON THE LENGTH OF EACH 10" SUSPENSION INSULATOR.

Suspension Insulators

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 6/5/73		0	SHEET 1	ED 6.02.01.05



MALLEABLE & BRONZE FOR COPPER CONDUCTOR

Range-MCM	Range-Inches	Tubing IPS	D.S. Co. Cat. No.	Bolt Circle	NSP Stock No.	B	C	Type
Up to 500	3/16 to 13/16	1/2	630013	3”	04-0620	15/16	1 9/16	D
4/0 to 1250	1/2 to 1 5/16	3/4 & 1	630023	3”	04-0634	1 5/16	2 1/8	D
Up to 500	3 16 to 13/16	1/2	630015	5”	04-0638	15/16	1 9/16	D
4/0 to 1250	1/2 to 1 5/16	3/4 & 1	630025	5”	04-0645	1 5/16	2 1/8	D
Up to 500	3/16 to 13/16	1/2	630011	bolt center	04-0626	15/16	15/16	D
4/0 to 1250	1/2 to 1 5/16	3/4 & 1	630021	bolt center	04-0632	1 5/16	1 5/8	D
	1.315	1	630333	3”	04-0814	1 1/8	2	R
	1.900	1 1/2	630353	3"	04-0822	1 5/8	2 1/2	R
FOR STRANDED ALUM CONDUCTOR (SAC)								
4/0 to 1272	1/2 to 1 5/16	3/4 & 1	630023AL	3"	04-0714	1 5/16	2 1/8	D
795 to 1590	1 to 1 7/8	1 1/4 & 1 1/2	630033AL	3"	04-0722	1 3/8	2 5/8	D
4/0 to 1272	1/2 to 1 5/16	3/4 & 1	630025AL	5”	04-0720	1 5/16	2 1/8	D
795 to 1590	1 to 1 7/8	1 1/4 & 1 1/2	630035AL	5"	04-0724	1 3/8	2 5/8	D

NOTE - Bus support fittings for special shapes, except 4"x4" IWCB items. Each project must be checked for the latest approved fittings are not stock.

Bus Support Fittings

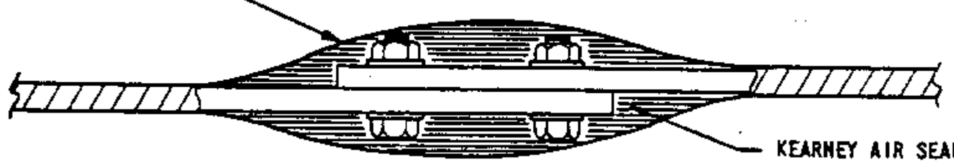
NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS
	CHECKED	APPROVED		
	DATE **6/5/73**		**0**	**SHEET 1** **ED 6.02.01.07**

Taping Bus Bars Connections With Polyvinyl Chloride (Pvc) Tape

Thickness and number of layers of 20 mil (.02") polyvinyl chloride tape for taping bus bars

	FULL VOLTAGE TAPING		FLASH VOLTAGE TAPING	
VOLTAGE	MILS	ONE HALF LAPPED	MILS	ONE HALF LAPPED
0 TO 600	120	3 LAYERS (6 THICKNESSES)	40	1 LAYERS (2 THICKNESSES)
601 TO 2000	160	4 LAYERS (8 THICKNESSES)	40	1 LAYERS (2 THICKNESSES)
2001 TO 3000	160	4 LAYERS (8 THICKNESSES)	40	1 LAYERS (2 THICKNESSES)
3001 TO 4000	200	5 LAYERS (10 THICKNESSES)	40	1 LAYERS (2 THICKNESSES)
4001 TO 6000	200	5 LAYERS (10 THICKNESSES)	40	1 LAYERS (2 THICKNESSES)

THE ABOVE TAPING IS BASED ON THE FOLLOWING
Full voltage taping is I.P.C.E.A. recommended thickness for one conductor cable 1000 MCM and larger. Flash voltage taping is based on the dielectric strength of PVC Tape which is equal to V.C. Tape (20% of 900 volts. - The acceptance test voltage for V.C. Tape under 6% elongation)



General Notes On Taping Bus Bars

1. PVC Tape shall not be used on bus bar voltages exceeding 6,000 volts.
2. Do not wrap bus below temperatures of 32°F unless arrangements are made to warm tape or bus before applying.
3. Tape to meet NSP Company tests on PVC Tape of Sept. and Oct. 1955
4. In the application of the tape apply just sufficient tension to the tape so that it is firm on the bus bar. Never over stress the tape.
5.. At the joints and tee connections, use Kearney Air Seal filler compound to make a uniform surface over which to tape.
6. Use narrower widths and thicknesses of tape at the joints and irregular surfaces because of its greater flexibility.

General Notes On Fireproofing Bus Bars

1. All bus bars should be fireproofed on voltage above 600 volts with a covering of 1 layer 1/2 lapped of asbestos tape.

Reference drawings

1. For terminating bus bars see other drawings.

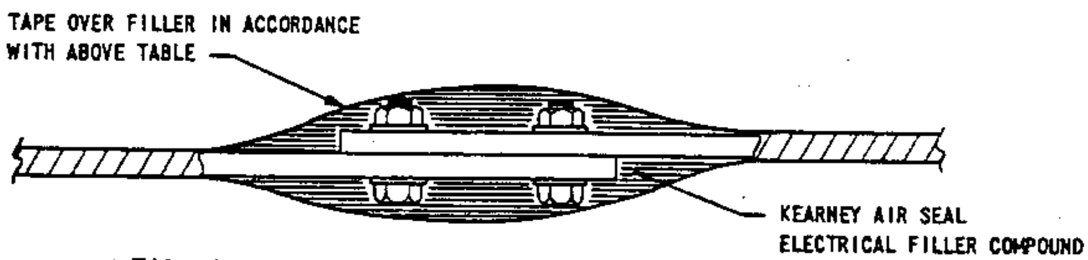
Width and Thickness Of PVC Tape
3/4" - 7 mil (Scotch electrical #88)
1" - 20 mil (Scotch electrical #21)
1/2" - 20 mil (Scotch electrical #21)

Bus & Connections - taping bus bars with polyvinyl chloride (PVC) Tape

Thickness and number of layers of 10 mill (.01") varnished cambric tape for taping bus bars

	FULL VOLTAGE TAPING		FLASH VOLTAGE TAPING	
VOLTAGE	MILS	ONE HALF LAPPED	MILS	ONE HALF LAPPED
0 to 600	140	7 layers (14 thicknesses)	20	1 layers (2 thicknesses)
601 to 4000	140	7 layers (14 thicknesses)	40	2 layers (4 thicknesses)
4001 to 7000	160	8 layers (16 thicknesses)	40	2 layers (4 thicknesses)
7001 to 8000	180	9 layers (18 thicknesses)	60	3 layers (6 thicknesses)
8001 to 11000	200	10 layers (20 thicknesses)	60	3 layers (6 thicknesses)
11001 to 12000220	10 layers (22 thicknesses)	80	4 layers (6 thicknesses)	
12001 to 14000240	12 layers (24 thicknesses)	80	4 layers (8 thicknesses)	
14001 to 15000260	13 layers (26 thicknesses)	100	5 layers (10 thicknesses)	
15001 to 25000420	21 layers (42 thicknesses)	140	7 layers (14 thicknesses)	

THE ABOVE TAPING IS BASED ON THE FOLLOWING:
Full voltage taping is I.P.C.E.A. recommended thickness of V.C Tape for one conductor cable 1000 MCM and larger.
Flash voltage taping is 20% of acceptance test voltage when tape is under tension (Acceptance test voltage is 900 volts per mil when tape is under 6% elongation)



GENERAL NOTES ON TAPING BUS BARS
1. Varnished cambric tape used on bus bar voltages up to 25,000 volts.
2. Use high quality insulating varnish between each layer of varnished cambric tape on voltages above 4160 volts.
3. Varnished cambric tape to meet NSP Co. Material standard No. 51
4. At joints and tee connections use Kearney Air Seal-to make a uniform surface over which to tape.
5. Use narrower widths of tape at joints and irregular surfaces because of its greater flexibility.

General notes on fireproofing bus bars
1. All bus bars insulated with varnished cambric tape should be fireproofed with a covering of 1 layer 1/2 lapped of asbestos tape. Fireproof all voltage bus bars with full voltage taping or flash voltage taping.

Reference drawings
1. For terminating bus bars see other drawings
   Varnished cambric tape
   2 inch
   4 inch
   6 inch

Taping bus bars with Varnish Cambric tape

NORTHERN STATES POWER COMPANY SUBSTATION/TRANSMISSION SERVICES	DRAWN	FILMED	REV	SUBSTATION ENGINEERING & DESIGN STANDARDS	
	CHECKED	APPROVED			
	DATE 3/7/79		0	SHEET 2	ED 6.02.02

Equipment Installation of Test Link

1.0 Scope

This document serves as an application guide for the installation of test links on substation power transformers.

2.0 General

Substation power transformers are equipped with test links to facilitate isolation of transformers for Doble tests. Transformers are Doble tested both on a routine basis (except in Wisconsin) and under emergency conditions. Tests are performed to determine insulation power factor and dielectric loss characteristics. Maintenance tests are done at two year intervals with the results recorded. Historic data can then be used to detect and/or foresee insulation deterioration before a catastrophic failure occurs.

The justification for installing test links is based on the following criteria:

2.01 Labor man-hours required to disconnect and remake terminations to the transformer bushing is significantly reduced. This savings in man-hours is associated with high ampacity connections (multiple conductors) and/or rigid bus connections. These connections are generally difficult to work with and can also require a considerable amount of joint surface preparation. Test links, however, can be operated with minimal effort and preparation.

2.02 Test links can be effectively used to eliminate the need for a bucket truck. Normally, a bucket truck would be required when the height of the connection is such that the terminations cannot be easily reached by hand while standing on top of the transformer tank. Since test links can be opened and closed with minimal effort it is acceptable practice to stand on the lower portion of the transformer bushing skirts to reach the test links. It is also possible to have a local troubleman operate the test links since very little time is required. Neither practice, however, is acceptable when disconnecting and remaking bolted connections.

2.03 Test links also provide a safe and reliable method of disconnecting the transformer leads. Again, this is true mainly for high ampacity connections. The rigidness and inherent strains associated with tubular bus can cause it to ‘snap’ apart when disconnected. This can result in equipment damage as well as being a personnel safety hazard. Flexible leads consisting of multiple large conductors are heavy enough to crack or chip a bushing skirt if dropped while working on termination. The probability of a bad connection also increases if the terminations have to be redone every time Doble tests are made. All of these problems are virtually eliminated with the use of test links.

3.0 Physical considerations

Some of the physical design factors influencing the use of test links are the number, size and type of connecting lead conductors, the height of the transformer bushings, and the location of disconnect switches and connections to surge arresters. Each of these factors are discussed in detail below.

3.01 **Rigid bus conductors:** In general, all transformer bushing connections utilizing rigid leads at 115 kV and above should have test links unless transformer -disconnect switches can be used for isolation as covered in section 3.04. The height of the bushing coupled with the bus rigidity make these connections difficult to work with. Installation at 69 kV and below should be considered individually. If the bus is flexible enough to allow an insulating block to be wedged between the bus and bushing terminal pads, then test links would not be required. Approximate lengths of unsupported bus required to provide this flexibility are as follows:

ASA Schd. 40 Pipe Size	Minimum Unsupported Span Length-Feet
1”	5
½”	7
2”	9
2 ½”	12
3”	15
3 ½”	17
4”	20
5”	25

This rule applies only to those connections expected to carry load currents of less than 2000 amperes. In other words, it is intended that this rule be applied to installations where rigid conductors are used due to physical conditions and not for ampacity requirements. The rigidity of the conductor would make it difficult to effectively prepare the joint for reconnection. Poor joint preparation can lead to hot spots and eventual failure. This is of particular concern with high ampacity connections since they are commonly designed for 40°C temperature rise conductors and as such are subject to more severe cycling.

3.02 **Multiple conductor leads:** Test links should be installed on all multiple conductor leads rated 2000 amperes and above unless disconnect switches can be used for isolation in accordance with section 3. This is partly justified based on the reduction of labor man-hours associated with joint preparation. These connections require twice as much surface area (generally two 4-hole lugs rather than one 4-hole or two 2-hole lug) as lower ampacity circuits. Additional care must also be taken when making a high ampacity connection to prevent hot spots from developing. Approximately 4 man-hours on each three-phase connection can be saved with the use of test links for this type of installation. This results in a decrease in maintenance expenditures over the life of the transformer (35 years) equivalent to approximately half of the installed cost of the test links.

This reduction in expenditures coupled with a lower probability of joint failure and/or equipment damage provides sufficient justification for installing test links on high ampacity multiple conductor terminations.

3.03 **Height of bushing:** For low ampacity (below 2000 ampere), non-rigid lead conductors, the height of the bushing is a determining factor in whether or not test links should be installed. Bushings for use on 161 kV system and below are short enough (less than six feet from mounting flange) for a person to effectively work with a connection while standing on the transformer tank. Test links are not normally required on such installations. Bushings rated 230 kV and above, however, would require a bucket truck if full joint preparation is necessary. Test links should therefore be used on these installations unless disconnect switches can be used for isolation in accordance with section 3.04 below.

3.04 **Disconnect switches:** The location or use of transformer disconnect switches at 34.5 kV and below has no impact on whether or not test .links should be installed. Even though the disconnect switch (or switches) can be opened to isolate the transformer from the rest of the system, it does not provide sufficient isolation for testing purposes. The switch insulators are too short (creepage distance) to provide the necessary insulation from ground for the Doble tests. Therefore, even with the switch open, the bushings connections would have to be removed for accurate test results.

At 69 kV and above, however. The switch insulators are sufficient height so that they would have only a negligible affect on the tests. Therefore, if a disconnect switch is located close enough to the transformer (25 feet or less to limit electrostatic interference and there are no intermediate bus supports, then test links would not be required.

Those installations where the leads to the transformer surge arresters can be readily disconnected without the use of a bucket truck. This would cover all installations at 161 kV and below when the surge arrester connections are made with hot-line clamps. This would not generally be true for installations above 161 kV or for those installations utilizing rigid lead with fixed connections to the surge arresters.

4.0 Location of test links

Test links should normally be installed on the transformer bushings. This makes them accessible from the top of the transformer.

If the design of the substation is such that a bucket truck will normally be required for Doble tests, the test links can be cantilevered off the rigid bus rather than on the bushings. This is acceptable at 500 kV installations since a bucket truck is required because of the bushing height. This practice may also be acceptable at lower voltages because of unique physical designs.

5.0 Application chart

The application chart shown in Figure 1 is based on criteria Outlined in the previous sections. It is expected that this chart can be applied for most installations. Unique equipment or substation designs may preclude the use of this chart. Such cases shall be reviewed with the physical design engineer to determine if test links are required.

SUBSTATION DC SYSTEMS

This document describes NSP's present practices with respect to direct current (DC) systems, in substations. Generally, a DC system consists of a substation battery, a charger, and a delivery system for equipment requiring DC power in substations. This document is not intended to be fully comprehensive or limiting in regard to the application and protection of the DC systems.

1.0 GENERAL

The DC system supplies power for the circuit breakers, motor operated switches, instrumentation, emergency lighting, communications, fire protection system, annunciators, protective relaying and fault recorders at substations.

A standard DC system consists of three major components: a battery, a charger, and a distribution system. Normally, the battery is float charged by the battery charger. That is, the battery charger supplies all the continuous DC load connected to the bus and powers the battery in order to maintain it in a full state of charge. Under normal conditions, the battery does not supply any load but is held in the fully charged condition, ready to supply the DC loads for continuous operation or simultaneous tripping events if all AC sources to the battery charger are lost.

2.0 BATTERY SELECTION CRITERIA

When selecting a battery based on capacity and/or performance, it is of great importance that all applicable criterion is reviewed to insure that the most reliable, cost affective battery has been selected for the life of the installation. All batteries exhibit different operating characteristics.

Factors to consider:

- Load on the DC system when the maximum output of the battery charger is exceeded.
- Demand on the battery when the output of the charger is interrupted.
- Duration of the battery carry over, when auxiliary AC power is lost.
- Battery Life - What is the projected minimum life of the installation?
- Cost/Reliability - What was the cost and quality of the battery initially selected?
- Operating Temperatures - Will the battery be subjected to temperature extremes?
- Maintenance Intervals - The overall reliability of the battery depends on proper maintenance.
- Location - Will the battery be located where required maintenance can be completed? Is the battery properly ventilated? Will any associated equipment be susceptible to damage from corrosive lead acid fumes?
- Cycle life - Will the battery be required to perform numerous charge/discharge operation throughout its life. Certain batteries are not conducive to repeated discharge/charge cycles.
- Vibration/Shock - Will the battery be located near rotating equipment? Lead-acid batteries easily shed their active materials from the surface of the plates, affecting battery life.
- Weight/size - Physical size and weight can play a significant role in determining the type of battery to be selected. Is there enough room for the battery and rack in the proposed location?

3.0 LEAD ACID BATTERY

Lead-acid batteries in various forms are currently in use at NSP, including: Wet cells (Lead-Selenium, Lead-Calcium, Lead-Antimony) and Valve-Regulated Sealed Batteries.

Lead-acid, "wet cell" batteries, use lead plates immersed in a water diluted solution of sulfuric acid, to produce electricity. Lead-peroxide, which is the active material on the positive plate when charged, reacts with the pure lead in the negative plate, through the electrolyte, to create the electric discharge. The chemical reaction results in the conversion of the active material to lead sulfate on each plate.

Present design of the plates, both positive and negative, use grids made from lead alloys. The grids contain small amounts of either selenium, antimony or calcium to provide strength. The amounts of these materials in the lead are small enough to preserve the good electrolytic properties of the lead. When the grids are filled with lead compounds in a paste form, they are called pasted plates. If the positive grids use pure lead with the surface area increased by mechanical means, they are called Plante' plates, after the inventor, Plante'.

The valve-regulated, sealed lead-acid batteries in use by NSP, are of the absorbed glass mat design. These batteries have the positive and negative plates separated by a highly porous fiberglass mat that contains the required electrolyte to deliver the desired capacity. The other valve-regulated, sealed lead acid battery available is a gel cell. These batteries have the lead plates surrounded by a gelled acid solution that provides the electrolyte to deliver the desired capacity. This type of battery is commonly referred to as "sealed" or "maintenance free". Both of these terms are incorrect because they are valve-regulated (not sealed) and they require, at minimum, annual routine inspections.

The valve-regulated batteries that are currently in limited use on NSP's system are being evaluated by the Electric Maintenance and Protection Department. At this point the valve-regulated batteries are only being purchased in special circumstances. The Electric Maintenance and Protection Department should be consulted before any new valve-regulated, sealed lead-acid battery systems are purchased. It is expected that at some point in the future, if the evaluation of the original valve-regulated batteries is positive, that additional valve-regulated systems will be purchased.

4.0 BATTERY SIZING

Three basic factors determine the size of the battery: 1) Minimum System Voltage, 2) Maximum System Voltage and 3) The Load Profile. Since substation batteries are composed of a number of cells connected in series, the voltage of the battery, is the voltage of a cell times the number of cells in series. The capacity of a battery, is the same as the capacity of a single cell, which depends upon the size and number of plates.

4.1 Maximum and Minimum DC System Voltage

The normal DC operating voltages at NSP are: 27 volts, for 24 volt nominal systems, 52 volts, for 48 volt nominal systems and 130 volts, for 125 volt nominal systems. The float voltages (voltage in the nominal charged condition) for an individual cell will vary from approximately 2.17 volts per cell to 2.25 volts per cell depending on the type of battery. In most cases, these batteries are equalize charged (continuation of the regular charge at a higher voltage to bring the battery back to a fully recharged condition) at approximately 2.33 volts per cell.

The number of cells connected in series is based on the required minimum and maximum voltages of the battery load. Currently, NSP is purchasing lead calcium and lead selenium battery systems whose individual nominal cell voltage is approximately 2.25 volts per cell. These batteries require 12 cells for the 24 volt system, 23 cells for the 48 volt system and 58 cells for a 125 volt system. Some older installations, where lead-antimony batteries (2.17 volts per cell nominal) were used have 24 cells for 48 volt DC systems and 60 cells for 125 volt systems.

The maximum acceptable cell voltage is approximately 2.40 volts per cell. At this point excessive battery gassing (evolution of hydrogen and oxygen) occurs and the maximum voltage limits of the connected equipment is approached. The minimum voltage for these battery cells is typically 1.75 volts per cell, which is normally considered fully discharged. As the voltage falls to this level the ability of connected equipment to operate may become questionable. Typically, breaker trip coils will operate at half their rated voltage but other DC operated equipment may not function properly at or around 1.75 volts per cell. Make sure to check connected equipment ratings if there are any questions.

The voltage of the battery is calculated by using the following formula:

$$(Voltage\ of\ the\ Cell) * (\#\ of\ Cells\ in\ Series) = Battery\ System\ Voltage$$

The number of cells and the end voltage of a battery system can be calculated using the following formulas:

$$Number\ of\ Cells = \frac{Max.\ Allowable\ Battery\ Voltage}{Max.\ Cell\ Voltage\ Required\ for\ Charging} = 58 Cells = \frac{140V}{2.40Vpc}$$

$$End\ of\ Voltage = \frac{Min.\ Allowable\ Battery\ Voltage}{Number\ of\ Cells} = \frac{1.75 Volts}{Cells} = \frac{101.5V}{58}$$

4.2 LOAD PROFILE - Sizing Criteria

At NSP, substation batteries are usually sized to operate during a "Worst Case" tripping event after a 12 hour blackout. The "Worst Case" event consists of a fault occurring somewhere in the substation and while attempting to clear, a single breaker fails to open (single contingency), causing additional breakers to operate. The scenario that causes the most current to be drawn from the battery is considered the "Worst Case" event. The engineer must randomly place faults at different locations in the substation and add up the DC loads, until the "Worst Case" is found. Often this "Worst Case" scenario occurs during a transformer fault.

The load profile typically associated with NSP substations consists of a continuous load (Ic) that starts on loss of ac (black-out), and lasts **11 hours and 59 minutes**. At that point, a momentary load (Im) occurs from the tripping of equipment and lasts for one minute.

The operation of DC equipment in any substation may consist of a different load profile than that assumed here. It is the responsibility of the individual sizing the battery to investigate the DC loads connected to the battery and develop a new "Worst Case" load profile.

TYPICAL NSP SUBSTATION D.C. LOAD PROFILE

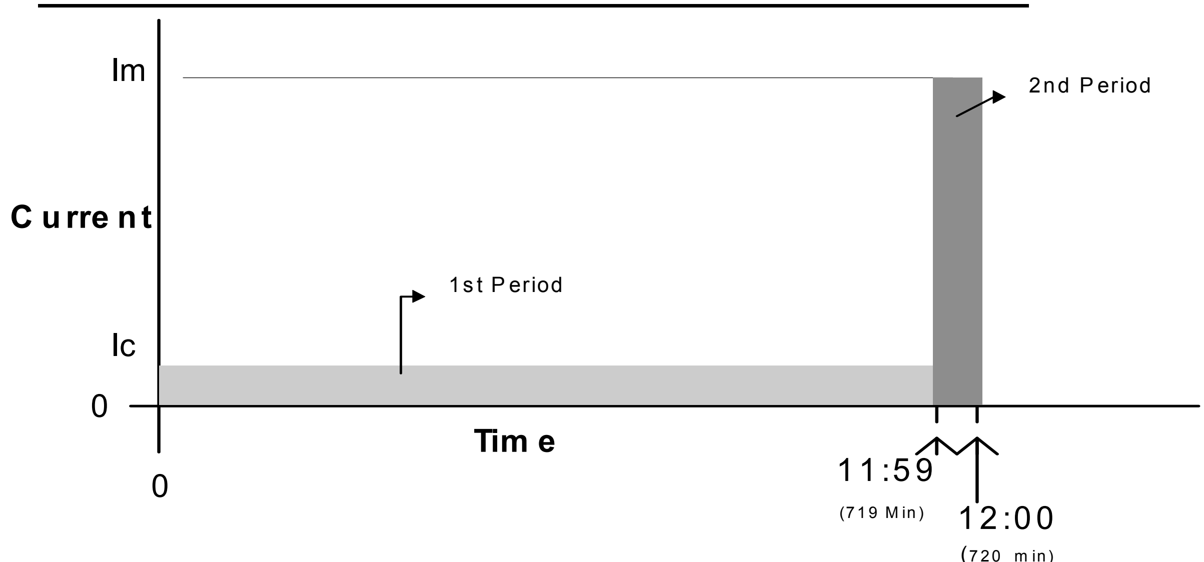


Figure 1

The following is the basic formula used by Substation/Transmission Services to size substation batteries with the load profile in Figure 1: This formula is consistent with IEEE 485-1983 for sizing a battery with two load periods.

$$C = \left[(\frac{Ic}{TCF}) * K_T + (\frac{Im}{TCF}) * * K_T \right] * [\,AF\,] * [\,DFEM\,]$$

Where :	C	=	Ampere our capacity (at the 8 hour rate)
	K_T	=	"K_T" value, (Constant from manufacturers data)
	Im	=	Momentary current (less than 1 minute)
	Ic	=	Continuous current
	TCF	=	Temperature Correction Factor to 55°F
	AF	=	Aging Factor
	$DFEM$	=	Design and future equipment margin

"K_T" is the ratio of rated ampere hour capacity at a standard time rate, at 25°C (77°F), to a standard end of discharge voltage of a cell, to the amperes that can be supplied by that cell for "T" minutes at 25°C.

4.2.1 Continuous loads (Ic) - Loads that the substation battery would have to carry throughout the duty cycle once the battery charger quits operating. This is the load typically carried by the battery charger when it is operational. (Example: indicating lights, continuously energized coils, relays, carrier equipment, etc.) When replacing an existing battery, the continuous load used for sizing can be taken from the ampere meter on the existing charger. If the continuous load is being calculated, then all loads connected to the DC cabinet must be included.

Typical Continuous DC loads (engineer to verify for each specific device)

- Line relay = 3 amps
- Annunciator = 2 amps
- Telephone = 0.5 amps
- Data retrieval = 3 amps

4.2.2 Non Continuous Loads - Loads that are energized only during a portion of the duty cycle and may come and go for any length of time. (Example: generator pump motors, emergency lighting). This type of load is not typically seen in NSP substations. There may be some cases (plant batteries) when a "non-continuous" load needs to be incorporated into a DC load profile.

4.2.3 Momentary loads (Im) - Loads lasting for short time periods, usually less than 60 seconds. Loads lasting less than 60 seconds, are considered to last a full minute, even if the duration is for only a few seconds. This is because the voltage drop of the battery for a given momentary load of only a few seconds, is essentially the same as the voltage drop for that same load, after one minute. For NSP substations a worst case tripping scenario must be found and the amount of current that each trip coil and motor will draw during this event must be calculated.

4.2.3.1 Breakers - Use trip coil ratings. Typically, breakers with two trip coils will have them both energized during a worst case event (primary and secondary relaying). Thus, when adding the number of breakers that will operate and the amount of current that will be drawn, make sure you assume both trip coils being energized. Trip Coil ratings range from 3-100 amperes.

4.2.3.2 MOD's - Use the locked rotor current when defining the momentary current drawn for MOD's. This value is used because the worst case scenario is when the switch is asked to open and hesitates because it's covered with ice. Typical values for locked rotor current will run from 10 - 60 amperes.

4.2.3.3 Base Load - An additional 20 amperes of "base load" should be added to the trip coil and motor currents to allow for the current used by control systems when clearing a worst case fault.

4.2.4 Aging Factor - ANSI/IEEE Std 485-1983 recommends that a battery be replaced when its actual capacity drops to 80% of its rated capacity. Therefore, the battery's rated capacity should be at least 125% of the load expected at the end of its service life. Currently, NSP does not use an aging factor when determining the size of its battery system. The reason is most of NSP's batteries are failing, for reasons other than age, after 12 to 14 years of service. It is felt, that at the present time it is not economically feasible to purchase additional battery capacity for a time frame, in the life of a battery, that the battery will probably never reach, due to other failures.

4.2.5 Design and Future Equipment Margin A design margin should be used based on the confidence of the load profile that was developed. It should also account for **less-than-optimum** operating conditions of the battery due to improper maintenance or recent discharge. A future equipment design margin should also be added based on the probability of additional DC load being introduced during the expected life of the battery. A typical design margin used in a substation where there is very little future DC load growth expected and a relative high confidence in the load profile exists would be 10%-20%.

4.2.6 Temperature Correction Factor When sizing a battery, the minimum and maximum temperatures that might be seen must be considered. Typically, the batteries that are bought for NSP substations are rated at 77°F at the eight-hour rate. As temperatures increase from 77°F, the available capacity increases and as temperature decreases the capacity decreases. Besides the change in capacity, there are side effects that occur as the temperature changes.

If temperatures in the area around the battery are expected to deviate from 77°F, then a temperature correction factor must be used. A temperature correction factor is required to select a cell large enough to have the required capacity available at the lowest expected temperature. Currently, NSP sizes the battery based on the assumption, that the minimum battery cell temperature will not drop below **55°F** during the "worst case" 12 hour black out in a substation. This is a difficult temperature to verify because cell temperatures have not been monitored for extended periods of time, in extremely cold weather when AC power is lost in the substation. Manufactures have gone as far as to saying that the cell temperature will lag ambient temperature changes by several hours. This is an item that needs to be addressed in the future, especially in NSP's northern substations.

The following temperature correction factor (TCF) table is used by NSP is sizing batteries.

Electrolyte Temperature °F	°C	Temperature Correction Factor	Electrolyte Temperature °F	°C	Temperature Correction Factor
25	-3.9	0.658	76.0	24.4	0.994
30	-1.1	0.699	77.0	25.0	1.000
35	1.7	0.741	78.0	25.6	1.006
40	4.4	0.769	79.0	26.1	1.013
45	7.2	0.800	80.0	26.7	1.020
50	10.0	0.840	81.0	27.2	1.025
55	12.8	0.870	82.0	27.7	1.029
60	15.6	0.909	83.0	28.3	1.033
65	18.3	0.926	84.0	28.9	1.037
66	21.1	1.040	85.0	29.4	1.042
67	19.4	0.940	85.5	29.7	1.046
68	20.0	0.947	86.0	30.0	1.050
69	20.6	0.954	87.0	30.5	1.055
70	21.1	0.962	88.0	31.1	1.059
71	21.7	0.967	89.0	31.7	1.064
72	22.2	0.972	90.0	32.2	1.075
73	22.8	0.977	95.0	35.0	1.090
74	23.3	0.983	100.0	37.8	1.136
75	23.9	0.989	120.0	48.9	1.163

TABLE 1

Note: A more detailed procedure for sizing substation batteries is described in the IEEE standard 485-1983. The method shown above is a simplified version of one of the two methods of sizing batteries that are outlined in IEEE 485-1983. NSP has preferred to use this simplified method for sizing substation batteries because of the simplistic load profile that is assumed for most substation application.

Application spreadsheets have been created and exist on the LAN to assist in calculating the size of the battery.

M:\ENG\BATTERY\BATPROF.XLS	Calculates the size of battery and battery charger required based on load profile.

5.0 BATTERY RACKS AND CELL PLACEMENT

5.1 Battery Racks

The main concern with battery racks should be to reduce height variations between upper and lower racks. Height variations will cause differences in cell temperatures within the same battery system. Since temperature can have such a drastic effect on battery characteristics, interconnecting cells at different temperatures can lead to an early failure of the battery system. As a general rule, temperature gradients in excess of 5 degrees Fahrenheit should be avoided.

When selecting a battery rack, there are several things including temperature differences, weight of the battery, available space and maintenance requirements that must be considered. A battery rack should be selected in the following order based on the constraints listed above.

1. **Single tier**
2. **Two step**
3. **Two tier**
4. **Three step**
5. **Three tier**
6. **Two step/tier**

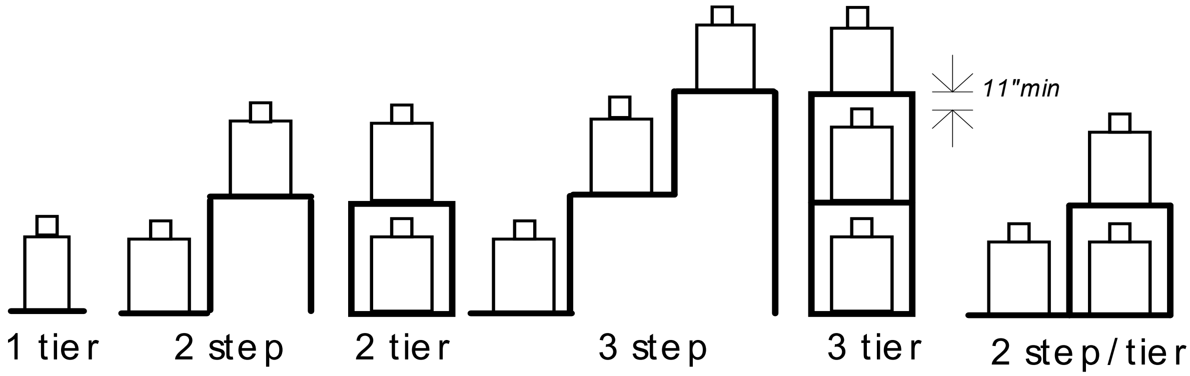


FIGURE 2

Single tier racks are preferred, because the battery is easily accessible for maintenance and installation. A single tier rack also ensures that the cells are held at a closer temperature. Maintenance prefers the use of step racks, instead of tiered racks. Often this is impossible because of the space limitations. When selecting a step rack make sure there is sufficient width available in the control house or battery room. Two and three tier racks are probably the most widely used at NSP because of space limitations in the control houses.

5.2 Battery Cell Placement

In general, the battery jars should be located 1 inch from the side supports of the battery rack and should be spaced approximately 1/2 inch from adjacent jars. When using two or three tier racks, maintenance requires at least 11 inches between the top of the battery and the bottom of the rack above the cell. The 11 inches, is the room required to place a hydrometer in the top of a battery when taking specific gravity readings.

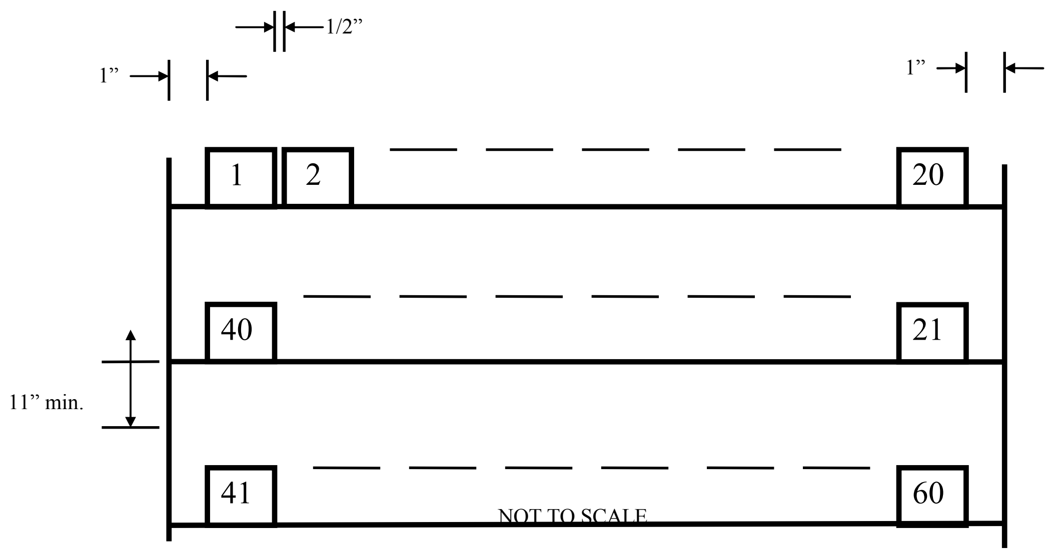


FIGURE 3

Once on the rack, the battery cells should be labeled such that the #1 cell is located in the upper left hand corner of the rack and should follow the convention in figure 3. The positive lead to the battery should also connected to the upper left hand (#1) cell and the negative lead should be connected to the lower right hand cell (see figure 6).

For many years, NSP fabricated its own battery racks. In recent times many of these racks have shown evidence of bowing in the middle, causing pressure on the post seals of the battery. Because of cost, ease of installation and stronger racks, NSP has been purchasing new battery racks directly from the battery manufacturer. See EE 1.2903 for information regarding the details and sizing criteria that were used in the past for these NSP fabricated battery racks.

6.0 GROUNDED VS UNGROUNDED SYSTEMS

NSP has two types of DC systems, **grounded** and **ungrounded**. Nominal voltage ratings for ungrounded DC systems in substations are 24 volt, 48 volt, and 125 volt DC. Grounded systems are typically seen only on older 48 volt batteries at NSP.

6.1 Ungrounded Systems

Most of NSP DC systems are of the ungrounded type. This means that positive and negative terminals are connected across all loads without using a station ground. Ungrounded systems are safer to use. Unintentional grounds can be easily detected by checking the voltage to ground from the positive and negative terminals. The location of battery main fuses should be installed as shown below.

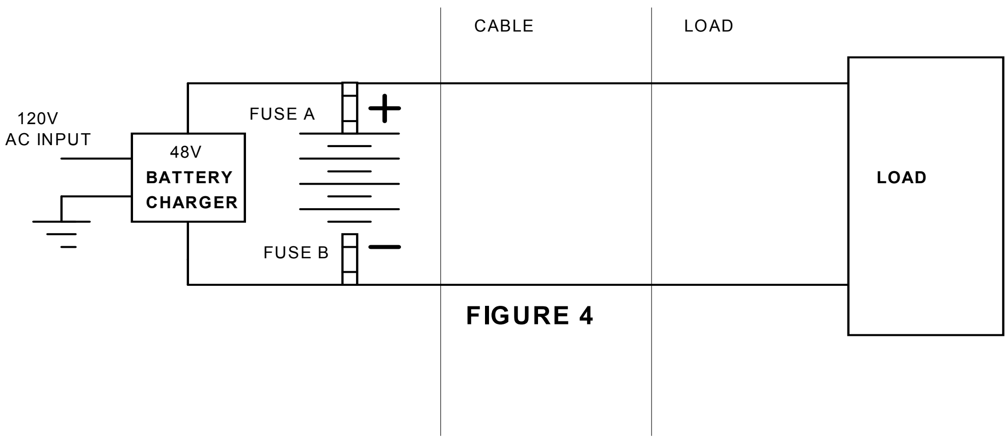


FIGURE 4

6.2 Grounded Systems

Some DC systems require a positive ground and some a negative ground. The ground is used to protect semiconductor devices from transients and noise. Radio noise is very high when an ungrounded chassis is used. This reduces the "signal to noise ratio" potentially causing the device to misoperate. A grounded system also makes it more difficult to locate unintentional grounds with de-energizing the load equipment. Wherever it is technically and economically possible, grounded DC systems should be avoided. Grounded DC systems should never be allowed where the load includes power circuit breaker trip coils.

Whenever a grounded DC system is unavoidable for electronic equipment the following procedures are recommended. The battery main fuses should be installed in both the positive and the negative main battery cables, at the battery end, as close as possible to the battery. The permanent ground should be installed at the equipment or load end, not at the battery end. Ground detectors need not be installed. A sign should be mounted on the battery charger, warning personnel that a grounded system is present. Battery leads must stay within the control house. (See CE 1.1100)

The location of battery main fuses and permanent ground should be installed as shown below.

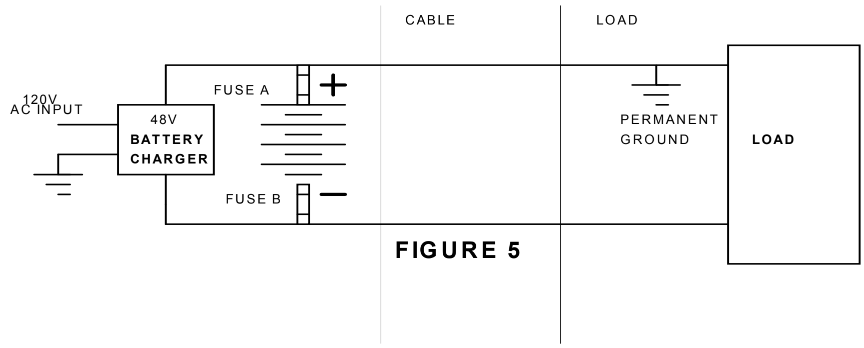


FIGURE 5

7.0 MAIN BATTERY FUSING

The battery main fuses protect the battery against faults in the cable between the battery and the DC fuse cabinet or against faults on the bus in the DC fuse cabinet. These fuses shall not be considered as backup protection for the branch fuses. The main fuses are sized to allow all but a solidly bolted fault to cause them to operate. This is to avoid the nuisance of blown fuses and keep DC power operating the control systems as long as possible. The fuse is also used as a disconnect point to isolate the battery when necessary. This is true for both grounded and ungrounded battery systems.

The main fuses should be placed in an individual cabinet and positioned on either both sides of the battery rack or next to each other on one side of the battery rack. The cabinet placement should be made by looking at the type of rack (two tier vs. three tier) and the physical constraints surrounding the battery (See examples in Figure 6).

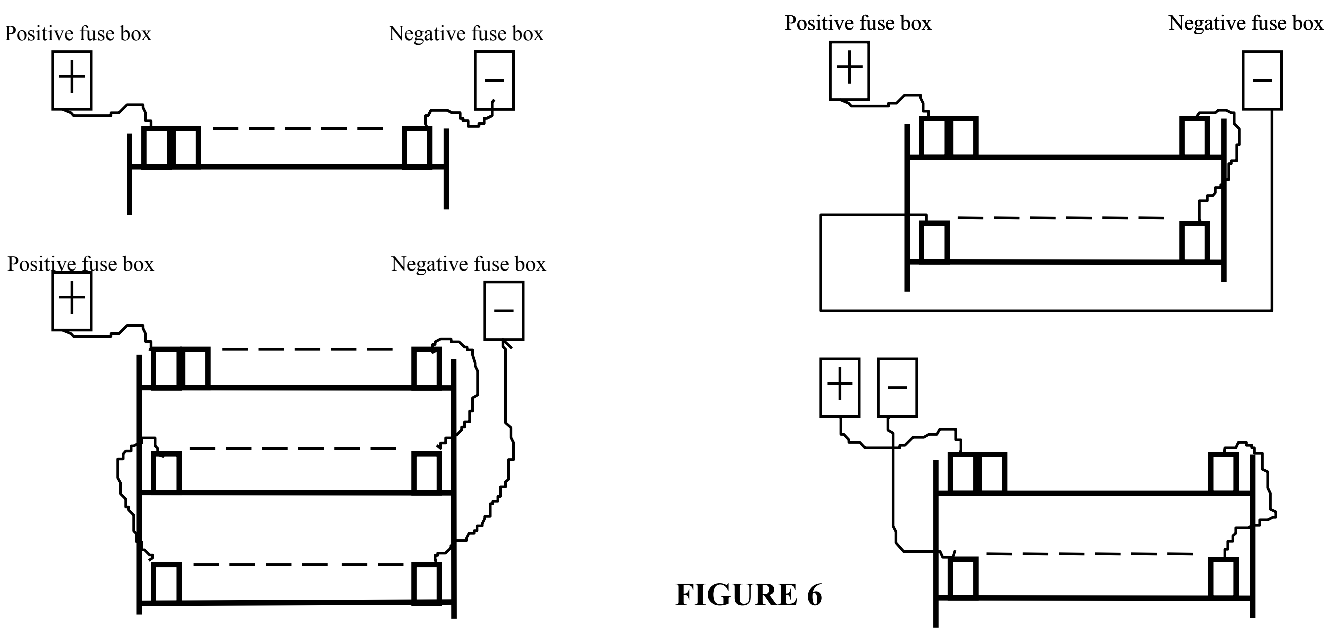


FIGURE 6

The fuse cabinets, based on one fuse per cabinet, shall be sized in accordance with the Table 2.

Fuse Block Size	Cabinet Size
31 - 60 Amp.	1'- 8" H x 8" W x 6" D
61 - 100 Amp.	1'- 8" H x 8" W x 6" D
101 - 200 Amp.	1'- 8" H x 8" W x 6" D
201 - 400 Amp.	2'- 0" H x 10" W x 6" D
401 - 600 Amp.	2'- 6" H x 12" W x 6" D

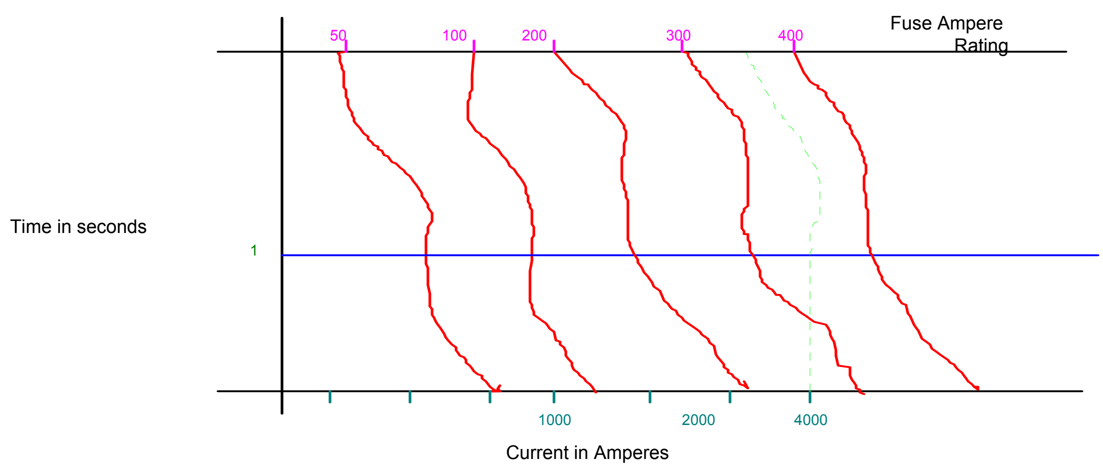
TABLE 2

The lead acid batteries that NSP purchases can produce fault currents from 7 to 12 times the 1 minute discharge rating of the battery. The battery can withstand the full fault current for more than a second without damage to the battery. NSP selects battery main fuses to operate in **one second for a fault 10 times the one minute discharge rating of the battery**. The main fuse should be selected from the time current characteristic curves for Bussman type FRN-R, 250 volt AC fuses. These fuses are fully UL listed for 125 volt DC.

EXAMPLE

BATTERY MANUFACTURER	TYPE	BATTERY SIZE	1-MIN. RATING	BOLTED FAULT	SELECTED FUSE TYPE
C&D	KCR-9	330 A.H.	404A	4040 A	FRN-R 250V/400A

Find the one minute current rating (to 1.75 v/c) of the battery (404A). Multiply the 1 minute rating by 10 (4040A) and locate this value on the time current characteristic curves for the FRN-R fuse. Find the intersection of the current value and the one second point on the graph. Follow the nearest curve to the top of the graph to locate the proper fuse size (400A fuse). If the curve ends between two fuse sizes use the larger of the two sizes. (See graph below)



SAMPLE TIME CURRENT CHARACTERISTIC CURVE

8.0 OVER & UNDER VOLTAGE ALARMS

Over and Under voltage alarms are set to give operating personnel a warning signal that something is not operating properly with the DC system. It is important that low and high battery alarms be set at voltages, which will indicate a battery warning and not give erroneous alarms. These alarms are typically sent to the annunciator panel and the RTU. See CE 1.0111 for current alarm requirements.

8.1 Low Voltage Alarm:

The low voltage alarm should be set at a voltage that indicates to the annunciator that the battery is beginning to discharge into the load. This is of concern since the battery voltage may drop quickly in the first hour after AC is lost. A battery starts to lose capacity quickly after it reaches 2V/cell. Little capacity is lost until the battery discharges to 2V/cell, that usually takes about an hour after the charger loses power.

8.2 High Voltage alarms:

The high battery alarm, when received, indicates an unstable voltage condition caused by the charging source. The high alarm should be set at a point where excessive battery gassing occurs or hydrogen over voltage begins. It is also set at a point to protect connected equipment from higher than recommended bus voltages.

The following high/low voltage ranges have been established for lead acid stationary batteries, intended for general substation use. It should be noted that the values are initial settings and can be varied if battery configurations or connected load requires another setting. The settings are intended to give an early indication of trouble but not unwarranted over-protection.

LEAD ACID BATTERY ALARMS

No of Cells Lead Acid	Low Voltage Alarm	High Voltage Alarm	Acceptable Range Low Voltage Alarm	Acceptable Range High Voltage Alarm
120	240	288	240 - 242	288 - 289
60	120	144	120 - 121	144 - 145
58	116	139	116 - 117	139 - 140
24	48	58	48 - 49	48 - 59
23	46	55	46 - 47	55 - 56
12	24	29	24 - 24.5	29 - 29.5
11	22	26	22 - 22.5	26.5 - 27

* Low battery alarm set at 2.00 volts per cell
* High battery alarm set at 2.40-2.41 volts per cell

9.0 DC CABLE SIZING - (From Battery to DC Cabinet)

The cable size for the DC distribution system depends on the acceptable voltage drop, continuous current rating and burn off characteristics (fault current).

9.1 Voltage Drop

Voltage drop is not normally a problem because the battery, charger and DC cabinet are usually in close proximity. If this is not the case, then the cable size should be investigated. See standard EE 1.3511 for further cable sizing information.

9.2 Continuous Current Rating

Since the continuous current delivered through the main battery cables, in almost all cases, is relatively small (≤ 20 amps) there is little concern with sizing the cable for continuous current. **This does not relieve the engineer from making sure the main battery cable is properly sized.**

9.3 Burn-off Characteristics

The available fault current from the lead-acid batteries that NSP buys is somewhere between 7 and 12 times the one minute rating of the battery. NSP uses 10 times the one minute rating to select the cable size and coordinate fusing.

The size of the cable from the battery to the main fuses and from the main fuses to the DC cabinet should be large enough to withstand the full fault current for a period of time long enough for the main fuse to blow. The main fuse is coordinated to blow for a bolted fault at approximately one second. The cable should be designed to carry the full fault current for a longer period of time, (approximately two to three seconds). Currently, NSP uses extra flex welding cable. This cable has excellent high current characteristics and is very flexible allowing tight bends and easy installation. The following are guidelines NSP uses for sizing this cable.

a) #1/0 rubber insulated extra flex copper welding cable for batteries 0 to approximately 350 A.H. (The 1 minute rating must be < 400 amperes)

b) #4/0 rubber insulated, extra flex, copper welding cable for batteries 350 to approximately 1000 A.H., (the one minute rating must be < 1200 amperes).

c) The conductor size for a battery over 1000 A.H., one minute ratings over 1200 amperes or with continuous current in the system over 40 Amps. should be reviewed with engineering.

10.0 DC CABINETS AND CONTENTS

10.1 DC Distribution Cabinets

All fuse cabinets must have doors hinged on the longest side of the cabinet. Cabinet dimensions depend upon the fuse and wire sizes. Those over 2'- 0" wide must have double doors similar to the Telephone Equipment Cabinets shown on master drawing NH-59197. Conductors normally enter from the top and/or bottom. Master drawings NH-57687 (for steel cabinets) and NH-59208 (for aluminum cabinets) are used for design and ordering information.

The following is a list of standard size dc distribution cabinet drawings:

50 Position (Alum) - NH-94258
50 Position (Steel) - NH-94259
34 Position (Alum) - NH-94260
34 Position (Steel) - NH-94261

10.2 Fusing

Branch type circuits with motors shall use time-lag type FRN fuses. All other circuits should use one-time, type NON fuses which are sized according to the load. Normally, the wire size shall be based on the fuse size and voltage drop. (See Engineering Design Std. EE 1.3511 and Control Engineering & Design Std CE 1.0803).

All fuses 60 amps and below, including those for outdoor boxes, are supplied and installed by the field according to the Schematic Diagram. However, so that they are not overlooked, they should be included in the material list as one item, to be ordered "By Field" and described as "Fuses per Schematic Diagram". No quantities are required.

10.3 Cables Originating from the DC Cabinets

The main supply cables should be sized for the load that they carry. In some cases, DC must be provided across very long distances (Example: to a MOD in a remote corner of a very large substation). In these cases, the voltage drop should be calculated so the correct size cable can be selected to provide proper voltage to the equipment being served.
The nominal voltage and the permissible ranges for the DC distribution system for switching and interrupting devices are as shown. (ANSI C37.16-1980). Check each individual piece equipment for its specific electrical ratings.

Rated Voltage	Voltage Range
24 VDC	14 - 28 Volts
48 VDC	38 - 56 Volts
125 VDC	105 - 130 Volts

11.0 BATTERY CHARGER

Battery chargers convert AC into a regulated DC output, which is used to charge the battery and to supply all continuous loads connected to the bus. The standard nominal AC input, is single-phase, 240 volts. Some older installations have a single-phase, 120 or 108 volt AC input. There are a few chargers that operate from 480 volts, three-phase sources. These are typically chargers with DC outputs of 50 amperes or greater.

The battery charger can tolerate AC input voltage variations of $\pm$ 10%. Nominal DC output voltages are: 27 volts, 52 volts, and 130 volts DC and are normally regulated to within $\pm$ 1%. The DC output of battery chargers normally contains a ripple voltage superimposed on the average output voltage.

In nearly all substation installations the battery chargers are required to supply "float" and "equalizing" voltage for the battery. The "float voltage" is the voltage required to maintain the battery in a fully charged condition, compensating for the internal losses in the battery. The equalizing or high charging voltage is required to **recharge the battery to 95% of full charge within 12 hours after a discharge**. The charging voltage is normally set at 2.33 v/cell (for lead calcium batteries).

The equalizing charge voltage is used to equalize the cell voltage of the battery. Because not all cells charge at the same rate, the voltages of the individual cells can be higher or lower then the average voltage, even though the battery terminal voltage is normal. A longer charging period, at elevated voltage, helps to correct low capacity cells and even out their voltages. Equalizing of lead selenium, lead calcium, or the valve-regulated type battery system is normally not required. Each battery manufacturer has specific instructions regarding equalizing voltage and time to satisfy their design.

11.1 BATTERY CHARGER SIZING

The battery charger is sized to recharge the battery to **95% of full capacity within 12 hours.** The charger is sized with the following formula:

$$\left(\frac{A}{t}\right)g + Ic = I$$

I	=	Calculated charge (amps) of the battery charger
A	=	Size of the battery to be charged (Amp-hours at 8 hour rate)
t	=	Time (typically 12 hours for substations)
Ic	=	Continuous current. This is the same as Ic used to size the battery
g	=	Growth factor (typically 1.15)

The following are some items that should be obtained to properly size a battery using the IEEE Method:

- Sequence of the load on a battery during a worst case tripping event
- Number of circuit breakers & MOD's that will operated
- Individual breaker trip and close currents
- Individual MOD motor currents and run time
- Individual breaker trip and close times
- Individual breaker spring recharge current (if the breaker uses DC motor)
- What is the continuous load current (from the battery charger)?
- Is there emergency lighting? What are the load and time duration?
- What is the minimum and maximum system DC voltage?
- What is the design margin?
- What is the aging factor?
- What are the minimum and maximum temperature ranges?

12.0 MAINTENANCE

This section will be added to in future revisions.

13.0 TOPICS TO BE DISCUSSED IN FUTURE REVISIONS OF THIS DOCUMENT

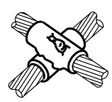
- NESC Rules
- Remote monitoring and testing of battery systems.
- Specification for sealed batteries
- Vendor partnering
- Sizing batteries and chargers in “Black Start” substations.

200902-1-1.DGN

LIST OF MATERIAL FOR THESE DETAILS (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43		4/0 CU. CABLE, 19 STRAND	265		CADWELD SHOT 65, COLOR DARK GREEN
261		GROUND ROD, 3/4" x 10' LONG	266		CADWELD SHOT 115, COLOR ORANGE
262		GROUND ROD COUPLING, 3/4" DIAMETER	267		CADWELD SHOT 150, COLOR DARK BLUE
263		CADWELD LUG TYPE GL	268		CADWELD SHOT 200, COLOR YELLOW
264		CADWELD SHOT 45, COLOR LIGHT BLUE	269		CADWELD SHOT 250, COLOR PURPLE

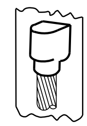
269 4/0 TO 4/0
268 1/0 TO 4/0



DETAIL "A"

TYPE "XB" MOLD
HORIZONTAL X-CONNECTION, LAPPED

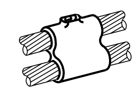
267 4/0
266 #4



DETAIL "B"

TYPE "VB" MOLD
CABLE DOWN TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.

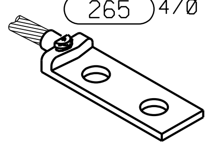
267 4/0 TO 1/0
268 4/0 TO 4/0



DETAIL "C"

TYPE "PT" MOLD
HORIZONTAL PARALLEL THRU CABLE

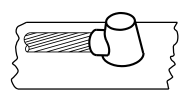
263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"

TYPE "GL" MOLD
CABLE TO LUG

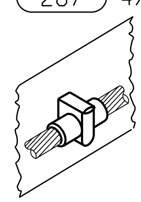
266 4/0 (TYPE "HS")
264 #4 (TYPE "HA")



DETAIL "E"

TYPE "HA" AND "HS"
CABLE TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.

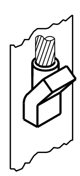
267 4/0



DETAIL "F"

TYPE "VT" MOLD (VTC-2Q-001)
CABLE TO STEEL OR CU.
(THRU CONNECTION)
USE BACKING PLATE ON CU BAR

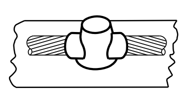
268 4/0
265 #4



DETAIL "G"

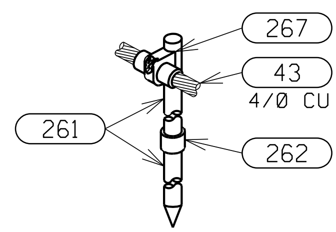
TYPE "VF" MOLD
CABLE UP TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.

264 #4



DETAIL "H"

TYPE "HC" MOLD
CABLE TO PIPE THRU CONNECTION
(ERICO CAT #XLHCA-1L-(PIPE SIZE)
ADD PIPE SIZE AT END OF CAT NUMBER. EXAMPLE: XLHCA-1L-2)



DETAIL "J"

TYPE "GY" MOLD
HORIZONTAL THRU CABLE TO 3/4" GROUND ROD

FIELD NOTE:
- FIELD TO ORDER ALL CADWELD MOLDS, IGNITORS, BRUSHES ETC.
- DESIGNER TO ORDER CADWELD SHOTS ONLY.
- FOR COMMONLY USED MOLDS AND ACCESSORIES SEE XCEL ENERGY STD ED 4.03.02.01.

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-1
SUBSTATION GROUNDING DETAIL
CADWELD MOLD TYPES AND SHOT REQUIRED FOR EACH MOLD

Xcel Energy

SCALE	DRAWING NO.	REV
NONE	NL-200902-1-1	F

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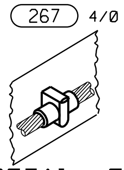
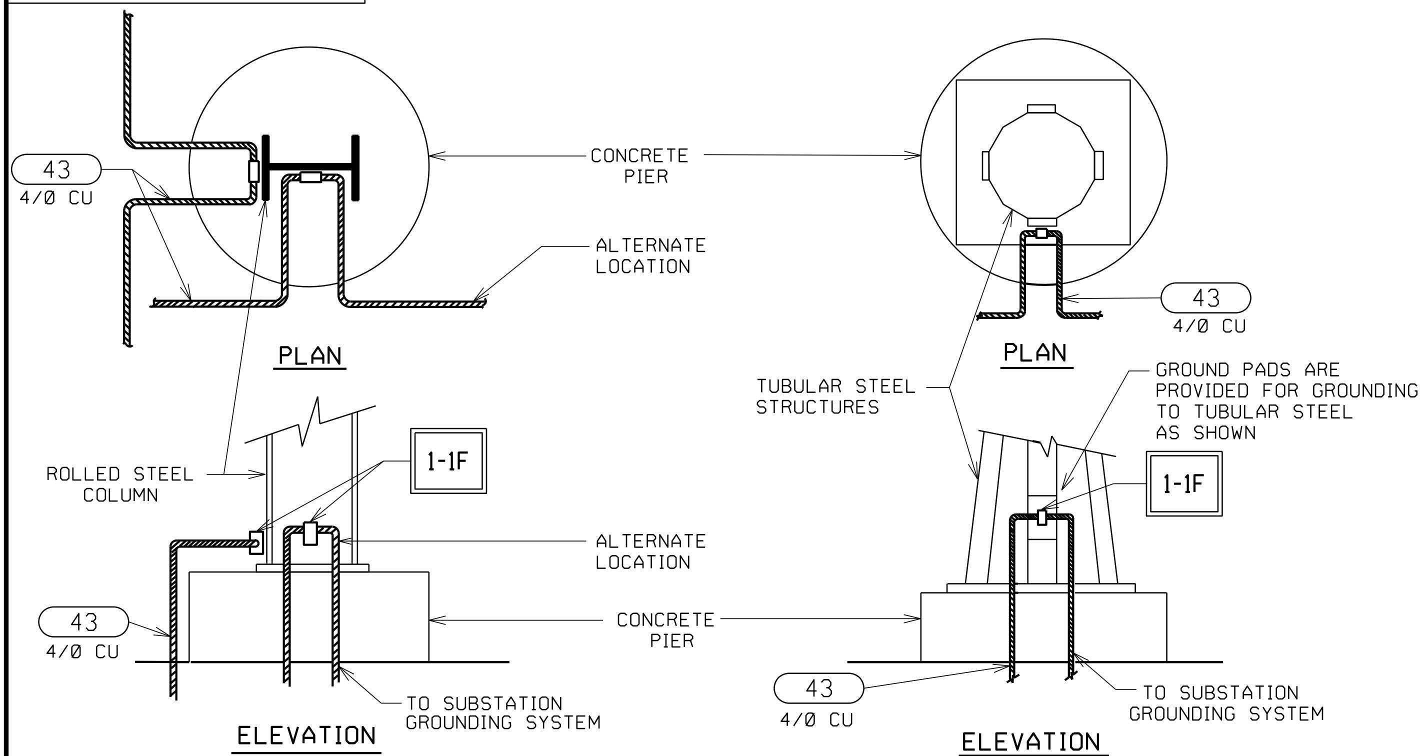
200902-1-2.DGN

MATERIAL REQUIRED FOR CONNECTION TO ONE STRUCTURE

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43		4/0 CU CABLE, 19 STRAND			
267	1 EA	CADWELD SHOT 150, COLOR DARK BLUE			



DETAIL "F"
TYPE "VT" MOLD (VTC-20-001)
CABLE TO STEEL OR CU.
(THRU CONNECTION)
USE BACKING PLATE ON CU BAR



ROLLED STEEL GROUNDING

TUBULAR STEEL GROUNDING

FEILD NOTE:
- STEEL COLUMN MAY HAVE TO BE TOUCHED UP WITH GALVANIZED PAINT AFTER CONNECTION IS MADE.
- LOCATION OF WELD DETERMINED BY CONSTRUCTION.

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-2
SUBSTATION GROUNDING DETAIL
GROUNDING FOR SUBSTATION STEEL STRUCTURES

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-1-2	D

9/19/2013 7:52:10 AM

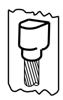
MATERIAL REQUIRED FOR SWING GATE

ITEM NO.	QTY	DESCRIPTION
43	4 FT	4/0 CU CABLE, 19 STRAND
267	3 EA	CADWELD SHOT 150, COLOR DARK BLUE
268	1 EA	CADWELD SHOT 200, COLOR YELLOW
C174	4 FT	4/0 CU INSULATED WELDING CABLE

MATERIAL REQUIRED FOR BARBED WIRE

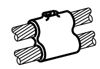
ITEM NO.	QTY	DESCRIPTION
43	4 FT	4/0 CU CABLE, 19 STRAND
53	3 FT	#4 SOLID CU. WIRE
111	3 EA	SPLIT-BOLT CONN. FOR #4 CU.
264	2 EA	CADWELD SHOT 45, COLOR LIGHT BLUE
265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN
266	1 EA	CADWELD SHOT 115, COLOR ORANGE
267	1 EA	CADWELD SHOT 150, COLOR DARK BLUE
268	1 EA	CADWELD SHOT 200, COLOR YELLOW

267 4/0
266 #4



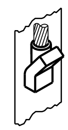
DETAIL "B"
TYPE "VB" MOLD
CABLE DOWN TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.

267 4/0 TO 1/0
268 4/0 TO 4/0



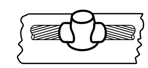
DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

268 4/0
265 #4

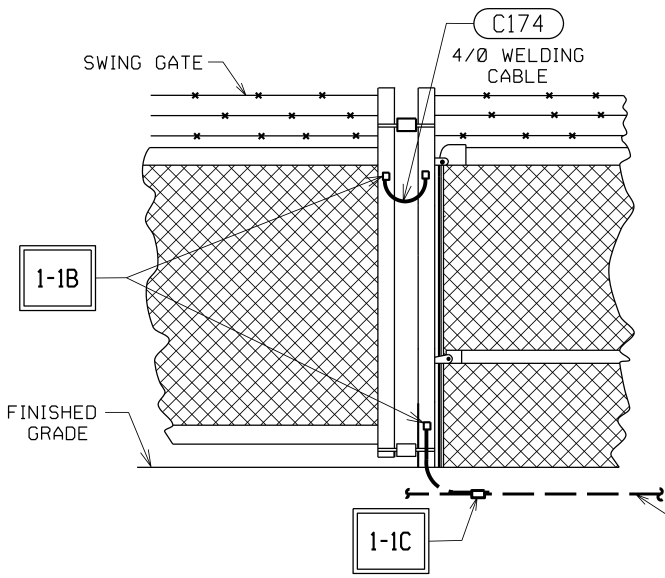


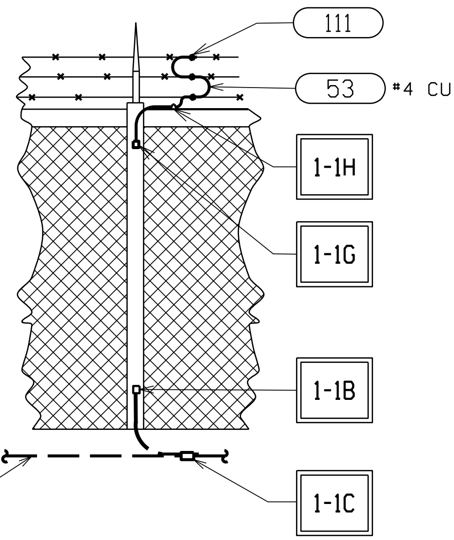
DETAIL "G"
TYPE "VF" MOLD
CABLE UP TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.

264 #4



DETAIL "H"
TYPE "HC" MOLD
CABLE TO PIPE THRU CONNECTION
(ERICO CAT #XLHCA-1L-(PIPE SIZE)
ADD PIPE SIZE AT END OF CAT
NUMBER. EXAMPLE: XLHCA-1L-2)





43
4/0 CU

SWING GATE

GROUND WIRE JUMPER ATTACHED TO FENCE FRAME INSIDE SUBSTATION. PROVIDE ENOUGH SLACK TO OPEN GATE (APPROXIMATELY 36")

BARBED WIRE GROUNDING DETAIL

SPACED EVERY 50'-0" AND POST MUST BE CONNECTED TO GROUNDING SYSTEM.

FIELD NOTE:
- A TEST WELD SHOULD BE MADE TO CHECK THE POSSIBILITY OF BURN-THROUGH ON THIN-WALL PIPE. A TYPE "GL" LUG MAY ALSO BE USED.

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-3
SUBSTATION GROUNDING DETAIL
GROUNDING FOR FENCE AND GATE

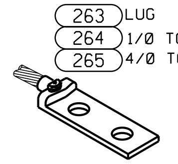
Xcel Energy

SCALE	DRAWING NO.	REV
NONE	NL-200902-1-3	C

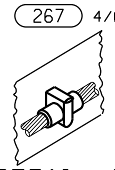
200902-1-3.DGN
11:14:38 AM
9/19/2013

MATERIAL REQUIRED FOR CONNECTION TO ONE TRANSFORMER

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	40 FT	4/0 CU CABLE, 19 STRAND	267	2 EA	CADWELD SHOT 150, COLOR DARK BLUE
72	*	1/4" x 3" x 12" LONG RECT. CU. BAR			
263	4 EA	CADWELD LUG TYPE GL			
265	4 EA	CADWELD SHOT 65, COLOR DARK GREEN			* VARIES

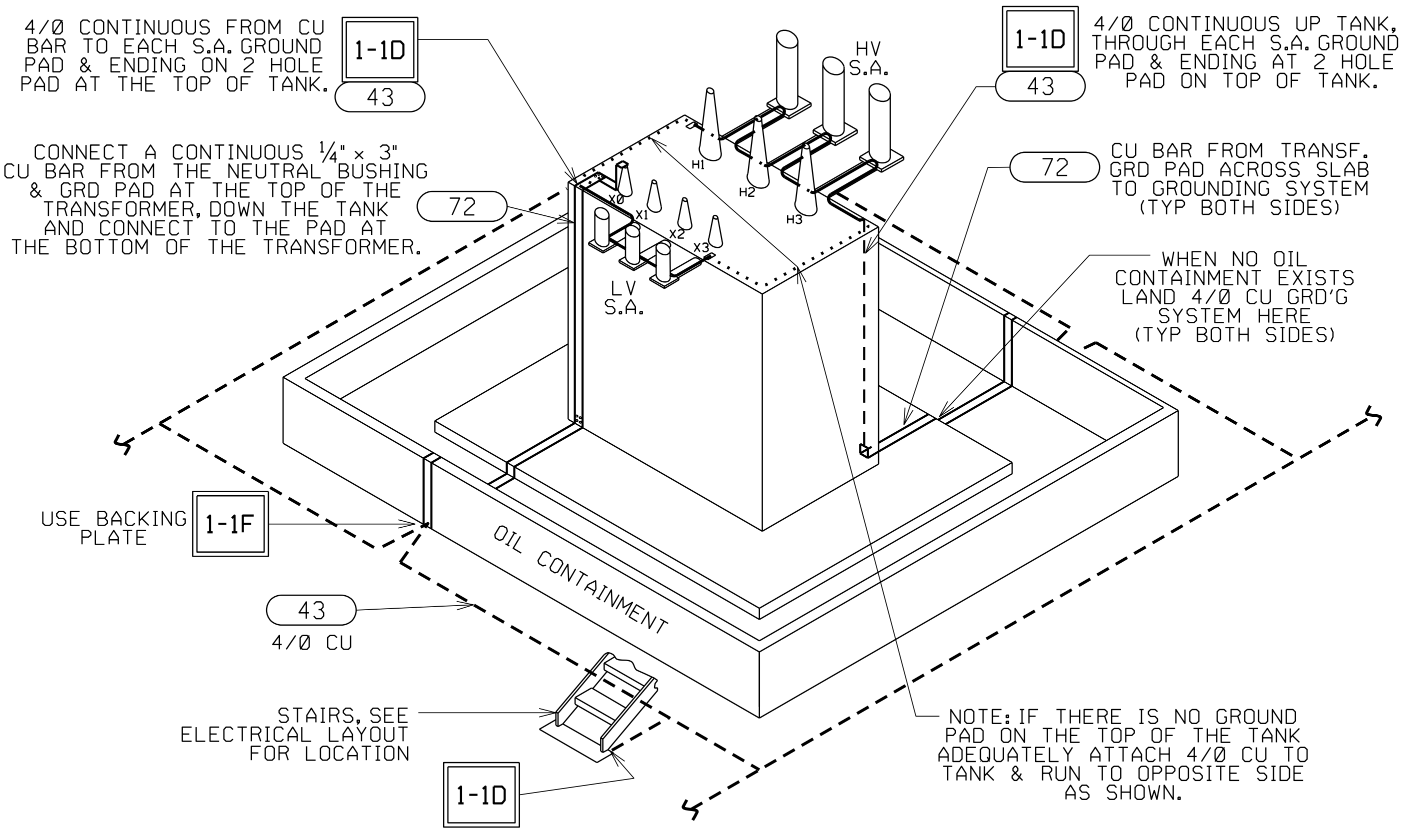


DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



DETAIL "F"
TYPE "VT" MOLD (VTC-2Q-001)
CABLE TO STEEL OR CU.
(THRU CONNECTION)
USE BACKING PLATE ON CU BAR

** NOTE: IF TERTIARY BUSHINGS ARE PROVIDED, GROUND THE SURGE ARRESTERS IN A LOOP SIMILAR TO LOW VOLTAGE ARRESTERS.



FIELD NOTE:
- THE GROUNDING SHOWN IS TO BE INSTALLED, UNLESS SUPPLIED BY MANUFACTURER.

LEGEND:
(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

[1-1F] INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
LOC GRP	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-4
SUBSTATION GROUNDING DETAIL
GROUNDING FOR TRANSFORMER

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-1-4	E

200902-1-4.DGN

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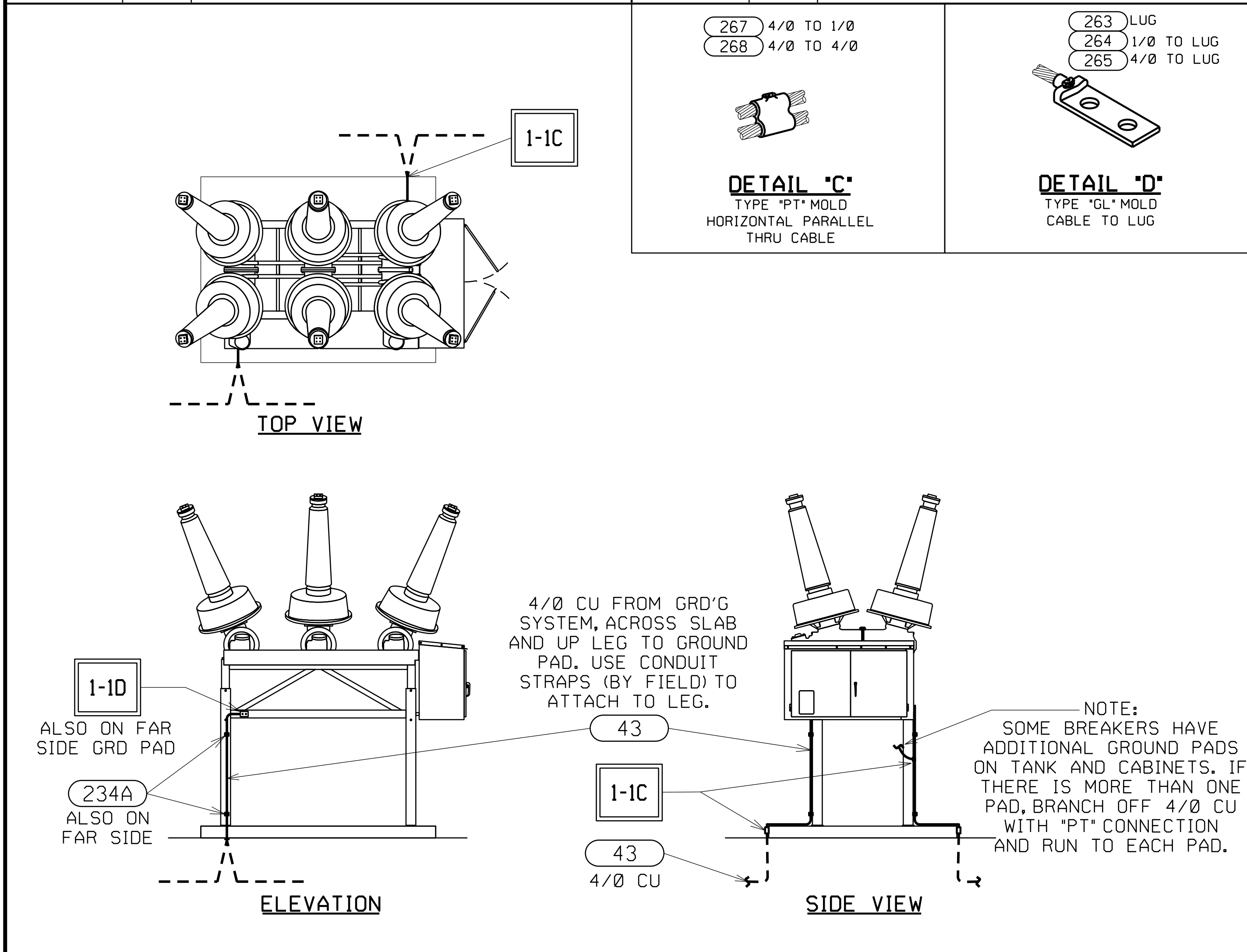
200902-1-5.DGN

MATERIAL REQUIRED FOR CONNECTION TO ONE BREAKER

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	20 FT	4/0 CU, 19 STRAND			
263	3 EA	CADWELD LUG TYPE GL			
265	3 EA	CADWELD SHOT 65, COLOR DARK GREEN			
268	3 EA	CADWELD SHOT 200, COLOR YELLOW			
234A	4 EA	SINGLE GROOVE, SINGLE TAPPED CONN.			



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

[1-1F] INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-5
SUBSTATION GROUNDING DETAIL
GROUNDING FOR BREAKERS

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-1-5	E

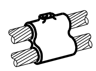
5/20/2011 12:23:46 PM

200902-1-6.DGN

MATERIAL REQUIRED FOR CONNECTION TO ONE NOVA RECLOSER

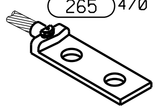
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	10 FT	4/0 CU, 19 STRAND	263	2 EA	CADWELD LUG TYPE GL
53	2 FT	#4 SOLID CU. WIRE	265	2 EA	CADWELD SHOT 45, COLOR LIGHT BLUE
234A	3 EA	SINGLE GROOVE, SINGLE TAPPED CONN.	268	2 EA	CADWELD SHOT 200, COLOR YELLOW
244	1 EA	TEE CONNECTOR FOR #4 TO 250 MCM CU			

267 4/0 TO 1/0
268 4/0 TO 4/0

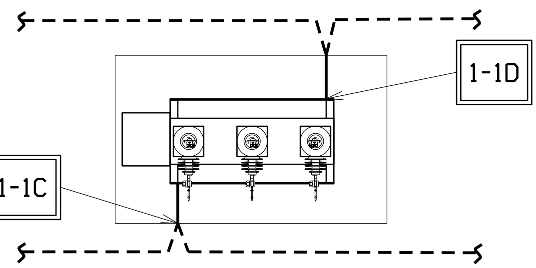


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

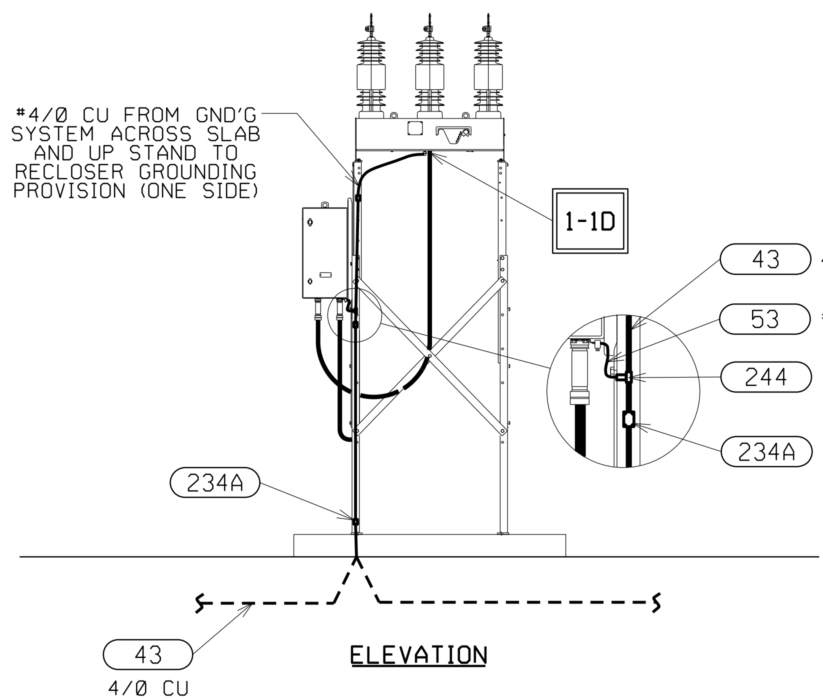
263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



TOP VIEW



ELEVATION

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-6
SUBSTATION GROUNDING DETAIL
GROUNDING FOR NOVA RECLOSER

Xcel Energy®

SCALE		REV
NONE	NL-200902-1-6	C

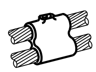
12:24:23 PM 5/20/2011

200902-1-7.DGN

MATERIAL REQUIRED FOR CONNECTION TO ONE BREAKER

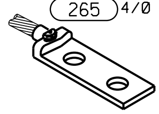
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	20 FT	4/0 CU, 19 STRAND			
234A	2 EA	SINGLE GROOVE, SINGLE TAPPED CONN.			
263	6 EA	CADWELD LUG TYPE GL			
265	6 EA	CADWELD SHOT 65, COLOR DARK GREEN			
268	2 EA	CADWELD SHOT 200, COLOR YELLOW			

267 4/0 TO 1/0
268 4/0 TO 4/0

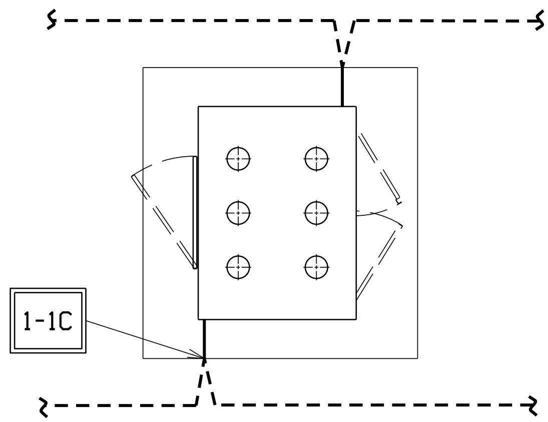


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

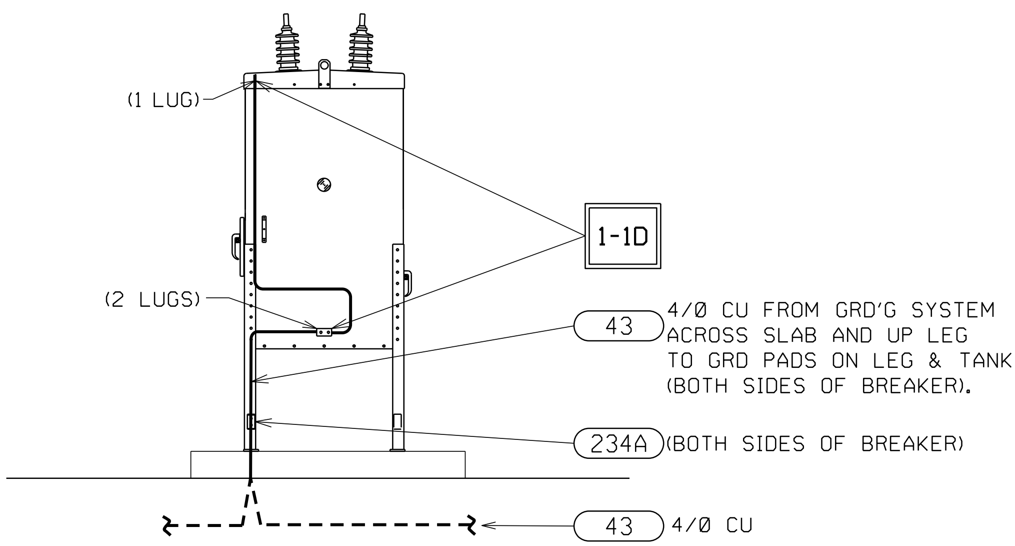
263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



TOP PLAN



ELEVATION

FEILD NOTE:
- ALL GROUND PADS ON BREAKER NEED TO BE CONNECTED TO GROUND GRID.

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-7
SUBSTATION GROUNDING DETAIL
GROUNDING FOR DIST BREAKER

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-1-7	E

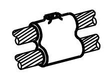
10/26/2012 10:30:24 AM

200902-1-8.DGN

MATERIAL REQUIRED FOR CONNECTION TO ONE SET OF 3 REGULATORS

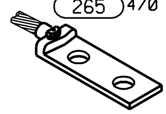
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	50 FT	4/0 CU CABLE, 19 STRAND			
234A	6 EA	SINGLE GROOVE, SINGLE TAPPED CONN.			
263	12 EA	CADWELD LUG TYPE GL			
265	12 EA	CADWELD SHOT 65, COLOR DARK GREEN			
268	10 EA	CADWELD SHOT 200, COLOR YELLOW			

267 4/0 TO 1/0
268 4/0 TO 4/0

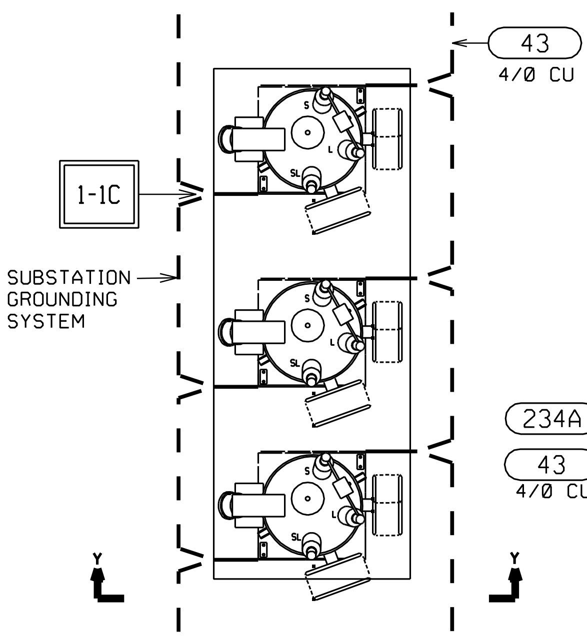


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

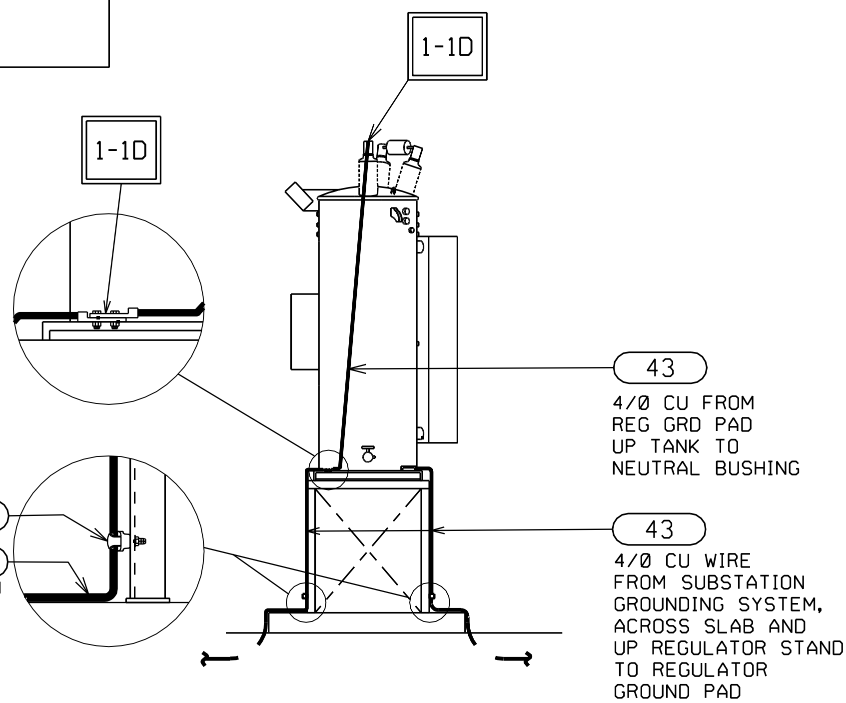
263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



TOP VIEW



ELEVATION Y-Y

FIELD NOTE:
- DO NOT CADWELD TO REGULATOR STAND

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

[1-1F] INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-8
SUBSTATION GROUNDING DETAIL
GROUNDING FOR REGULATOR

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy®

SCALE		REV
NONE	NL-200902-1-8	B

$TIME$
02/20/2008

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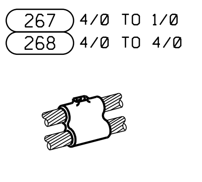
200902-1-9.DGN

MATERIAL FOR DEAD-END TOWER

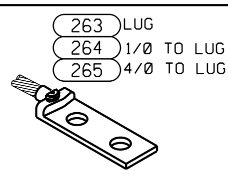
ITEM NO.	QTY	DESCRIPTION
43	90 FT	4/0 CU, 19 STRAND
263	3 EA	CADWELD LUG TYPE GL
265	3 EA	CADWELD SHOT 65, COLOR DARK GREEN
267	2 EA	CADWELD SHOT 150, COLOR DARK BLUE
268	6 EA	CADWELD SHOT 200, COLOR YELLOW
275	1 EA	TERM LUG, 1 HOLE

MATERIAL FOR SINGLE OR DOUBLE COLUMN STAND

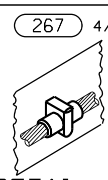
ITEM NO.	QTY	DESCRIPTION
43	20 FT	4/0 CU CABLE, 19 STRAND
263	3 EA	CADWELD LUG TYPE GL
265	3 EA	CADWELD SHOT 65, COLOR DARK GREEN
267	1 EA	CADWELD SHOT 150, COLOR DARK BLUE
268	3 EA	CADWELD SHOT 200, COLOR YELLOW



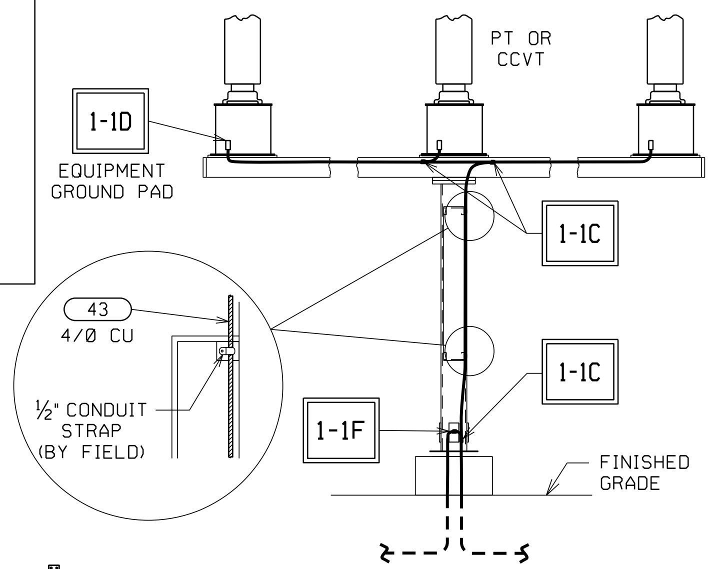
DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE



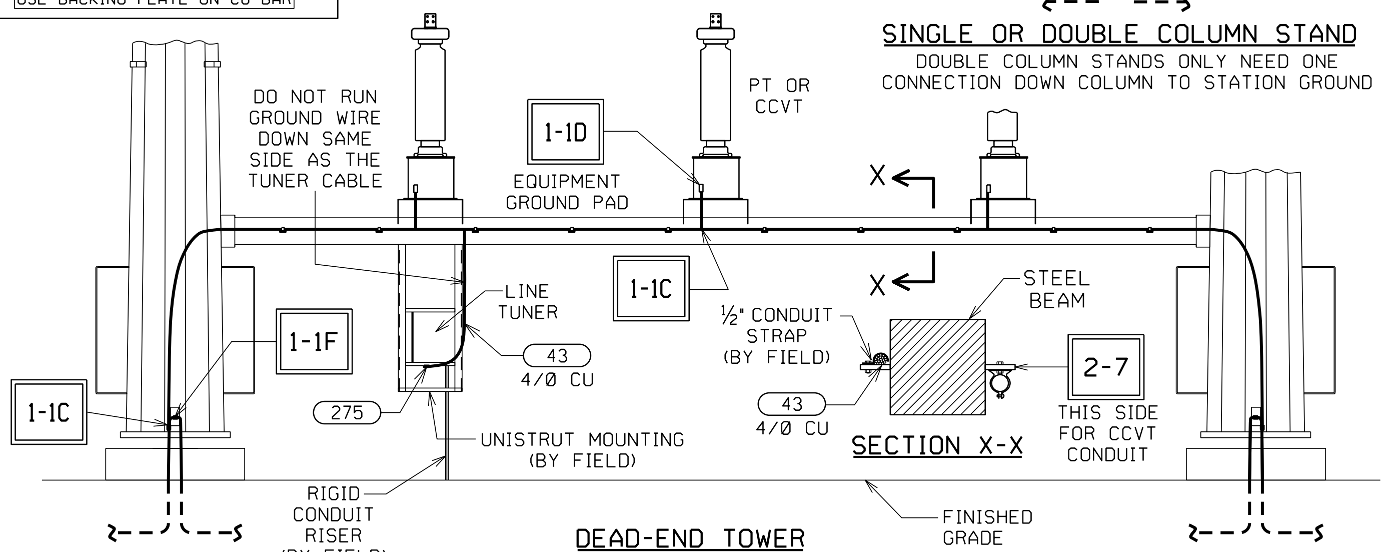
DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



DETAIL "F"
TYPE "VT" MOLD (VTC-2Q-001)
CABLE TO STEEL OR CU.
(THRU CONNECTION)
USE BACKING PLATE ON CU BAR



SINGLE OR DOUBLE COLUMN STAND
DOUBLE COLUMN STANDS ONLY NEED ONE
CONNECTION DOWN COLUMN TO STATION GROUND



DEAD-END TOWER

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-9
SUBSTATION GROUNDING DETAIL
GROUNDING FOR P.T. AND C.C.V.T.

Xcel Energy®

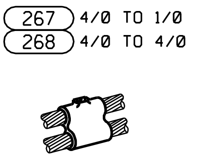
SCALE	DRAWING NO.	REV
NONE	NL-200902-1-9	E

9/19/2013 7:54:58 AM

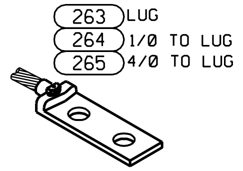
200902-1-10.DGN

MATERIAL REQUIRED FOR CONNECTION TO ONE CAPACITOR BANK

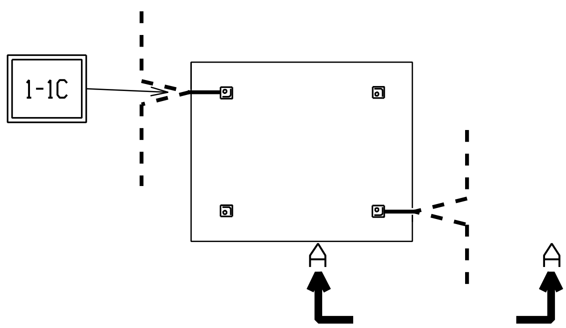
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	20 EA	4/0 CU CABLE, 19 STRAND			
263	2 EA	CADWELD LUG TPYE GL			
265	2 EA	CADWELD SHOT 65, COLOR DARK GREEN			
268	2 EA	CADWELD SHOT 200, COLOR YELLOW			



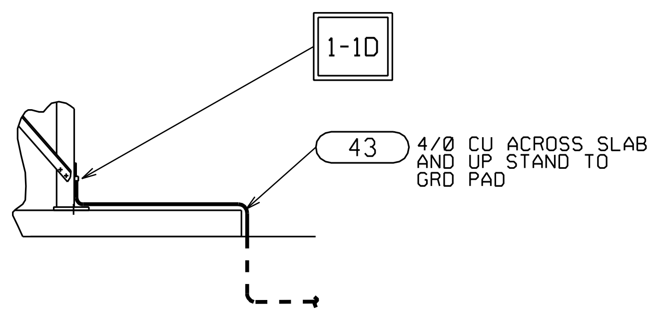
DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



VIEW OF CAP BANK LEGS



SECTION A-A

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-10
SUBSTATION GROUNDING DETAIL
GROUNDING FOR CAPACITOR BANK STAND

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy®

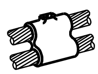
SCALE		REV
NONE	NL-200902-1-10	B

$TIME$
02/20/2008

MATERIAL REQUIRED FOR CONNECTION TO ONE CAPACITOR BANK

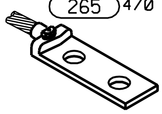
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	20 FT	4/0 CU CABLE, 19 STRAND			
234A	4 EA	SINGLE GROOVE, SINGLE TAPPED CONN.			
263	1 EA	CADWELD LUG TYPE GL			
265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN			
268	1 EA	CADWELD SHOT 200, COLOR YELLOW			

267 4/0 TO 1/0
268 4/0 TO 4/0

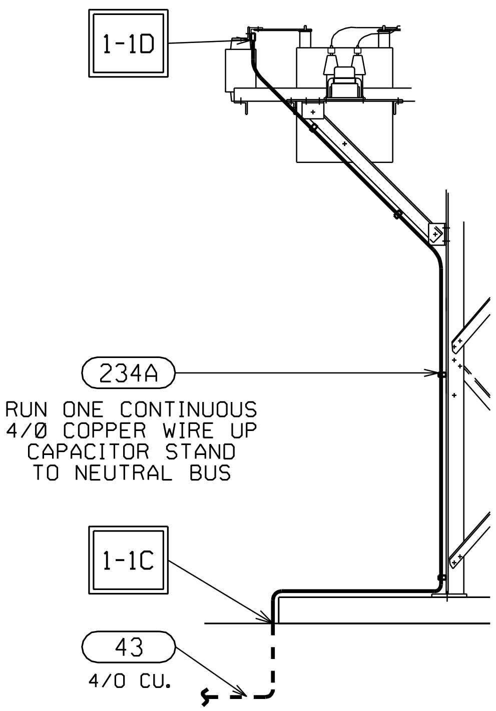


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

[1-1F] INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-11
SUBSTATION GROUNDING DETAIL
GROUNDING FOR SINGLE CAPACITOR BANK

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy®

SCALE		REV
NONE	NL-200902-1-11	B

200902-1-11.DGN
$TIME$
02/20/2008

MATERIAL REQUIRED FOR CONNECTION TO ONE CAPACITOR BANK CONNECTION

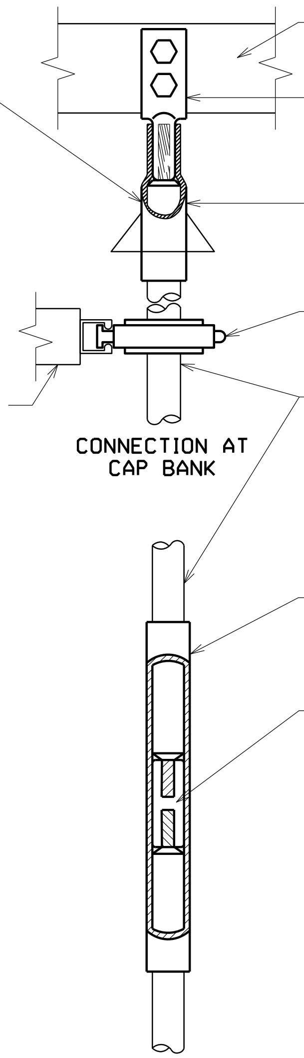
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
704	2 EA	WARNING SIGN	C402	*	SPLICE CONNECTOR
C26	*	15KV DIRECT BURIAL 4/0 CU CABLE	C403	1	CABLE TERMINATOR
C400	1 EA	TERMINAL LUG FOR 4/0 CU	C404	2	CABLE MOUNTING BRACKET
C401	*	COLD SHRINK SPLICE JACKET, 15KV CABLE			* DETERMINED BY DESIGNER

CONSTRUCTION NOTES:

CUT OFF CONCENTRIC NEUTRAL ON BOTH ENDS OF 15KV SINGLE POINT GROUND CABLE. DO NOT CONNECT SHIELD TO LUG AND DO NOT CONNECT TO GROUND.

MAINTAIN AT LEAST 6" OF EARTH BETWEEN WHERE THE POWER AND CONTROL CABLES CROSS AND 3'-0" WHERE THE RUNS ARE PARALLEL.

704
TWO SIGNS SHOULD BE PLACED ON EACH CAP BANK WITH AN INSULATED GROUNDED NEUTRAL. ONE SIGN MOUNTED ON THE FRONT SIDE OF THE CENTER PHASE RACK AND ONE ON THE BACK WHERE THE CABLE IS TERMINATED.



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
LOC ID GRP 2	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-12A
SUBSTATION GROUNDING DETAIL
GROUNDING FOR CAPACITOR BANK SINGLE POINT CONNECTION

Xcel Energy

SCALE		REV
NONE	NL-200902-1-12A	D

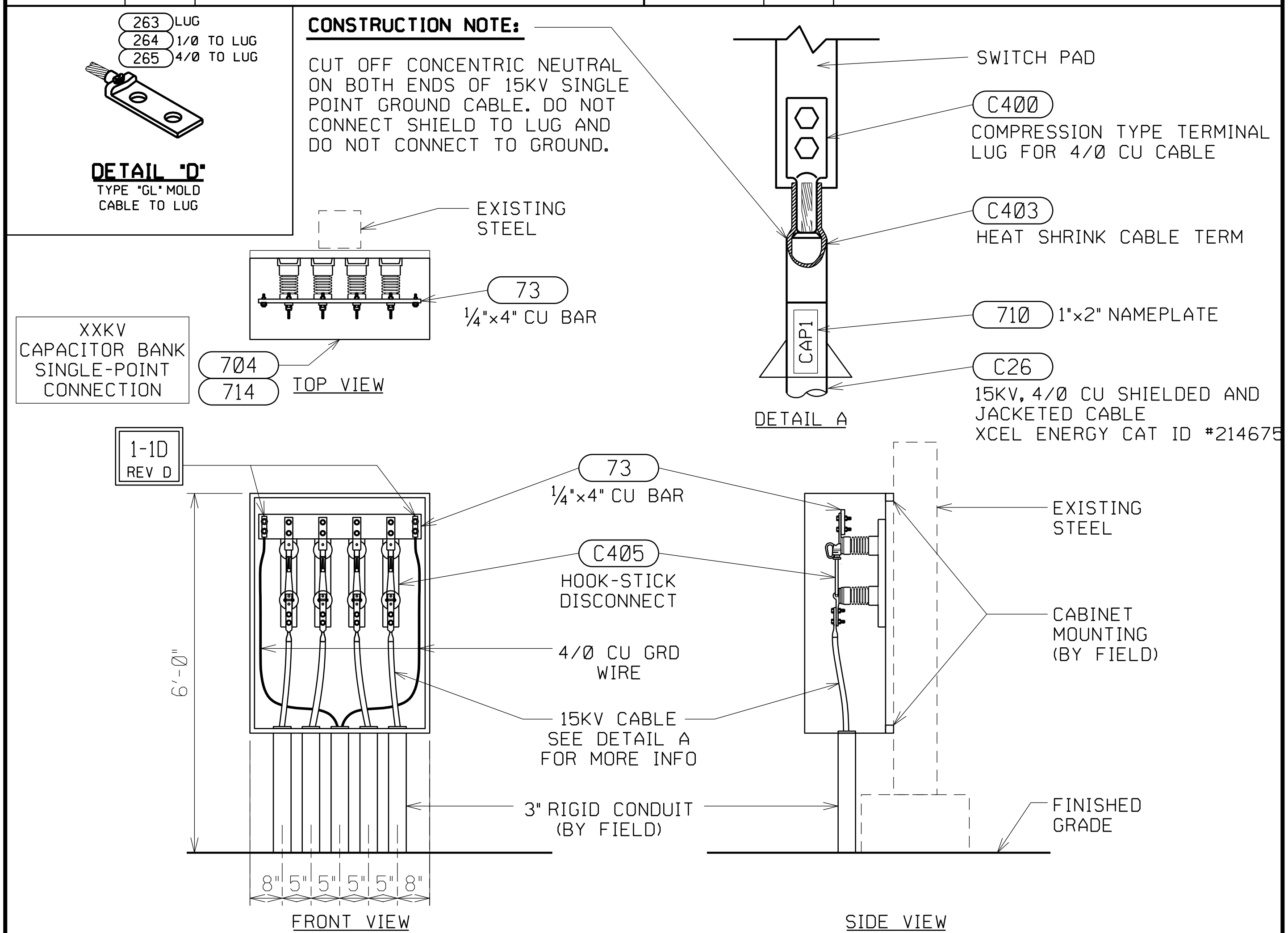
200902-1-12A.DGN

5/20/2011 12:18:50 PM

200902-1-12B.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	20 FT	4/0 COPPER	C257A	1	CABINET 48" x 36" x 16" WITH BACK PNL
73	3 FT	1/4"x4" CU BAR	C257C	1	HANDLE FOR ITEM C257A
263	2	CADWELD LUG	C257D	1	MOUNTING KIT FOR ITEM C257A
265	2	CADWELD SHOT	C257E	1	DOOR STOP FOR ITEM C257A
704	1	WARNING SIGN	C400	*	TERMINAL LUG FOR 4/0 CU (ONE PER CBL)
710	*	1"x2" NAMEPLATE (ONE FOR EA CAP BANK)	C403	*	CABLE TERMINATION (ONE PER CBL)
714	1	6"x10" NAMEPLATE (FOR CABINET)	C405	*	HOOK STICK DISCONNECT (ONE PER CBL)
C26	*	15KV DIRECT BURIAL 4/0 CU CABLE			* DETERMINED BY DESIGNER



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

[1-5] INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & [1-1E] INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-12B
SUBSTATION GROUNDING DETAIL
CAPACITOR BANK SINGLE POINT CONNECTION CABINET

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy®

SCALE: NONE

NL-200902-1-12B

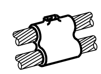
REV: D

5/20/2011 12:21:09 PM

MATERIAL REQUIRED FOR CONNECTION TO ONE GROUND WELL

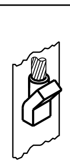
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43		4/0 CU. CABLE, 19 STRAND			
268	3 EA	CADWELD SHOT 200, COLOR YELLOW			

267 4/0 TO 1/0
268 4/0 TO 4/0

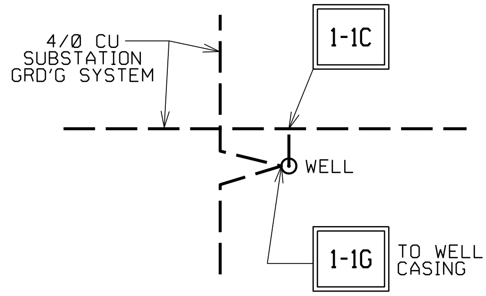


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

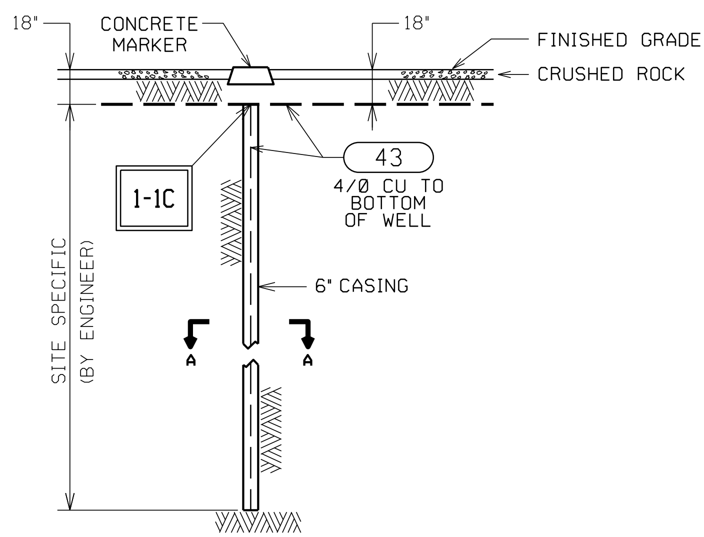
268 4/0
265 #4



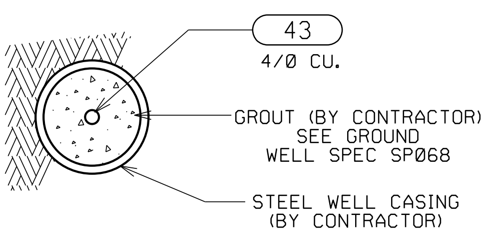
DETAIL "G"
TYPE "VF" MOLD
CABLE UP TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.



TOP VIEW



ELEVATION



SECTION A-A

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-13
SUBSTATION GROUNDING DETAIL
GROUND WELL

Xcel Energy®

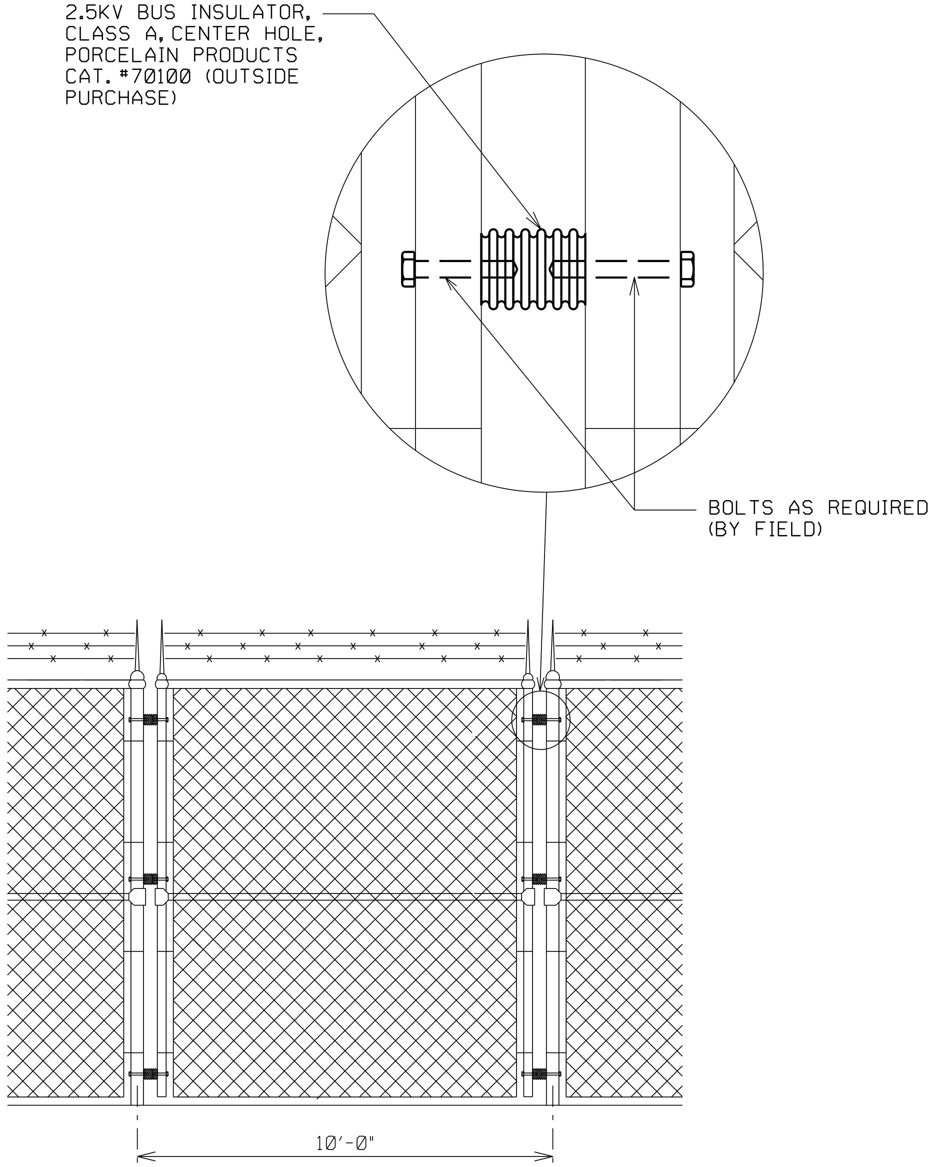
SCALE		REV
NONE	NL-200902-1-13	D

200902-1-13.DGN

9/19/2013 7:49:21 AM

MATERIAL REQUIRED FOR CONNECTION TO ONE ISOLATION POINT

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-14
SUBSTATION GROUNDING DETAIL
FENCE GROUND ISOLATION

Xcel Energy®

SCALE NONE

NL-200902-1-14

REV A

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

200902-1-14.DGN

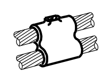
8/13/2013 2:55:08 PM

MATERIAL REQUIRED FOR CONNECTION TO ONE POLE

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
13	2 #	5/8 THREADED ROD 26" LONG	43	80 FT	4/0 CU. CABLE, 19 STRAND
24	4 #	M.F. LOCK NUT, FOR 5/8" DIA BOLT	263	1 EA	CADWELD LUG, TYPE GL
27	2 #	WASHER, 3" SQ. CUT, FOR 5/8" DIA BOLT	265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN
			268	1 EA	CADWELD SHOT 200, COLOR YELLOW

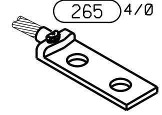
\# ORDERED WITH STEEL
* VARIES

267 4/0 TO 1/0
268 4/0 TO 4/0

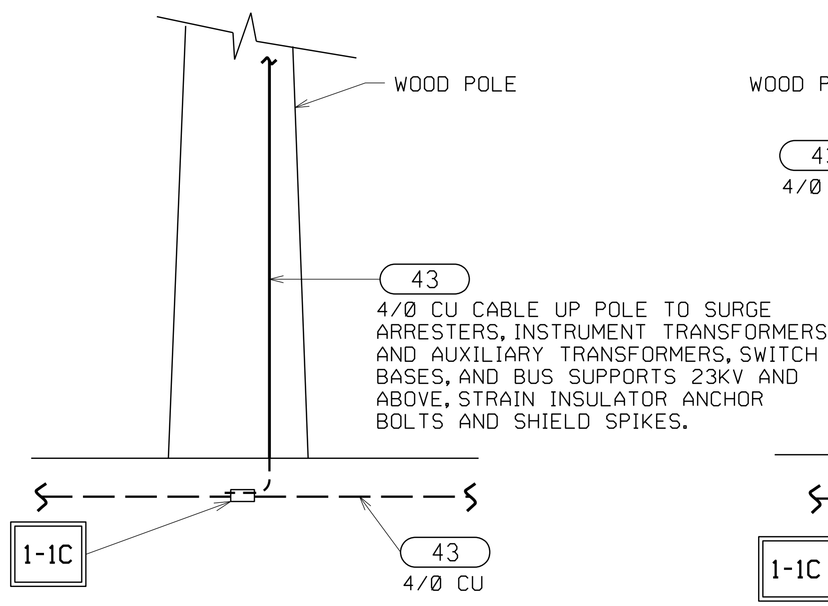
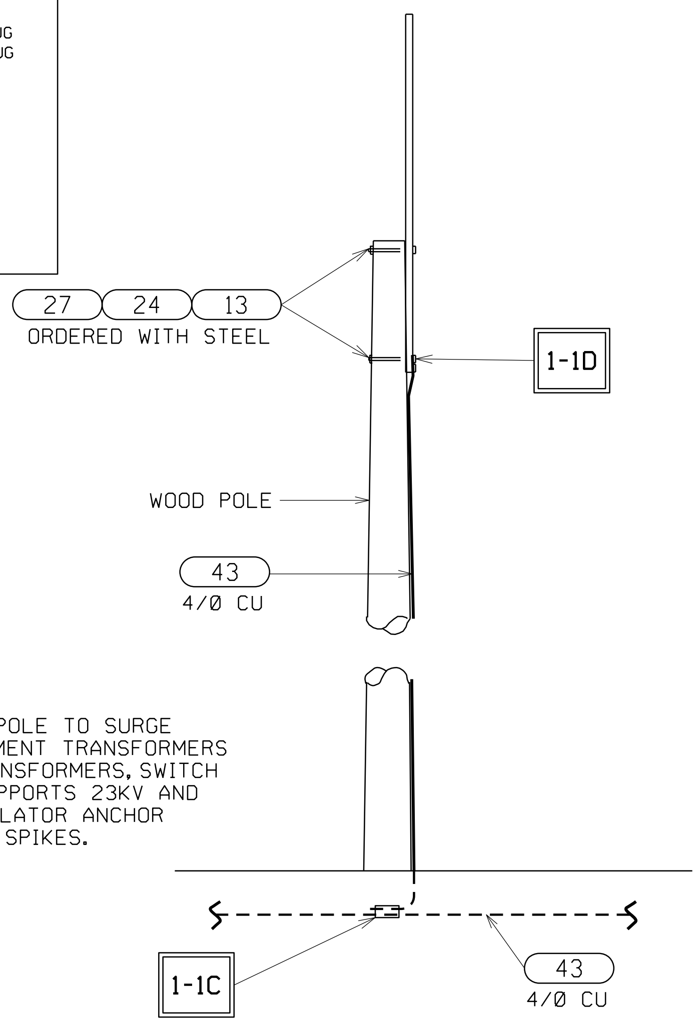


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG

WOOD STRUCTURE EQUIPMENT GROUNDING

SHIELD SPIKE GROUNDING

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)
1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-16
SUBSTATION GROUNDING DETAIL
GROUNDING FOR SHIELD SPIKE ON WOOD POLE

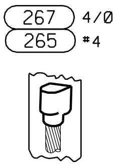
GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy | SCALE NONE | NL-200902-1-16 | REV C

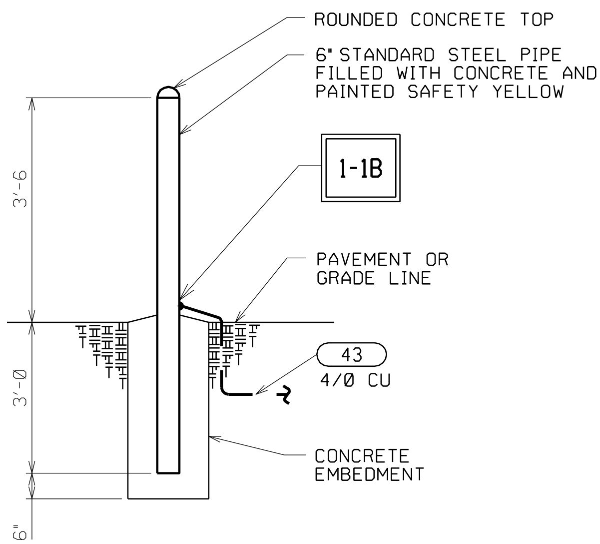
200902-1-16.DGN
12:23:00 PM
5/20/2011

MATERIAL REQUIRED FOR CONNECTION TO ONE POST

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43		4/Ø CU. CABLE, 19 STRAND			
267	¼PKG	CADWELD SHOT, CAT #XL15Ø (PKG 4)			



DETAIL "B"
TYPE "VB" MOLD
CABLE DOWN TO STEEL
NOTE: DIFFERENT DIES REQUIRED
FOR ROUND & FLAT SURFACES.



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 1-17
SUBSTATION GROUNDING DETAIL
GROUNDING FOR GUARD POST

Xcel Energy

SCALE: NONE

NL-200902-1-17

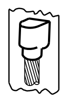
REV: A

10/19/2005 200902-1-17.DGN

MATERIAL REQUIRED FOR FOR ONE FEEDER

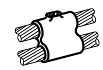
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	*	4/0 CU. CABLE, 19 STRAND	267	1 EA	CADWELD SHOT 150, COLOR DARK BLUE
64	*	¼" × 2" ALUMINUM BAR	268	2 EA	CADWELD SHOT 200, COLOR YELLOW
263	1 EA	CADWELD LUG TYPE GL			
		* VARIES			

267 4/0
266 #4



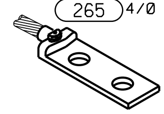
DETAIL "B"
TYPE "VB" MOLD
CABLE DOWN TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.

267 4/0 TO 1/0
268 4/0 TO 4/0

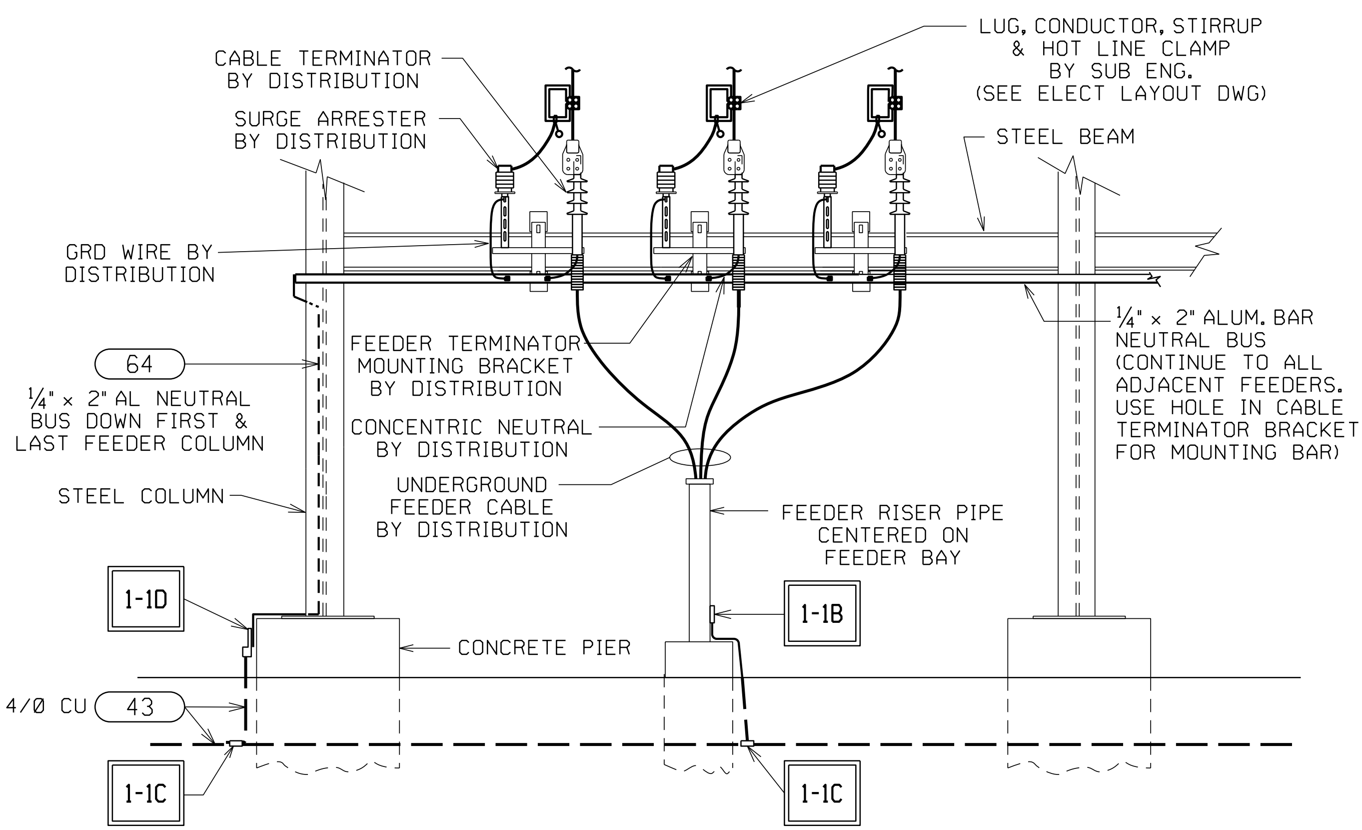


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL THRU CABLE

263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1F INDICATES DETAIL "F" SHOWN ABOVE & ON SHEET 1-1

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-18
SUBSTATION GROUNDING DETAIL
GROUNDING FOR OUTDOOR UNDERGROUND FEEDER NEUTRAL

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy

SCALE: NONE

NL-200902-1-18

REV: C

200902-1-18.DGN

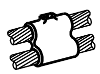
9/19/2013 7:51:03 AM

200902-1-19.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

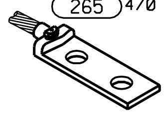
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	30 EA	4/0 CU. CABLE, 19 STRAND			
234A	6 EA	SINGLE GROOVE, SINGLE TAPPED CONN.			
263	1 EA	CADWELD LUG, TYPE GL			
265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN			
268	1 EA	CADWELD SHOT 200, COLOR YELLOW			

267 4/0 TO 1/0
268 4/0 TO 4/0

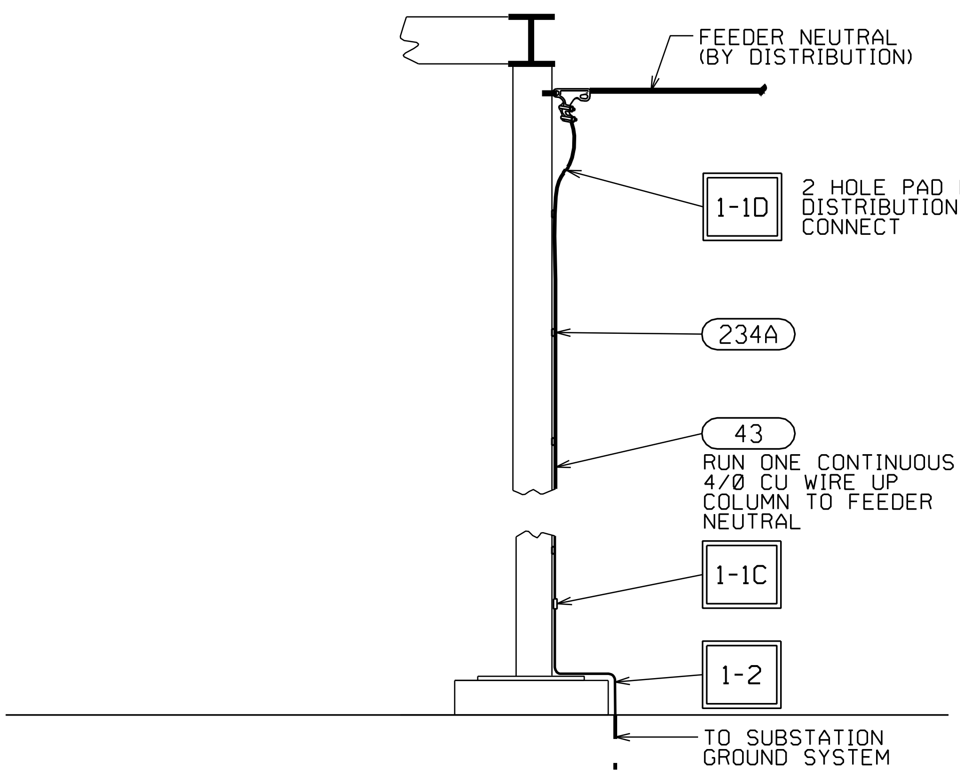


DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

263 LUG
264 1/0 TO LUG
265 4/0 TO LUG



DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

1-5 INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & 1-1E INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-19
SUBSTATION GROUNDING DETAIL
OVERHEAD FEEDER NEUTRAL CONNECTION TO GROUND GRID

Xcel Energy®

SCALE NONE

NL-200902-1-19

REV B

$TIME$

02/20/2008

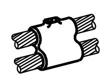
MATERIAL FOR CABINET MOUNTED ON COLUMN

ITEM NO.	QTY	DESCRIPTION
43	2 FT	4/0 COPPER WIRE
263	1 EA	CADWELD LUG TYPE GL
265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN
268	1 EA	CADWELD SHOT 200, COLOR YELLOW

MATERIAL FOR CABINET NOT MOUNTED ON COLUMN

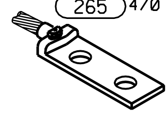
ITEM NO.	QTY	DESCRIPTION
43	5 FT	4/0 CU. CABLE, 19 STRAND
263	1 EA	CADWELD LUG TYPE GL
265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN
268	1 EA	CADWELD SHOT 200, COLOR YELLOW

267 4/0 TO 1/0
268 4/0 TO 4/0



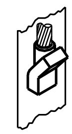
DETAIL "C"
TYPE "PT" MOLD
HORIZONTAL PARALLEL
THRU CABLE

263 LUG
264 1/0 TO LUG
265 4/0 TO LUG

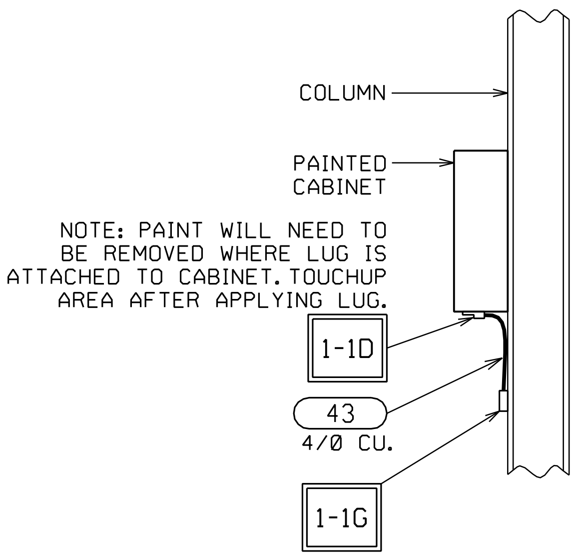


DETAIL "D"
TYPE "GL" MOLD
CABLE TO LUG

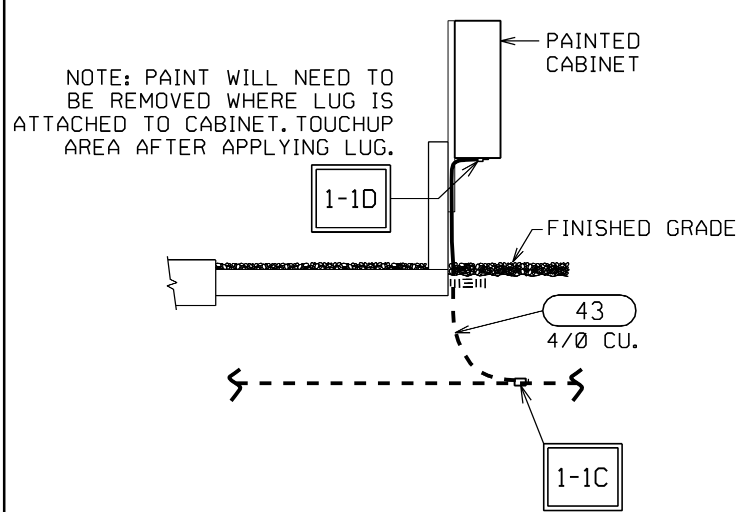
268 4/0
265 #4



DETAIL "G"
TYPE "VF" MOLD
CABLE UP TO STEEL
NOTE: DIFFERENT DIES REQUIRED FOR ROUND & FLAT SURFACES.



CABINET MOUNTED ON COLUMN



CABINET NOT MOUNTED ON COLUMN

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

1-5 INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & 1-1E INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

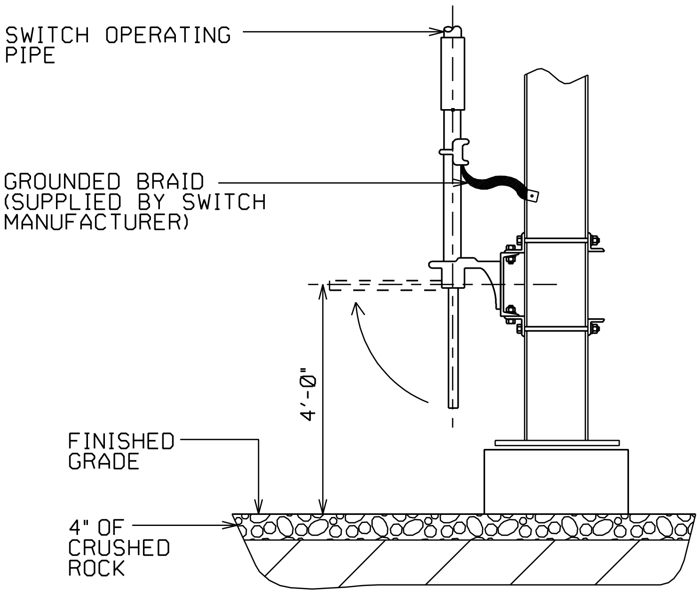
SUBSTATION PHYSICAL DETAIL 1-20
SUBSTATION GROUNDING DETAIL
GROUNDING FOR PAINTED CABINETS

Xcel Energy®

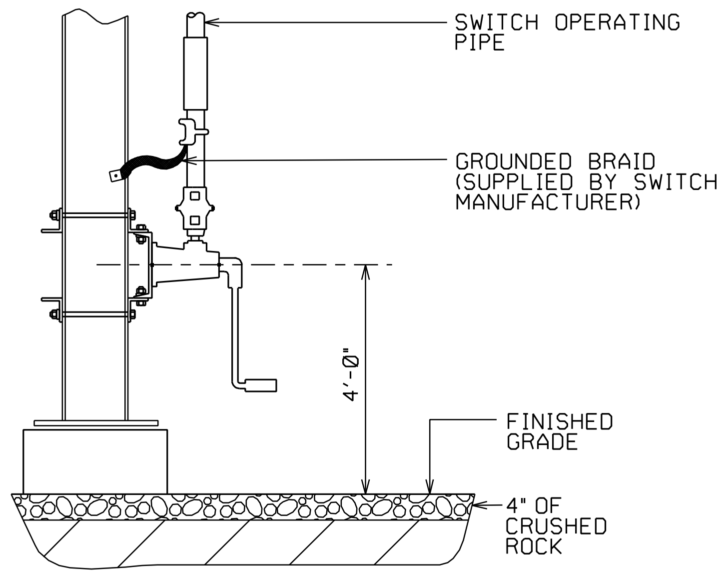
SCALE	DRAWING	REV
NONE	NL-200902-1-20	B

200902-1-20.DGN
$TIME$
02/20/2008

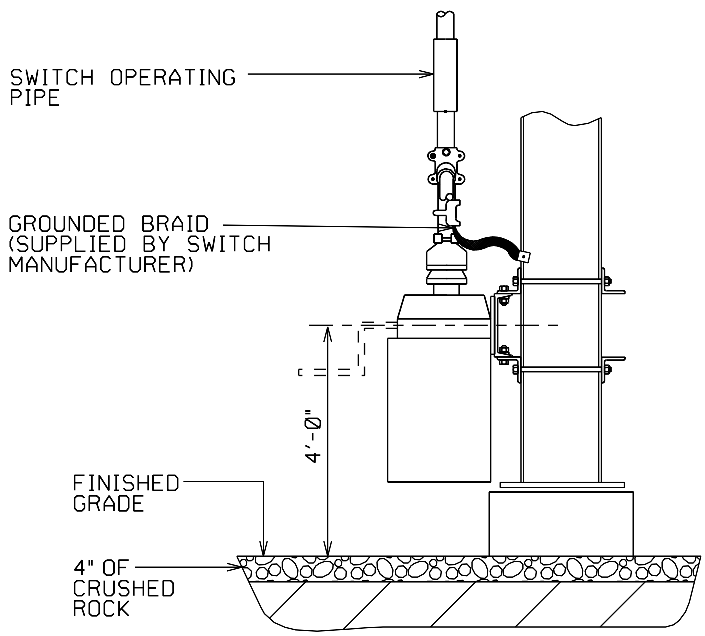
200902-1-21.DGN



OPERATING PIPE



OPERATING CRANK



MOTOR MECHANISM

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-21
SUBSTATION GROUNDING DETAIL
SWITCH OPERATING PIPE GRD'G & OPERATING CRANK MOUNTING HEIGHT

Xcel Energy

SCALE		REV
NONE	NL-200902-1-21	A

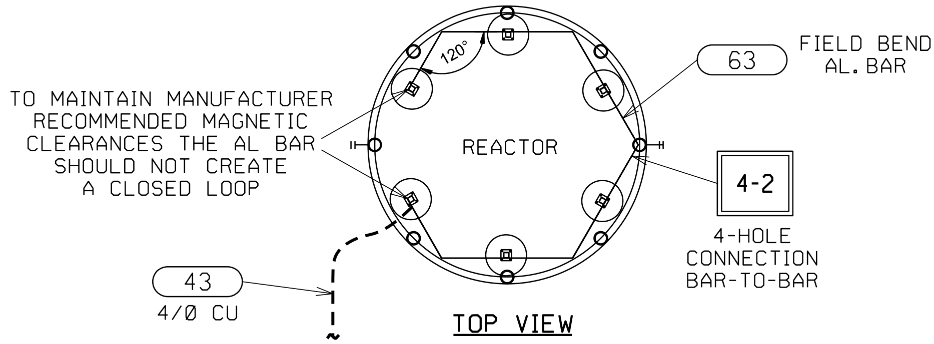
GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

$TIME$

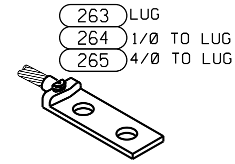
06/04/2007

MATERIAL REQUIRED FOR CONNECTION TO ONE REACTOR

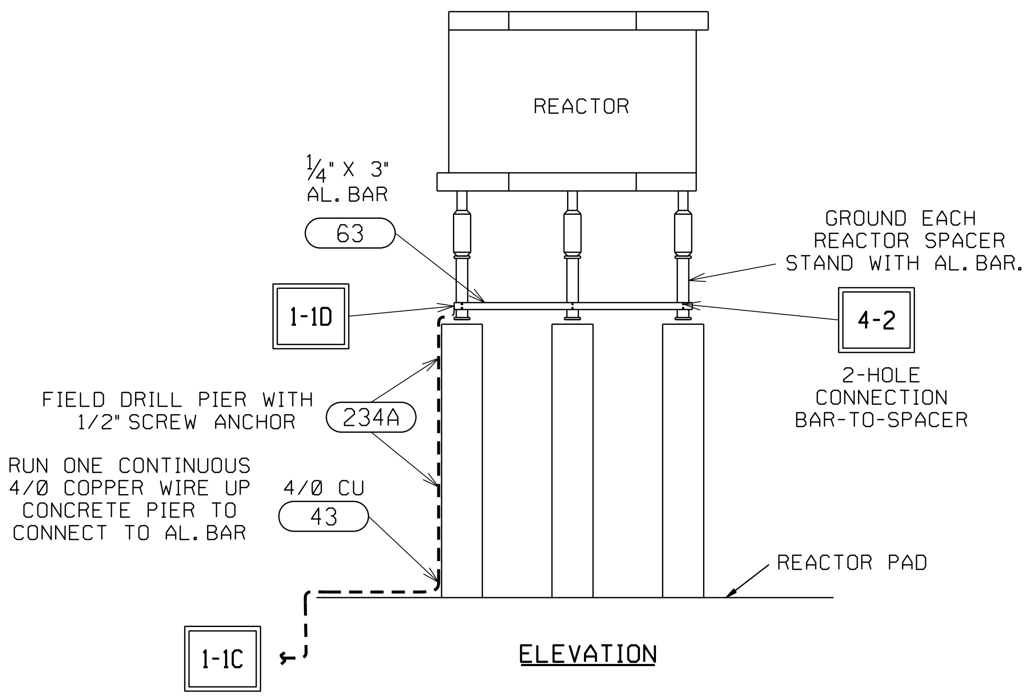
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
43	40 FT	4/0 CU, 19 STRAND	265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN
63	24 FT	1/4" x 3" ALUMINUM BAR	268	1 EA	CADWELD SHOT 200, COLOR YELLOW
234A	3 EA	SINGLE GROOVE, SINGLE TAPPED CONN.	263	1 EA	CADWELD LUG TYPE GL



TOP VIEW



DETAIL "D"
TYPE "GL" MOLD CABLE TO LUG



ELEVATION

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

1-1D INDICATES DETAIL "D" SHOWN ABOVE & ON SHEET 1-1

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 1-22
SUBSTATION GROUNDING DETAIL
GROUNDING FOR COLUMN MOUNTED REACTORS

Xcel Energy

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	0001
6	
CL	

SCALE NONE | NL-200902-1-22 | REV A

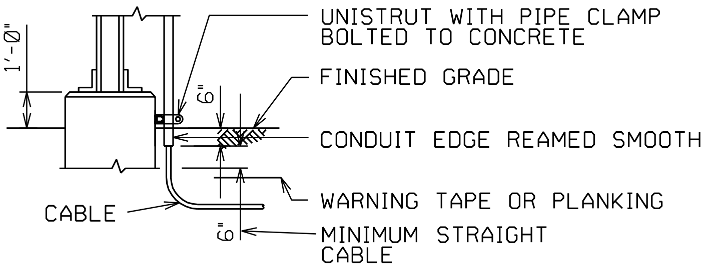
200902-1-22.DGN

7/31/2012 8:58:28 AM

ALL ITEMS SHOWN ARE ORDERED BY CONSTRUCTION

200902-2-1.DGN

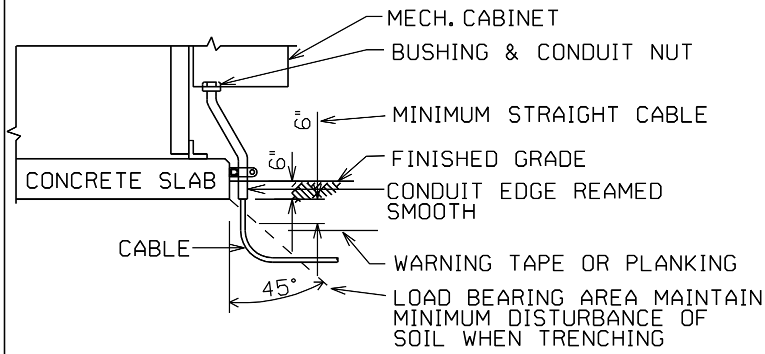
NOTE: GALVANIZED CONDUIT IS USED FOR ALL ABOVE GROUND CONDUITS.



DETAIL "A"

TYPICAL CONDUIT RISER FOR UNDERGROUND CABLE ADJACENT TO DEEP FOOTING

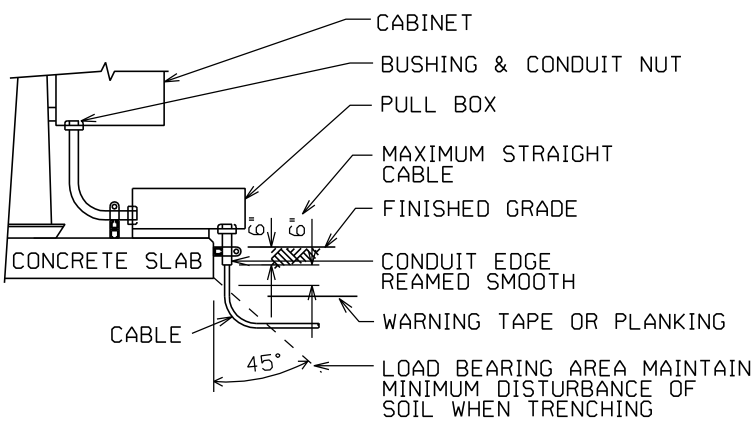
NOTE: GALVANIZED CONDUIT IS USED FOR ALL ABOVE GROUND CONDUITS.



DETAIL "B"

TYPICAL CONDUIT RISER FOR SLAB MOUNTED EQUIPMENT

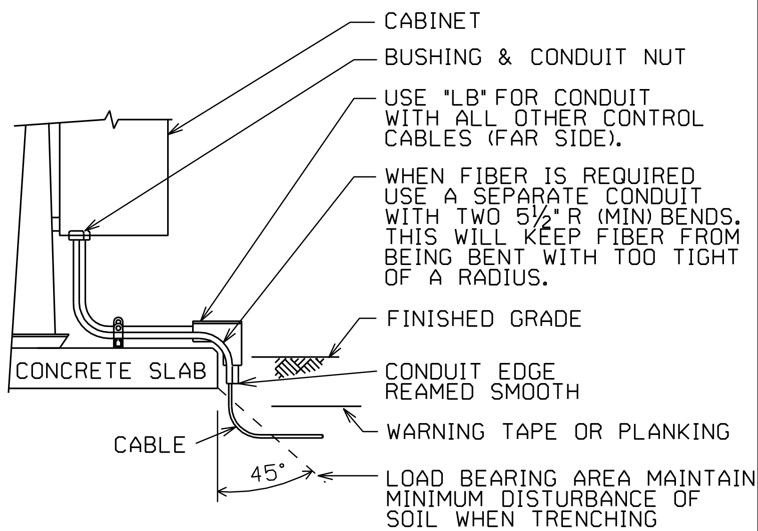
NOTE: GALVANIZED CONDUIT IS USED FOR ALL ABOVE GROUND CONDUITS.



DETAIL "C"

ALTERNATE CONDUIT RISER FOR SLAB MOUNTED EQUIPMENT

NOTE: GALVANIZED CONDUIT IS USED FOR ALL ABOVE GROUND CONDUITS.



DETAIL "D"

CONDUIT RISER FOR SLAB MOUNTED EQUIPMENT WITH OR WITHOUT FIBER OPTIC CABLE

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-1
SUBSTATION CONTROL AND LIGHTING DETAIL
CONDUIT RISER DETAIL "A", DETAIL "B", DETAIL "C" & DETAIL "D"

Xcel Energy®

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

SCALE		REV
NONE	NL-200902-2-1	C

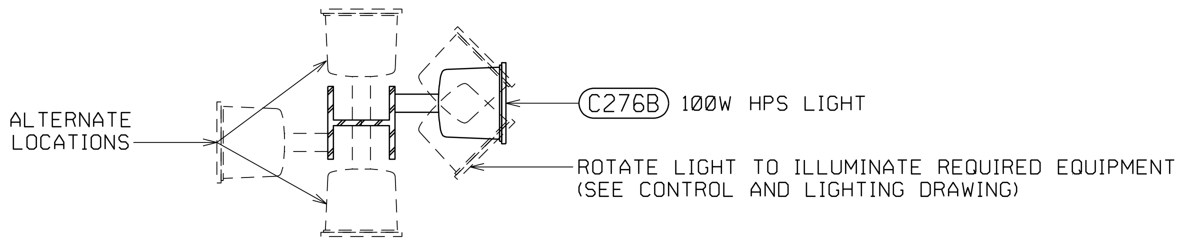
$TIME$

09/20/2007

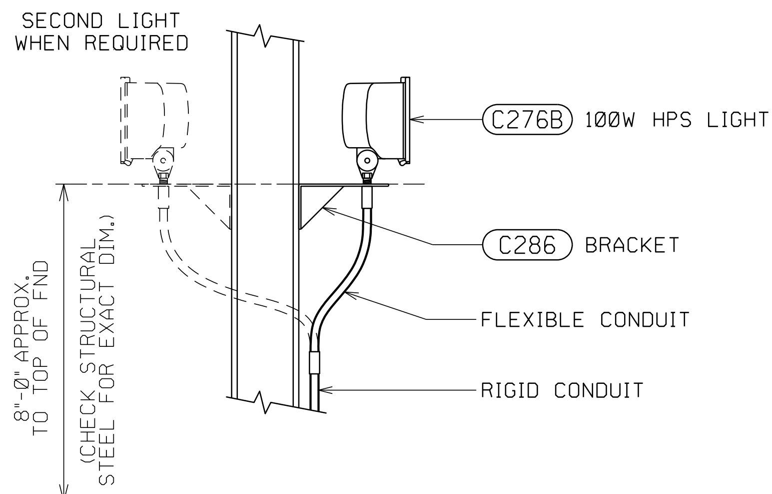
200902-2-2.DGN

BILL OF MATERIAL FOR FLOOD LAMPS

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C276B	*	100 WATT HPS LIGHT			
C286	*	BRACKET, ANGLE, 12½"			
		* VARIES			



TOP VIEW



SIDE VIEW

FIELD NOTE:
- LIGHT AIMING QUADRANT OPTIONAL FOR EACH LAMP. EQUIPMENT OR AREA TO ILLUMINATE IS DESIGNATED ON LAYOUT DRAWING.

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-2
SUBSTATION CONTROL AND LIGHTING DETAIL
FLOODLAMP LIGHTING FIXTURE MOUNTING

Xcel Energy

SCALE	DRAWING NO.	REV
NONE	NL-200902-2-2	B

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

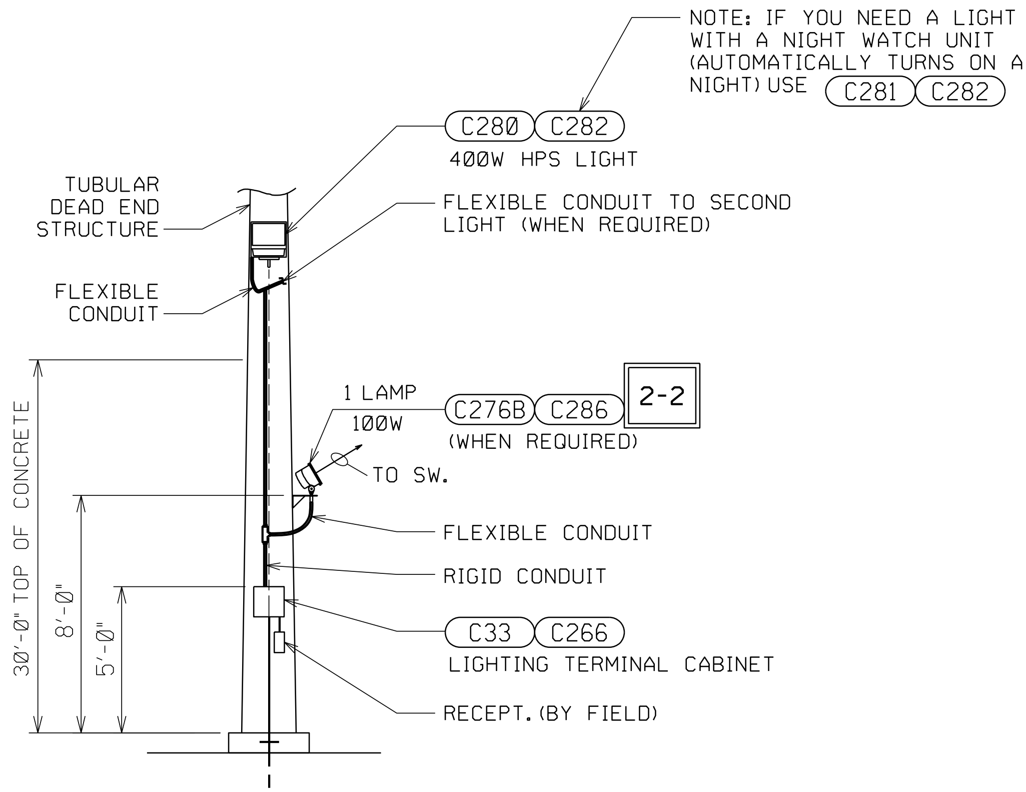
11/20/2013 11:06:57 AM

200902-2-3.DGN

BILL OF MATERIAL FOR 400W HIGH PRESSURE SODIUM LIGHT

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C33	1	4 POINT TERMINAL BLOCK	C280	*	400 WATT HPS LIGHT (NO BULB)
C266	1	TERMINAL CABINET, 12" x 12" x 6"	C281	*	400 WATT HPS LIGHT NIGHT - WATCH UNIT
C276B	*	100 WATT HPS LIGHT	C282	*	400 WATT BULB (FOR ITEM C280 & C281)
C286	*	BRACKET, ANGLE, 12½"			

* QUANTITY VARIES & SOME ITEMS MAY NOT BE NEEDED



NOTE: DO NOT MOUNT LIGHTS NEAR OR ABOVE ENERGIZED BUS. CONSIDER MOUNTING LOCATIONS THAT ALLOW ACCESSIBILITY WHEN BULBS NEED REPLACING.

FIELD NOTE:
- LIGHT AIMING QUADRANT IS 2½ TIMES MOUNTING HEIGHT.
- FIELD TO FABRICATE MOUNTING AS REQUIRED FOR EACH LIGHT.

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

2-1A INDICATES DETAIL "A" SHOWN ON SHEET 2-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-3
SUBSTATION CONTROL AND LIGHTING DETAIL
400W HIGH PRESSURE SODIUM LIGHT FIXTURE MOUNTING

Xcel Energy

SCALE		REV
NONE	NL-200902-2-3	E

11/20/2013 11:08:50 AM

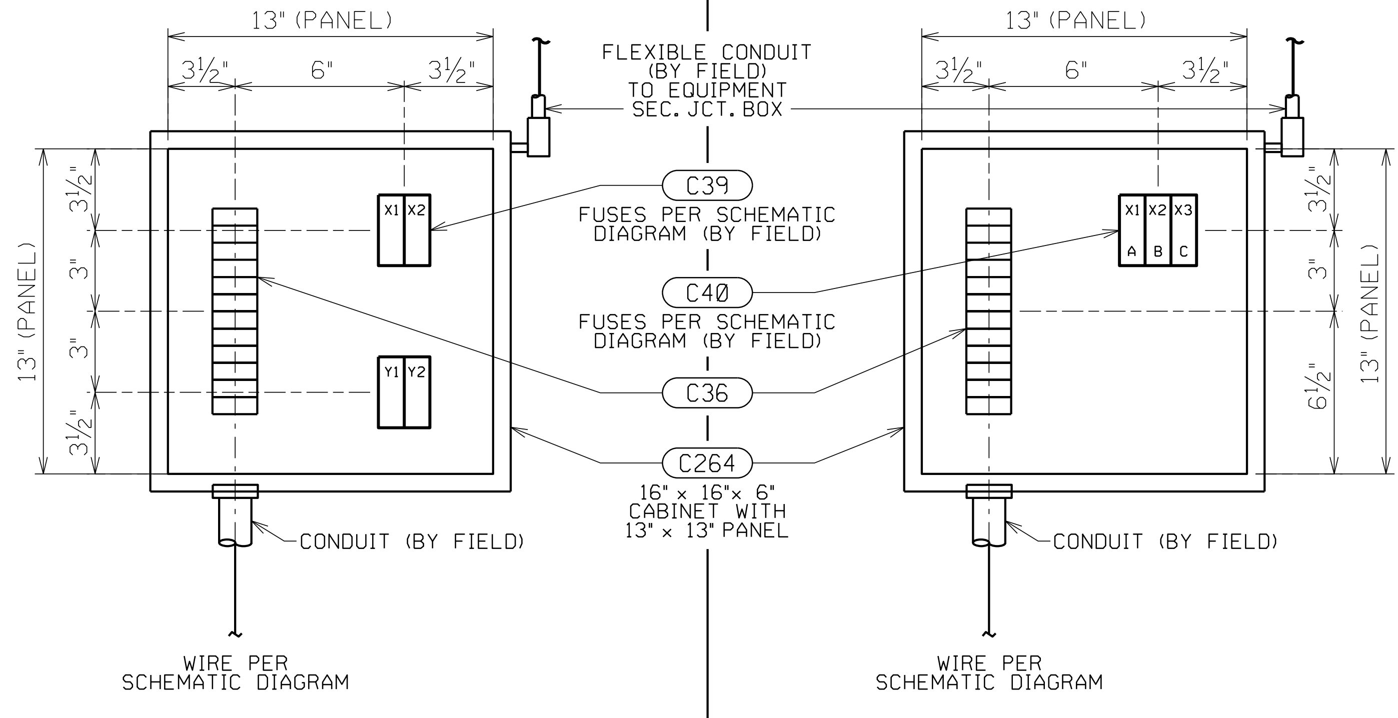
200902-2-4.DGN

BILL OF MATERIAL FOR DETAIL "A"

ITEM NO.	QTY	DESCRIPTION
C36	1	12 POINT TERMINAL BLOCK
C39	2	FUSE BLOCK, 30 AMP, 250V, DOUBLE POLE
C264	1	SEC. FUSE CAB., OUTDOOR, 16" x 16" x 6"

BILL OF MATERIAL FOR DETAIL "B"

ITEM NO.	QTY	DESCRIPTION
C36	1	12 POINT TERMINAL BLOCK
C40	1	FUSE BLOCK, 30 AMP, 250V, TRIPLE POLE
C264	1	SEC. FUSE CAB., OUTDOOR, 16" x 16" x 6"



DETAIL "A"

FOR USE IN SINGLE
PHASE PT'S OR CCVT'S

DETAIL "B"

FOR USE IN
DIST. BUS PT'S
(OR 3 SINGLE PH PT'S)

FIELD NOTE:
- WIRE CABINET PER SCHEMATIC DIAGRAM.
- PLACE A WOOD DOWEL IN ALL SPARE FUSE POSITIONS.

LEGEND:
(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-4
SUBSTATION CONTROL AND LIGHTING DETAIL
FUSE CABINET FOR SINGLE PHASE P.T. OR CCVT AND DIST. BUS PT'S

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

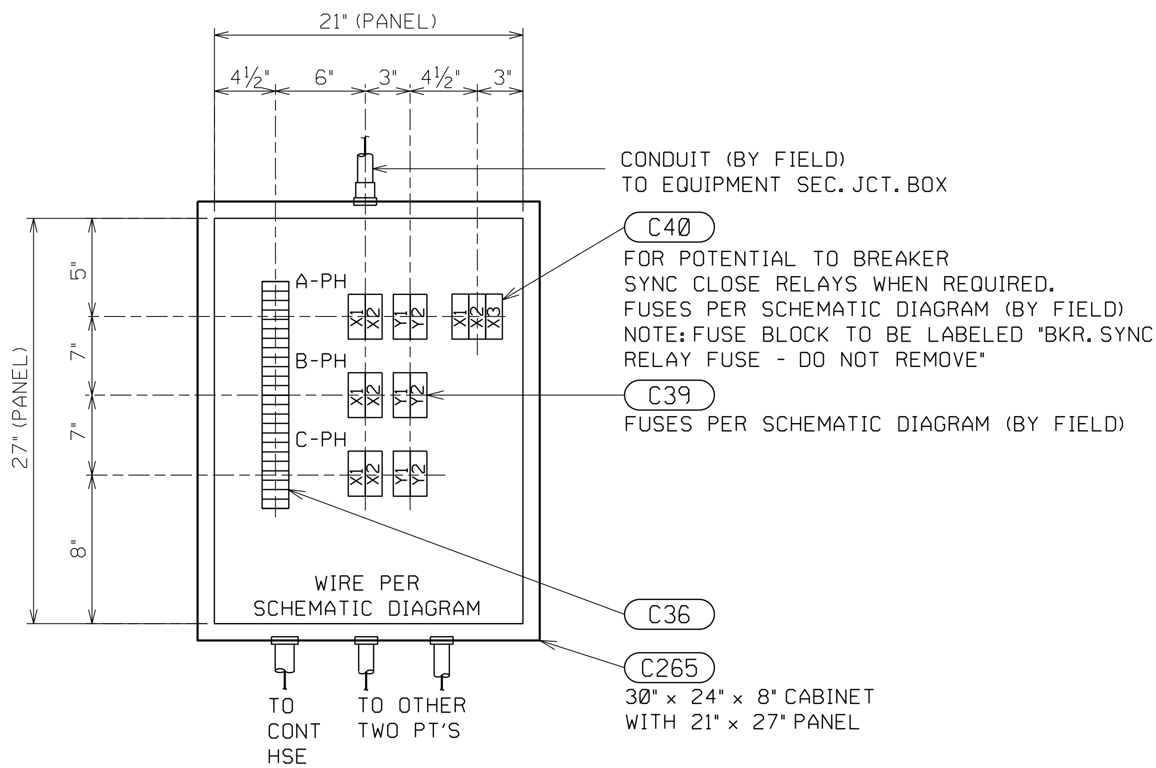
Xcel Energy

SCALE		REV
NONE	NL-200902-2-4	D

9/19/2013 7:56:31 AM

MATERIAL REQUIRED FOR THIS DETAIL

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C36	2	12 POINT TERMINAL BLOCK			
C39	6	FUSE BLOCK, 30 AMP, 250V, 2 POLE			
C40	1*	FUSE BLOCK, 30 AMP, 250V, 3 POLE			
C265	1	SEC. FUSE CAB. 30" x 24" x 8"			
		* ONLY WHEN REQUIRED			



FIELD NOTE:
- PLACE A WOOD DOWEL IN ALL SPARE FUSE POSITIONS.

LEGEND:
(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

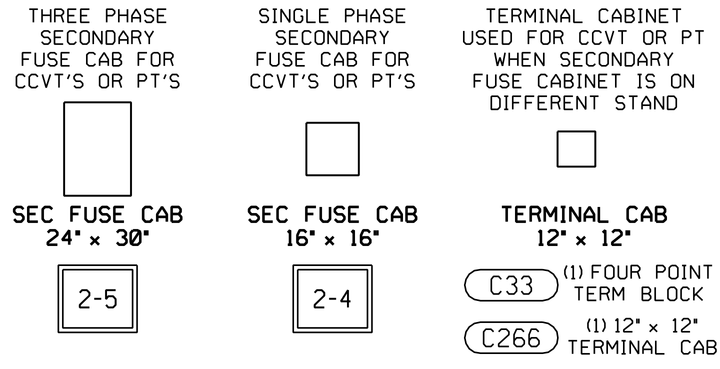
SUBSTATION PHYSICAL DETAIL 2-5
SUBSTATION CONTROL AND LIGHTING DETAIL
FUSE CABINET FOR THREE SINGLE PHASE PT'S OR CCVT'S

GRP	SIGNIFICANT NUMBER
LOC ID	
GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

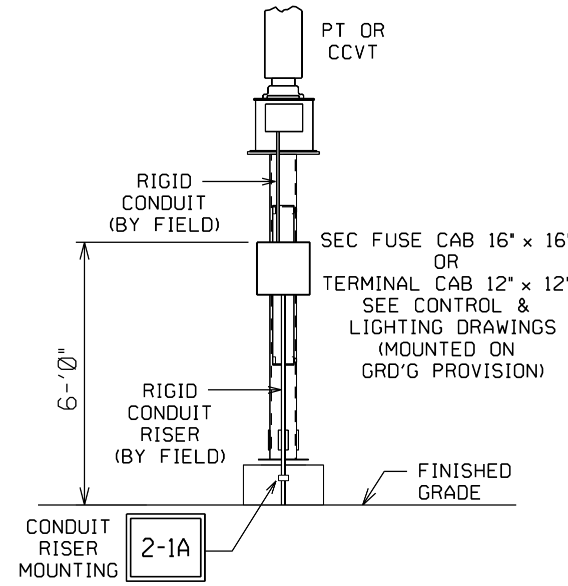
Xcel Energy

SCALE		REV
NONE	NL-200902-2-5	C

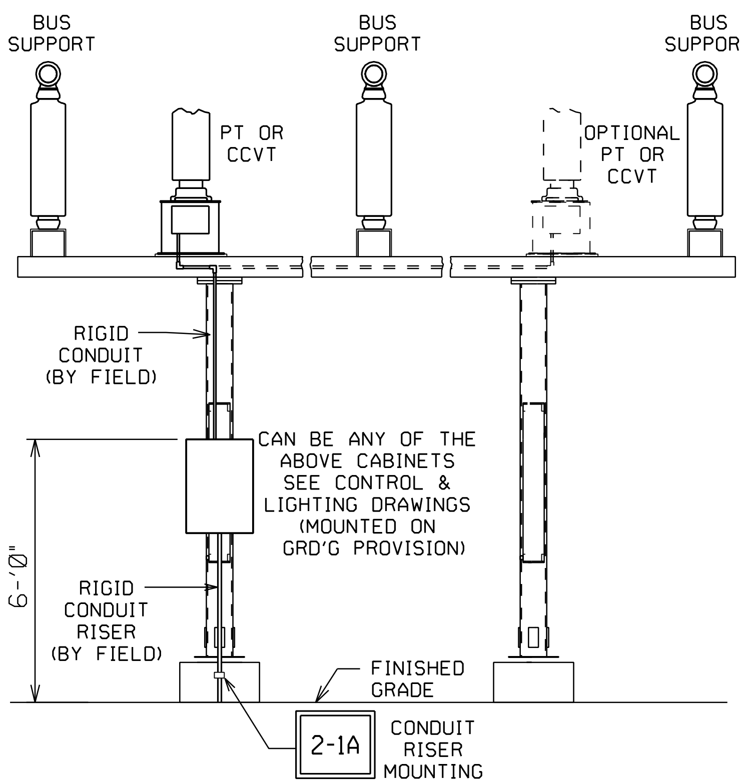
200902-2-5.DGN
9:56:55 AM
5/3/2013

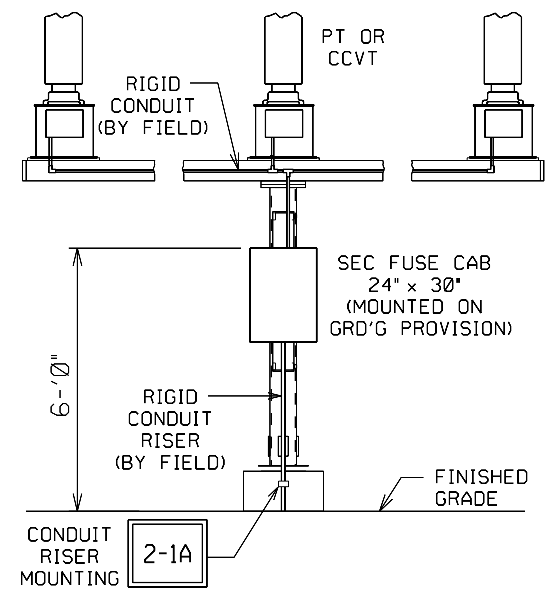


CABINET OPTIONS



SINGLE PHASE





ONE OR TWO PHASE - MOUNTED ON BUS SUPPORT STAND

THREE PHASE

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

[2-1A] INDICATES DETAIL "A" SHOWN ON SHEET 2-1 [2-5] INDICATES DETAIL ON SHEET 2-5

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-6
SUBSTATION CONTROL AND LIGHTING DETAIL
CONTROL CABLE CONNECTION FOR PT'S OR CCVT'S

Xcel Energy®

SCALE	NL-200902-2-6	REV
NONE		B

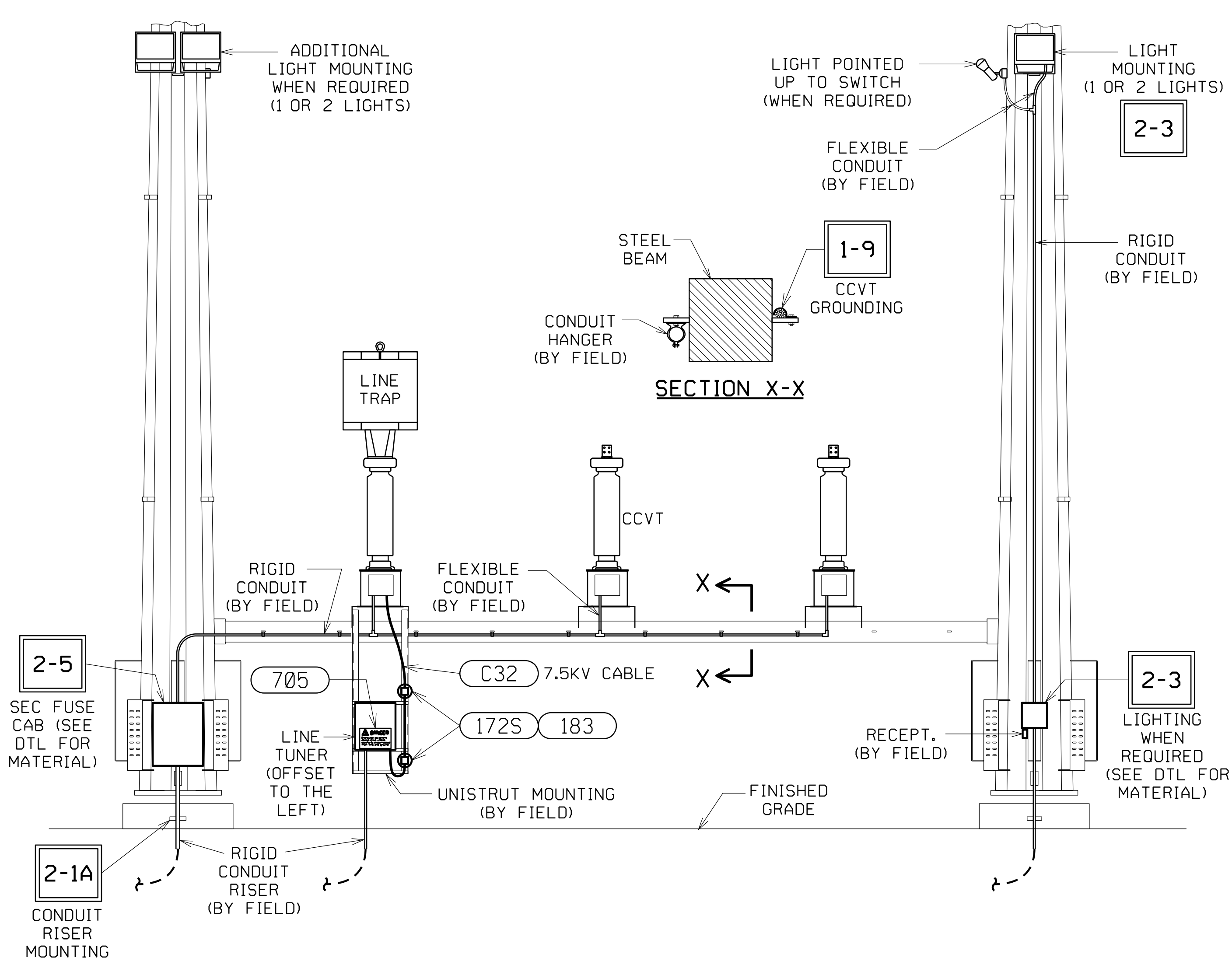
GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

200902-2-6.DGN
$TIME$
11/05/2008

BILL OF MATERIAL FOR LINE TRAP

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
172S	2	7.5KV BUS SUPPORT, 7½" HIGH	705	1	SIGN, "DANGER ENERGIZED EQUIPMENT..."
183	2	BUS SUPPORT CONDUCTOR FITTING	C32	15 FT	COMMUNICATION CABLE, 7.5KV

NOTE: SEE INDIVIDUAL DETAILS FOR MATERIAL OF OTHER ITEMS SHOWN ON THIS DRAWING.



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

2-1A INDICATES DETAIL "A" SHOWN ON SHEET 2-1

2-3 INDICATES DETAIL ON SHEET 2-3

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

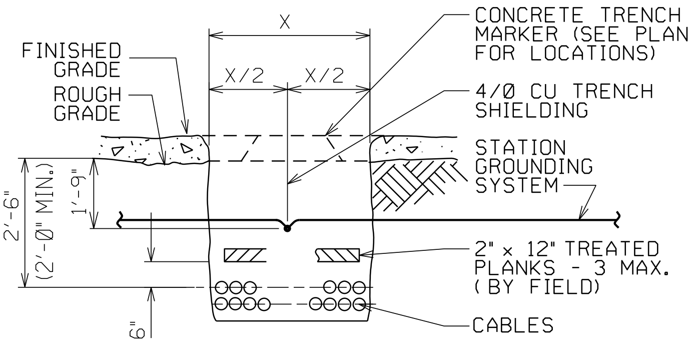
SUBSTATION PHYSICAL DETAIL 2-7
SUBSTATION CONTROL AND LIGHTING DETAIL
CONTROL CABLE CONNECTION FOR THREE SINGLE PHASE CCVT'S

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-2-7	C

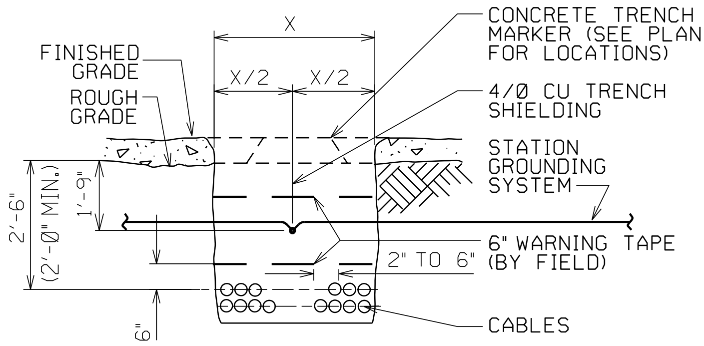
200902-2-7.DGN

5/20/2011 12:28:31 PM



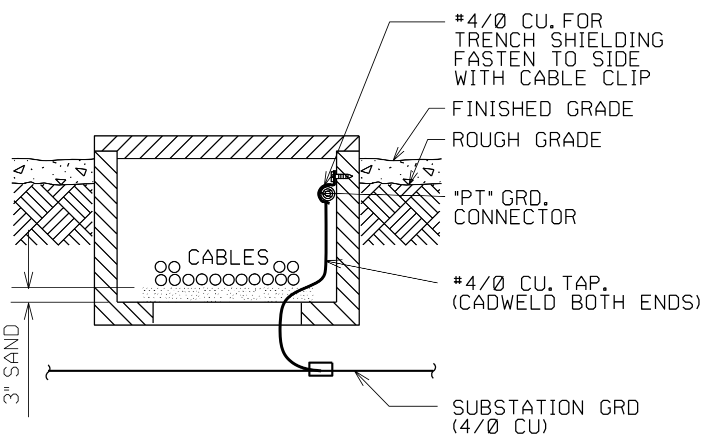
DETAIL "A"

DIRECT BURIAL TRENCH
WITH SHIELDING & PLANK



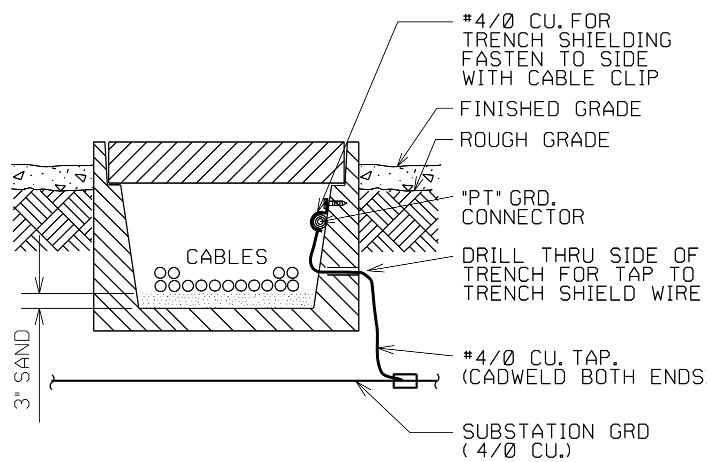
DETAIL "B"

DIRECT BURIAL TRENCH
WITH SHIELDING



DETAIL "C"

PRECAST CONCRETE LIGHT-WEIGHT
OPEN BOTTOM TRENCH
WITH SHIELDING



DETAIL "D"

PRECAST CONCRETE HEAVY
ROAD CROSSING TRENCH
SOLID BOTTOM
WITH SHIELDING

FIELD NOTE:
- TRENCH DEPTH DETERMINED BY THE NUMBER OF CABLE LAYERS REQUIRED.
- FOR BACKFILL USE EXCAVATED EARTH IF IT IS FREE OF SHARP OR ABRASIVE MATERIAL AND IS ADEQUATE FOR EASY REDIGGING.
- REMOVE SHARP OR ABRASIVE MATERIAL FROM TRENCH BOTTOM.
- SUBSTATION 4/0 CU GROUND CONDUCTOR AND 4/0 CU TRENCH SHIELDING MUST BE CONNECTED AT EACH INTERSECTION AND AT THE END OF EACH RUN.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
LOC ID GRP 2	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-8
SUBSTATION CONTROL AND LIGHTING DETAIL
CABLE TRENCH DETAIL "A", DETAIL "B", DETAIL "C" & DETAIL "D"

Xcel Energy

SCALE	DRAWING	REV
NONE	NL-200902-2-8	C

200902-2-8.DGN
5/3/2013 12:05:48 PM

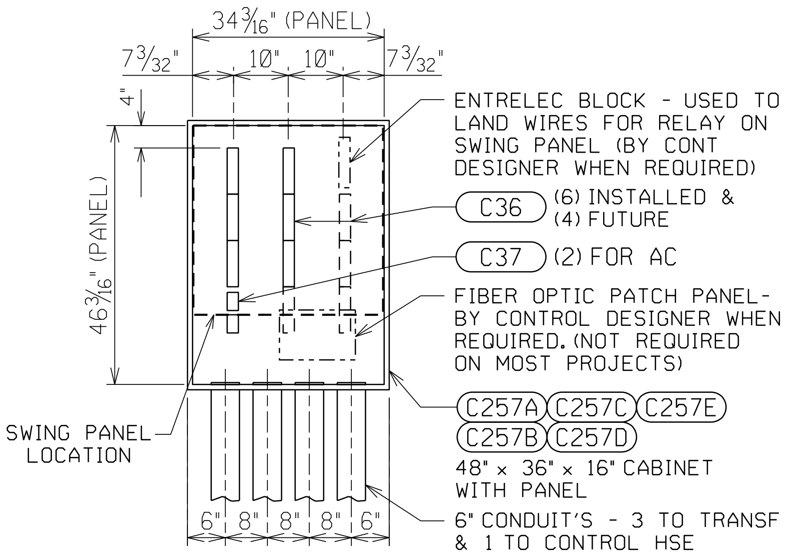
200902-2-9.DGN

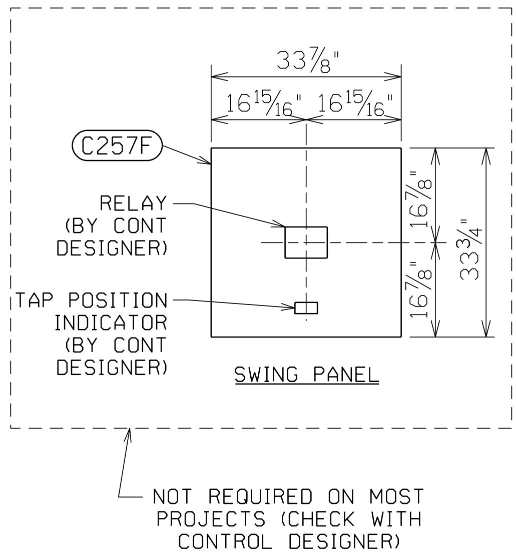
BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

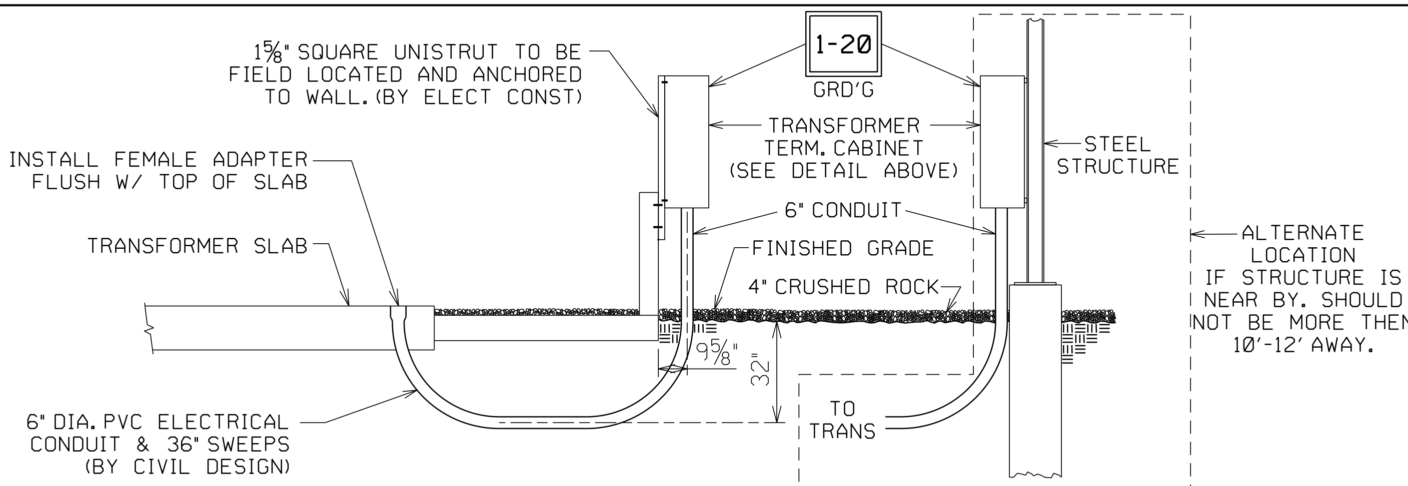
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C36	6	12 POINT TERMINAL BLOCK	C257C	1	HANDLE FOR ITEM C257A
C37	2	2 POINT TERMINAL BLOCK EB-1	C257D	1	MOUNTING KIT FOR ITEM C257A
C257A	1	CABINET 48" x 36" x 16" WITH BACK PNL	C257E	1	DOOR STOP FOR ITEM C257A
C257B	1	INTERIOR PANEL FOR ITEM C257A	C257F	*	SWING PANEL FOR ITEM C257A

NOTE: ON MOST PROJECTS THIS CABINET WILL BE USED AS A PULL BOX ON THE INITIAL INSTALLATION (ONLY ORDER ITEMS C257A THRU C257E). CONSTRUCTION TO PROVIDE ENOUGH SLACK TO LAND CABLES IN THE FUTURE.

*1 REQUIRED ONLY IF NEEDED BY CONTROL DESIGNER.







LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

1-5 INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & 1-1E INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-9
SUBSTATION CONTROL AND LIGHTING DETAIL
TRANSFORMER CABLE TERMINATION CABINET

Xcel Energy

SCALE	DWG NO.	REV
NONE	NL-200902-2-9	C

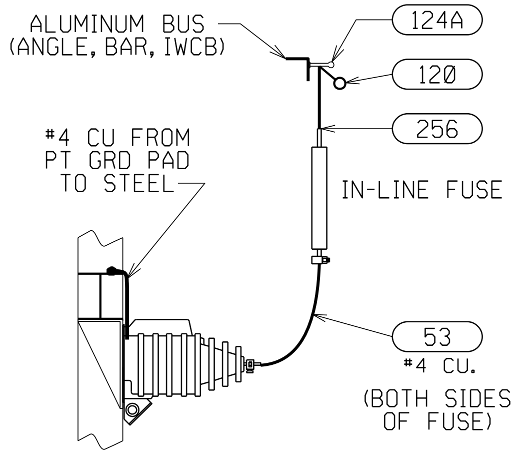
9:57:31 AM 5/3/2013

200902-2-10.DGN

MATERIAL FOR FUSE HANGING FROM RIGID BUS (PER PHASE)		
ITEM NO.	QTY	DESCRIPTION
53	*	4 AWG SOLID CU. WIRE
120	1	HOT LINE CLAMP
124A	1	GROUNDING STUD, ½" DIA x 7" LONG
256	1	SPLICE/REDUCER, BURNDY AMS-250

MATERIAL FOR FUSE HANGING FROM FLEXIBLE CONDUCTOR (PER PHASE)		
ITEM NO.	QTY	DESCRIPTION
53	*	4 AWG SOLID CU. WIRE
123	1	HOT LINE CLAMP (USE W/ 124)
124	1	GROUNDING STIRRUP
256	1	SPLICE/REDUCER, BURNDY AMS-250

* = VARIES



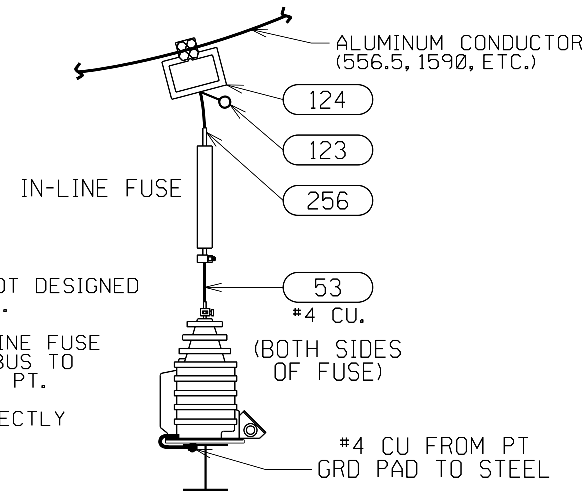
HORIZONTALLY MOUNTED PT

NOTES:

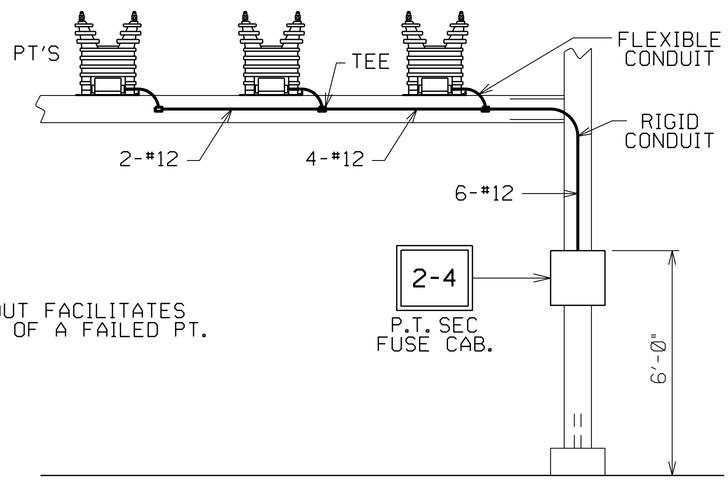
THE PT BUSHING IS NOT DESIGNED TO SUPPORT THE FUSE.

ALWAYS SUPPORT IN-LINE FUSE FROM THE OVERHEAD BUS TO AVOID DAMAGE TO THE PT.

DO NOT PUT FUSE DIRECTLY IN PT BUSHING.



VERTICAL MOUNTED PT



NOTE:
THIS CONDUIT LAYOUT FACILITATES EASY REPLACEMENT OF A FAILED PT.

EXAMPLE PT LAYOUT

SEE ELECTRICAL LAYOUT DRAWINGS FOR EXACT LAYOUT OF P.T.'S

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

[1-5] INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & [1-1E] INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-10
SUBSTATION CONTROL AND LIGHTING DETAIL
POTENTIAL TRANSFORMER MOUNTING AND CONDUIT LAYOUT

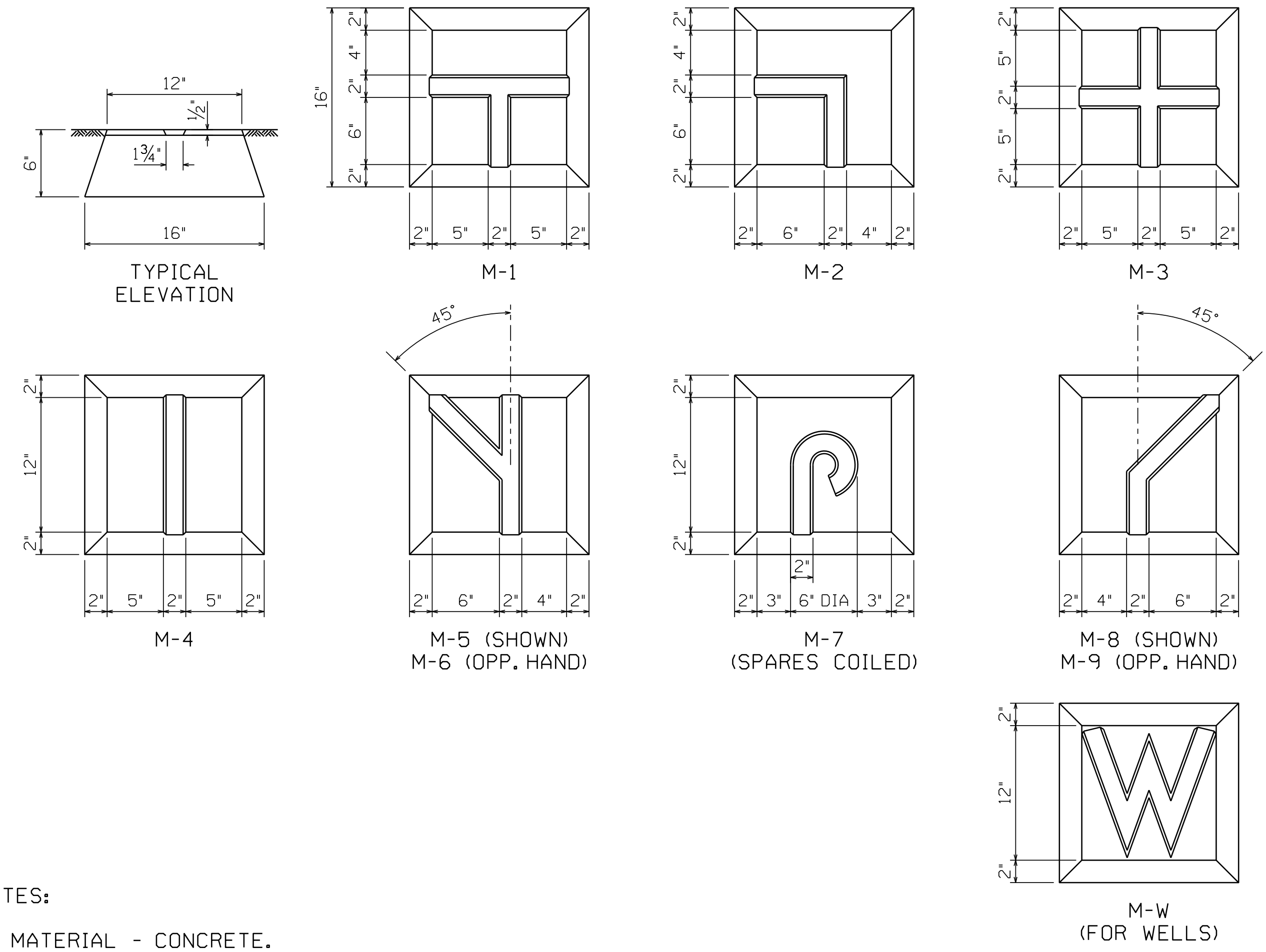
Xcel Energy

SCALE	DWG	REV
NONE	NL-200902-2-10	C

12:19:41 PM
5/3/2013

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION



NOTES:

1. MATERIAL - CONCRETE.
2. SLOTS UNPAINTED FOR POWER CABLES 600V AND BELOW AND FOR CONTROL
3. SLOTS PAINTED RED FOR POWER CABLES OVER 600V. (CALLED OUT ON DWG AS MR-1, MR-2...)
4. SLOTS PAINTED BLUE FOR WATER OR SEWER LINES. (CALLED OUT ON DWG AS MB-1, MB-2...)
5. SLOTS PAINTED ORANGE FOR PHONE CABLES. (CALLED OUT ON DWG AS MO-1, MO-2...)
6. MARKERS TO BE PLACED 5'-0" MAX. FROM EACH SIDE OF THE FENCE AND APPROXIMATELY 20FT INTERVALS ALONG CABLE ROUTE TO PROPERTY LINE. USE DISCRETION IN SPACING ON LONG RUNS.

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

1-5 INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & 1-1E INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 2-11
SUBSTATION CONTROL AND LIGHTING DETAIL
CONCRETE MARKERS FOR UNDERGROUND CABLE RUNS

Xcel Energy

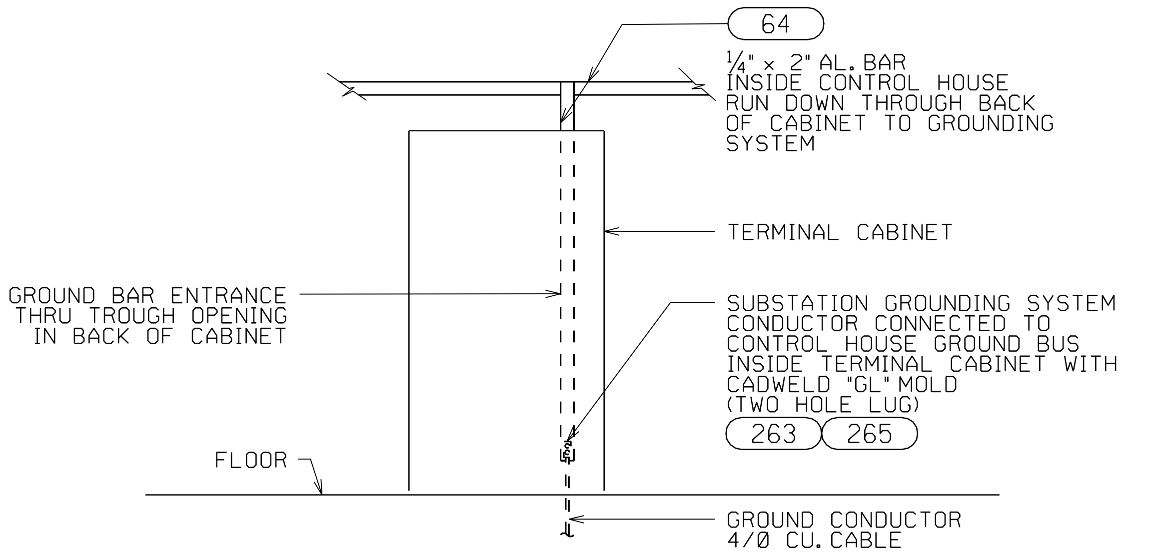
SCALE	DWG	REV
NONE	NL-200902-2-11	B

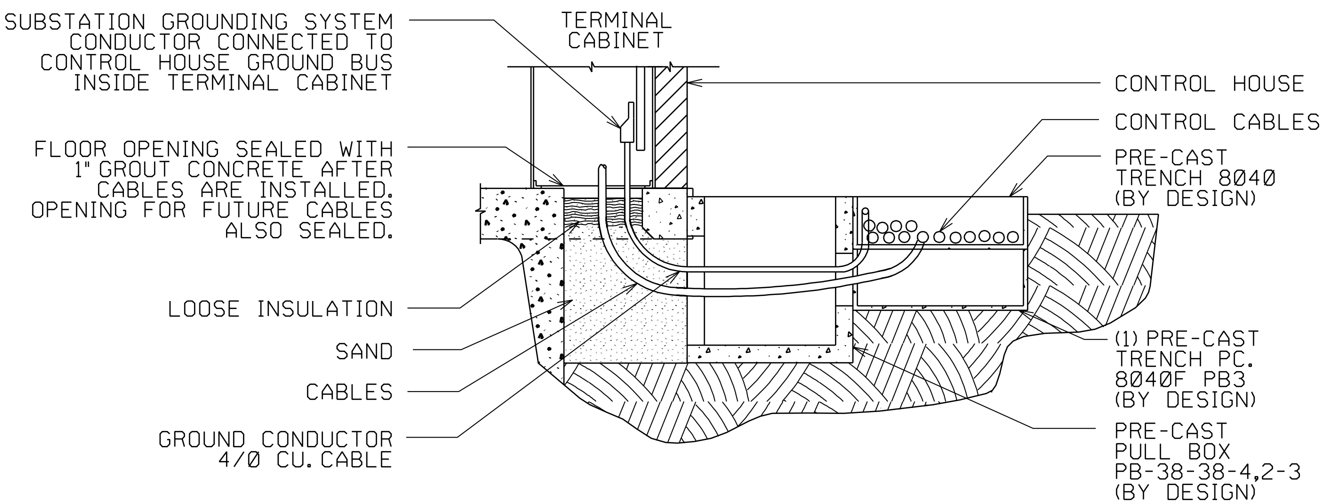
200902-2-11.DGN

9/19/2013 11:05:10 AM

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
64		1/4" x 2" x 20' LONG RECT. AL. BAR			
263	1	CADWELD LUG, TYPE GL			
265	1/4PKG	CADWELD SHOT, CAT #XL65 (PKG 4)			





LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-1
CONTROL HOUSE DETAIL
CABLE ENTRANCE TO CONTROL HOUSE (PRE-CAST PULL BOX)

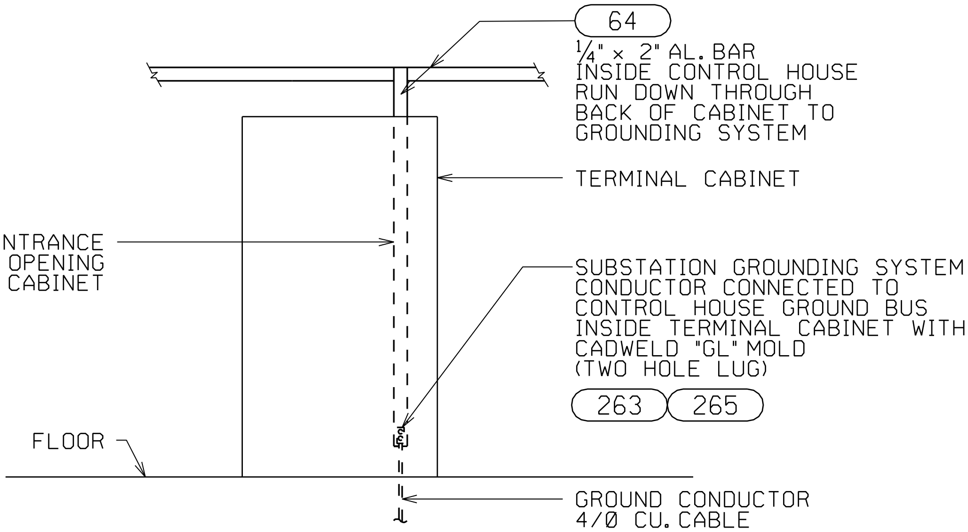
Xcel Energy

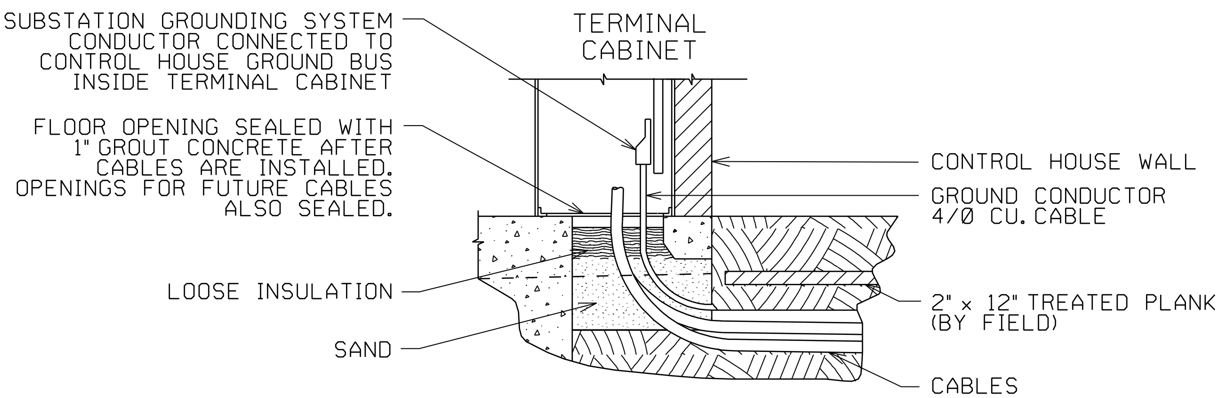
SCALE		REV
NONE	NL-200902-3-1	B

08/16/2006 200902-3-1.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
64		1/4" x 2" x 20' LONG RECT. AL. BAR			
263	1	CADWELD LUG, TYPE GL			
265	1/4PKG	CADWELD SHOT, CAT #XL65 (PKG 4)			





LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-2
CONTROL HOUSE DETAIL
CABLE ENTRANCE TO CONTROL HOUSE (BURIED CABLE)

Xcel Energy

SCALE: NONE

NL-200902-3-2

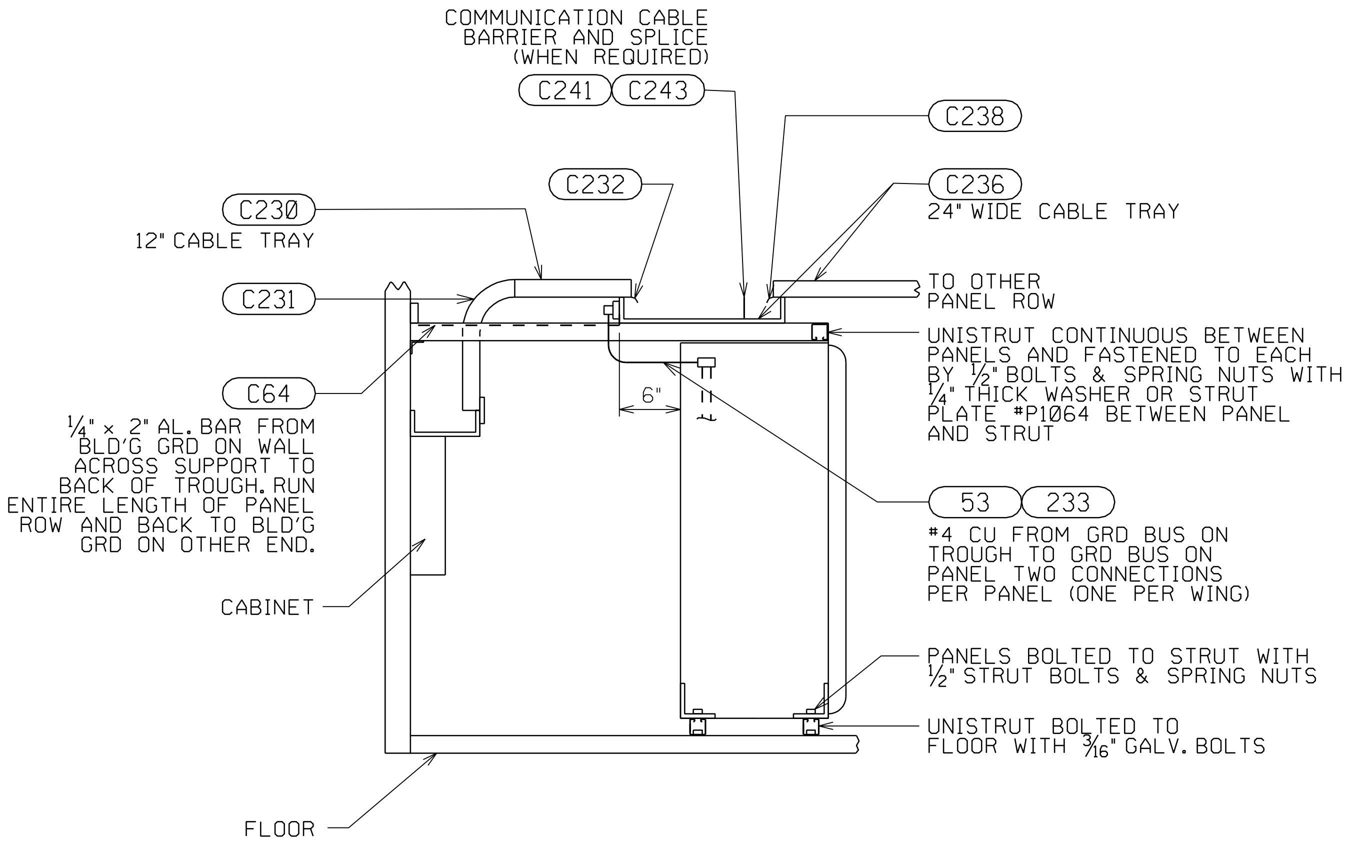
REV: B

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

08/16/2006 200902-3-2.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
53		4 AWG SOLID COPPER WIRE	C236		24" AL. LADDER CABLE TRAY
64		¼" x 2" x 20' LONG RECT. AL. BAR	C238		END DROP OUT FOR 24" WIDE CABLE TRAY
233		TERMINAL LUG, 14 AWG - 4 AWG CU.	C241		STRAIGHT SECTION BARRIER
C230		12" AL. LADDER CABLE TRAY	C243		BARRIER STRIP SPLICE
C231		90 DEG ELBOW, FOR 12" WIDE CABLE TRAY			
C232		END DROP OUT FOR 12" WIDE CABLE TRAY			



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-3
CONTROL HOUSE DETAIL
TYPICAL PANEL AND CABLE TRAY MOUNTING

Xcel Energy

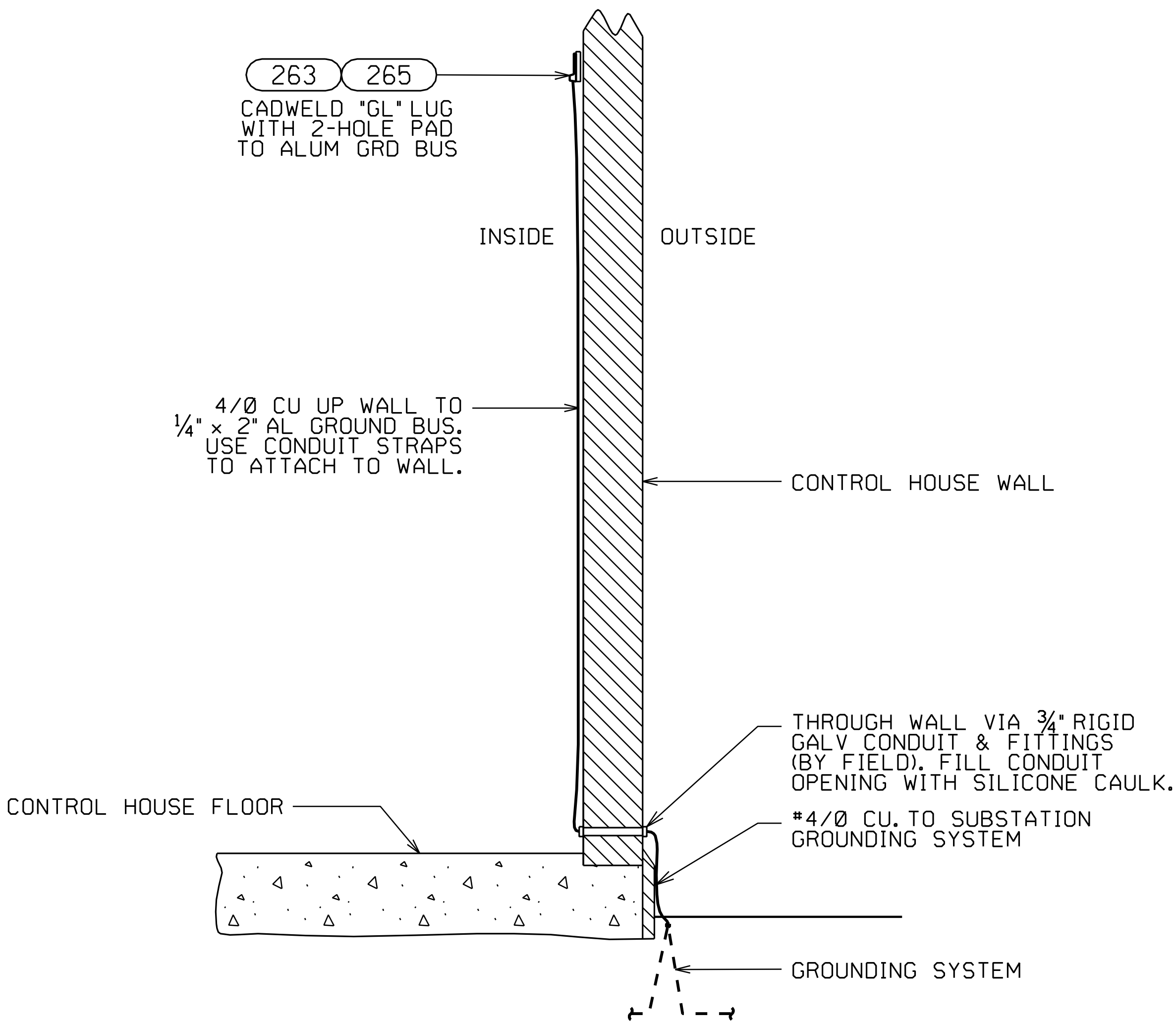
SCALE	DRAWING NO.	REV
NONE	NL-200902-3-3	A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

05/25/2006 200902-3-3.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
263	1 EA	CADWELD LUG, TYPE GL			
265	1 EA	CADWELD SHOT 65, COLOR DARK GREEN			



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 3-4
CONTROL HOUSE DETAIL
GROUND BUS ENTRANCE

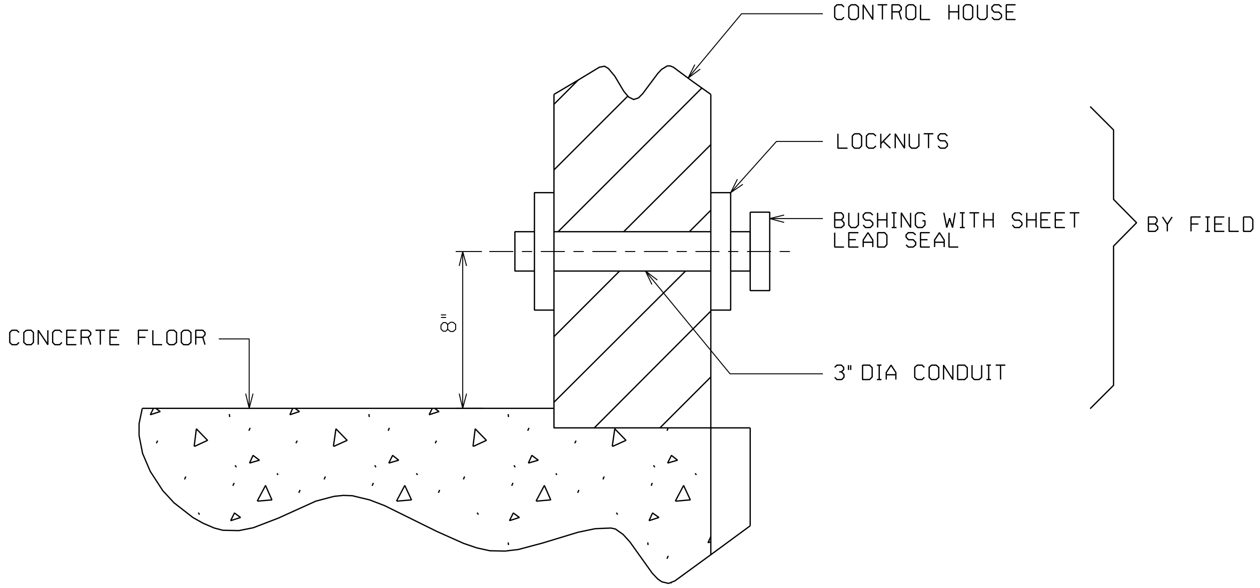
GRP	SIGNIFICANT NUMBER
LOC ID GRP I	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy

SCALE		REV
NONE	NL-200902-3-4	B

$TIME$

09/20/2007



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

ENGINEERING DEPARTMENT MINNEAPOLIS, MN	SUBSTATION PHYSICAL DETAIL 3-5 CONTROL HOUSE DETAIL MOBILE TRANSFORMER CONTROL CABLE ENTRANCE
Xcel Energy	SCALE: NONE — NL-200902-3-5 — REV: A

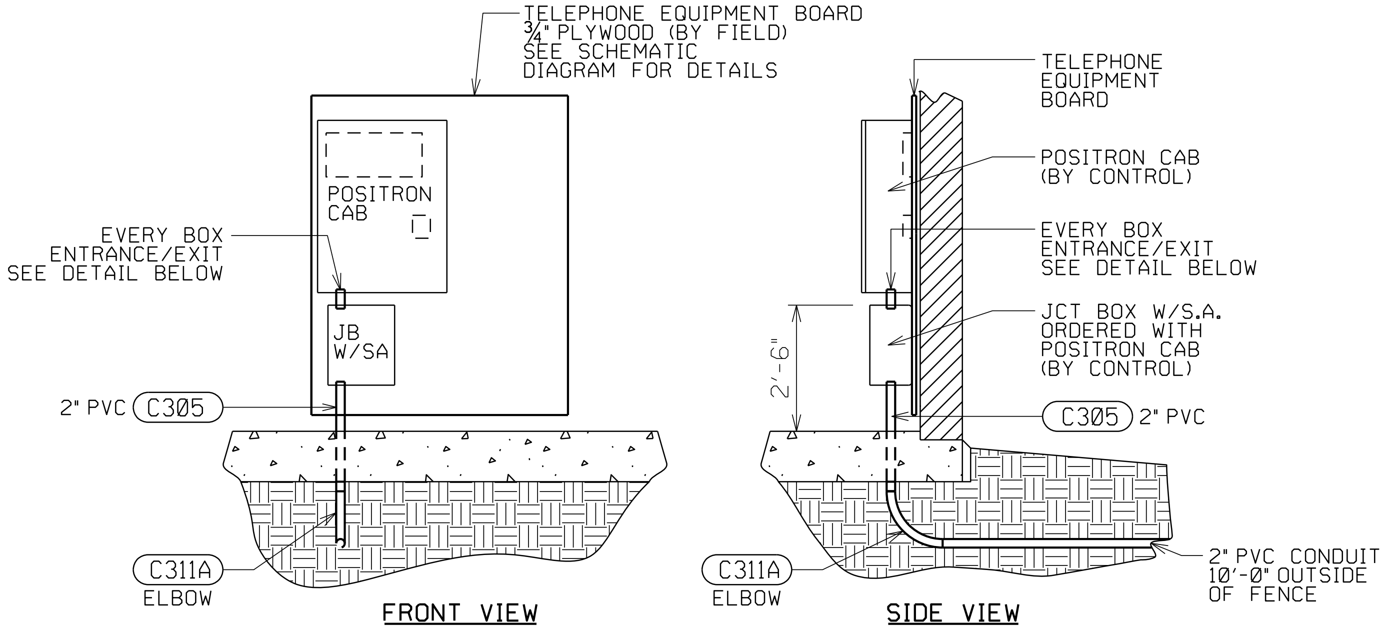
GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

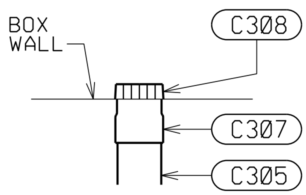
05/25/2006 200902-3-5.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
703	1 EA	CAUTION SIGN	C308	3 EA	INSULATED CONDUIT BUSHING FOR 2" PVC
C305	* FT	2" PVC CONDUIT, SCHEDULE 40	C310	1 EA	CLEAR PVC CEMENT
C307	3 EA	TERMINAL ADAPTERS FOR 2" PVC	C311A	1 EA	ELBOW, 24" RADIUS FOR 2" PVC SCHED 40
					* DETERMINED BY DESIGNER

200902-3-6.DGN





DETAIL

PVC TERMINATION TO BOX

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 3-6
ELECTRICAL EQUIPMENT ENCLOSURE DETAIL
TELEPHONE CABLE ENTRANCE

Xcel Energy®

SCALE NONE

NL-200902-3-6

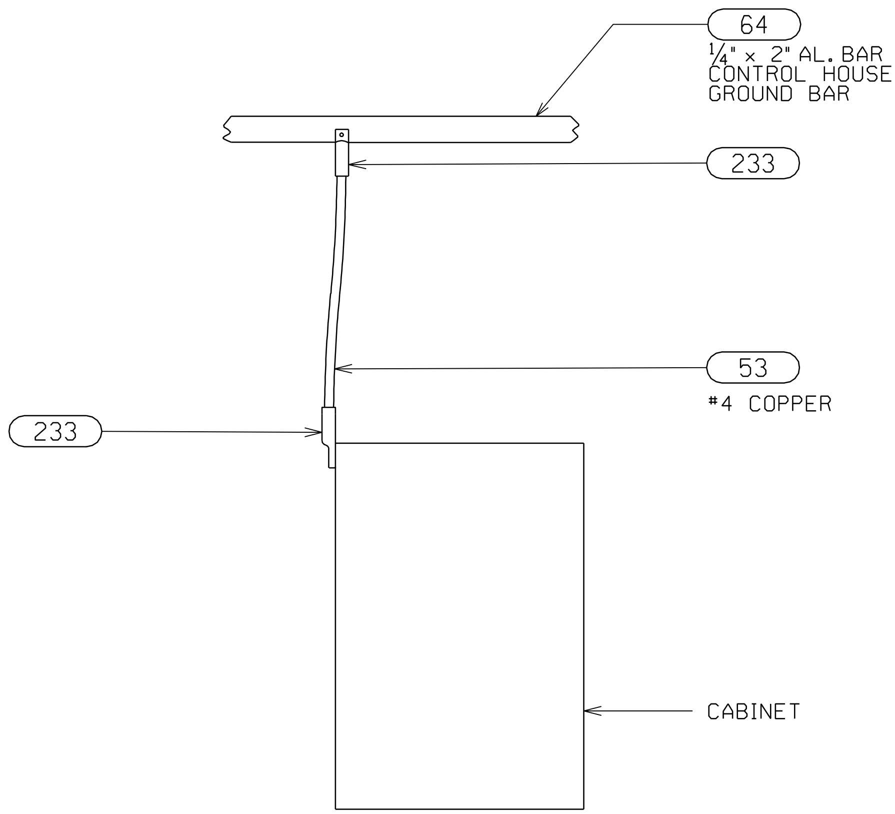
REV D

11/17/2011 11:41:16 AM

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
53	3 FT	#4 AWG SOLID COPPER WIRE			
64	*	1/4" x 2" AL. BAR			
233	2	TERMINAL LUG, 14 AWG - 4 AWG			

* VARIES



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-7

CONTROL HOUSE DETAIL

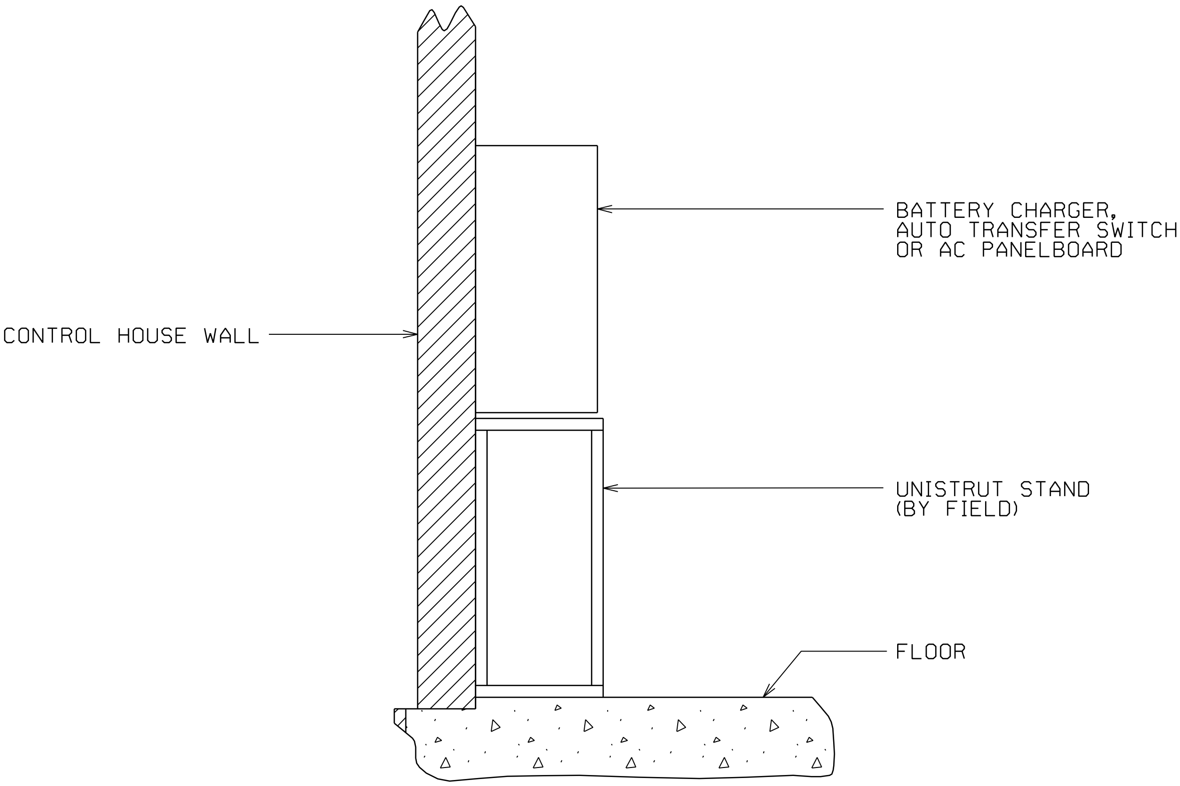
TYP GRD'G FOR ALL CAB., BOXES, SAF. SW., BATT. RACK & CHARGER

Xcel Energy

SCALE	DRAWING NO.	REV
NONE	NL-200902-3-7	A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

05/25/2006 200902-3-7.DGN



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-8
CONTROL HOUSE DETAIL
MOUNTING FOR HEAVY EQUIPMENT

Xcel Energy

SCALE NONE

NL-200902-3-8

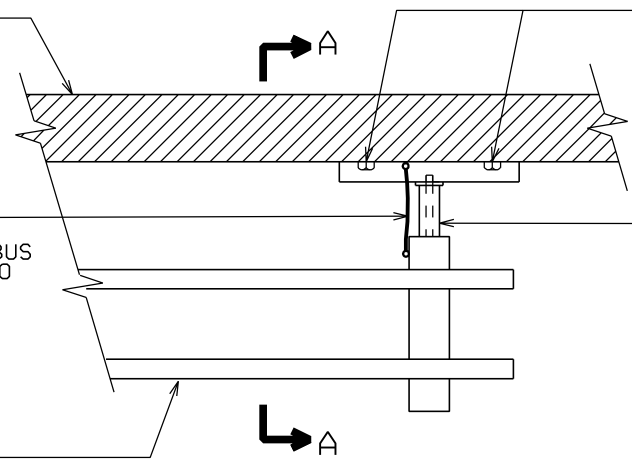
REV A

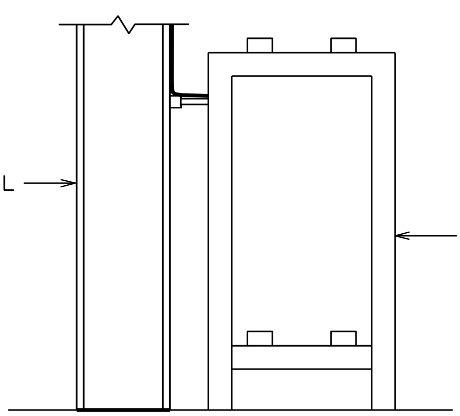
05/25/2006 200902-3-8.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
53	10 FT	4 AWG SOLID COPPER WIRE			
233	2	TERMINAL LUG, 14 AWG - 4 AWG			

200902-3-9.DGN





SECTION A-A

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 3-9
ELECTRICAL EQUIPMENT ENCLOSURE DETAIL
TYPICAL MOUNTING OF BATTERY RACK TO WALL

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy

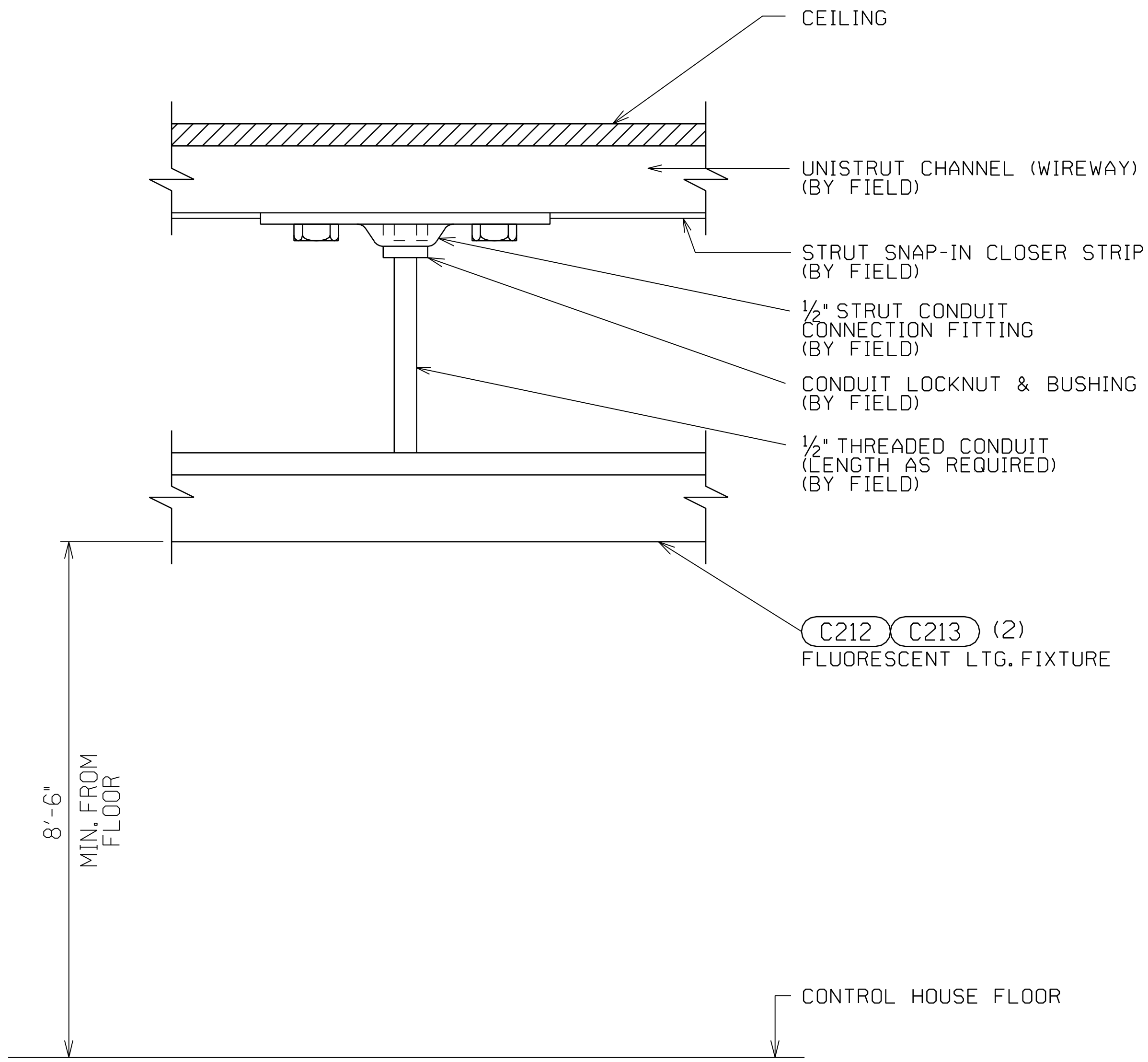
SCALE		REV
NONE	NL-200902-3-9	B

$TIME$ 02/20/2008

.

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C212		FLUORESCENT LIGHTING FIXTURE 4'-0" UNIT			
C213		FLUORESCENT LAMP, 35W, 48"			



FIELD NOTE:
- AN OPTION WOULD BE TO MOUNT THE LIGHTS FLUSH WITH STRUT.

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-10
CONTROL HOUSE DETAIL
FLUORESCENT LIGHT FIXTURE HANGER

Xcel Energy

SCALE: NONE

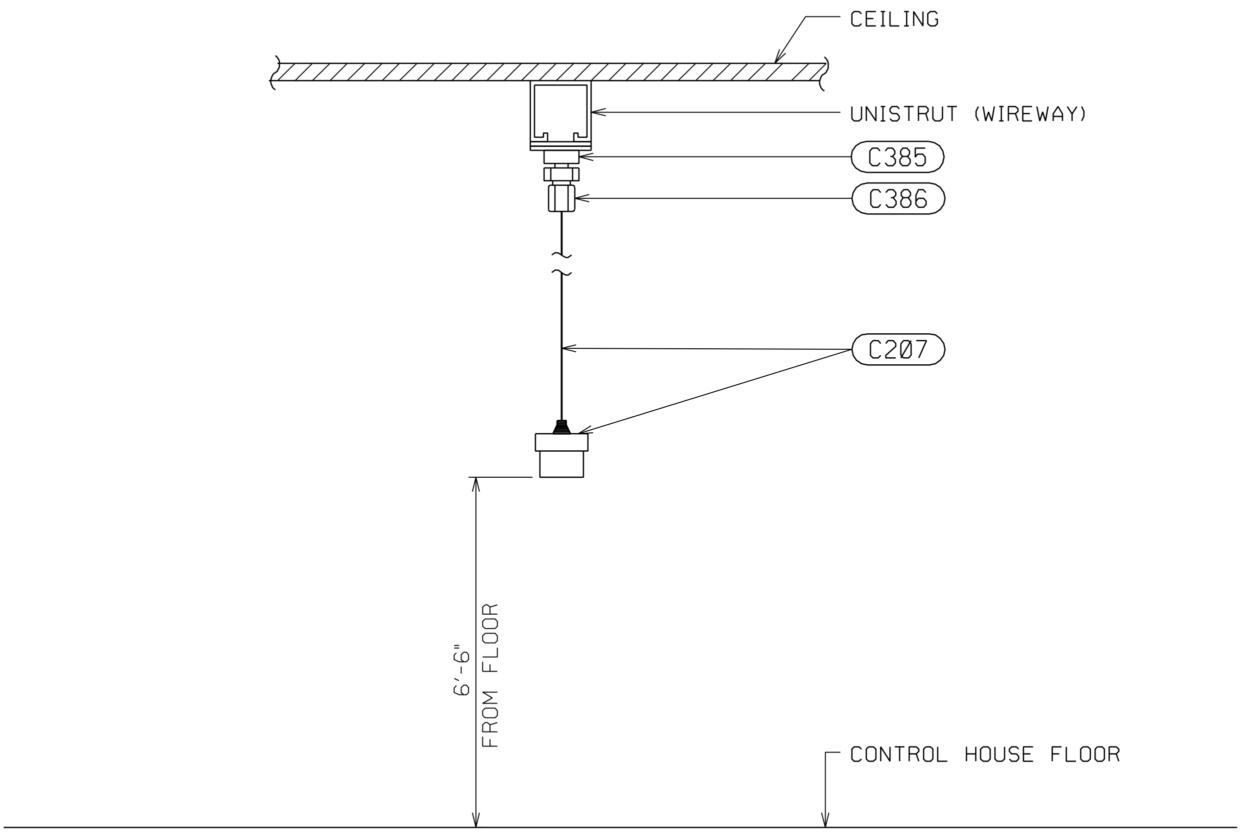
NL-200902-3-10

REV: A

05/25/2006 200902-3-10.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C207	1	GROUND RECEPTACLES ON DROP CORD.			
C385	1	CONDUIT CONN. PLATE FOR ¾" CONDUIT			
C386	1	STRAIGHT CORD. CONNECTOR			



FIELD NOTE:
- RECEPTACLES LOCATED IN BACK OF PANEL ROWS AT APPROXIMATELY 10'-0" INTERVALS.

LEGEND:
(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-11
CONTROL HOUSE DETAIL
MOUNTING DETAIL FOR PANEL DROP CORD RECEPTACLES

Xcel Energy

SCALE: NONE

NL-200902-3-11

REV: A

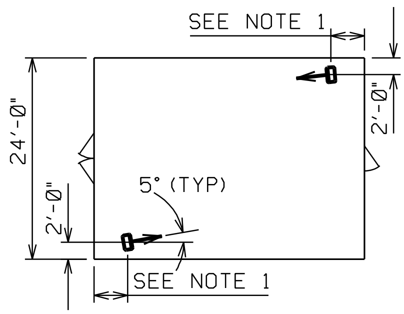
05/25/2006 200902-3-11.DGN

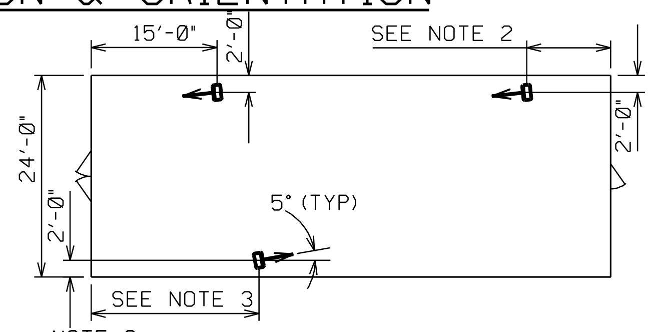
200902-3-12.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C195		5KW HEATER, 240 VOLT, SINGLE PHASE			
C198		HEATER THERMOSTAT			

HEATER LOCATION & ORIENTATION

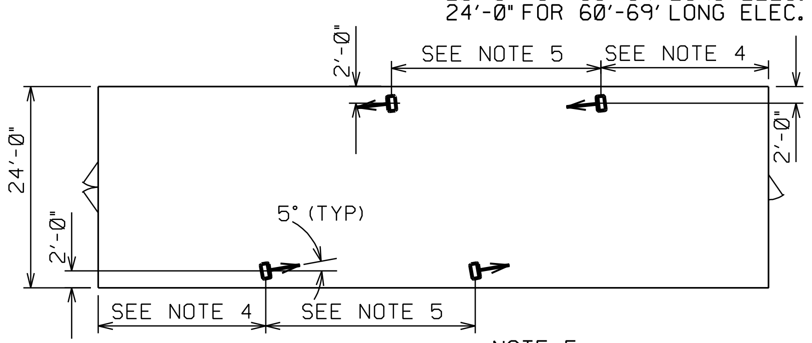




NOTE 1:
4'-0" FOR 20'-29' LONG ELEC. EQUIP. ENCLOSURE
5'-0" FOR 30'-39' LONG ELEC. EQUIP. ENCLOSURE
8'-0" FOR 40'-49' LONG ELEC. EQUIP. ENCLOSURE

NOTE 2:
10'-0" FOR 50'-59' LONG ELEC. EQUIP. ENCLOSURE
12'-0" FOR 60'-79' LONG ELEC. EQUIP. ENCLOSURE

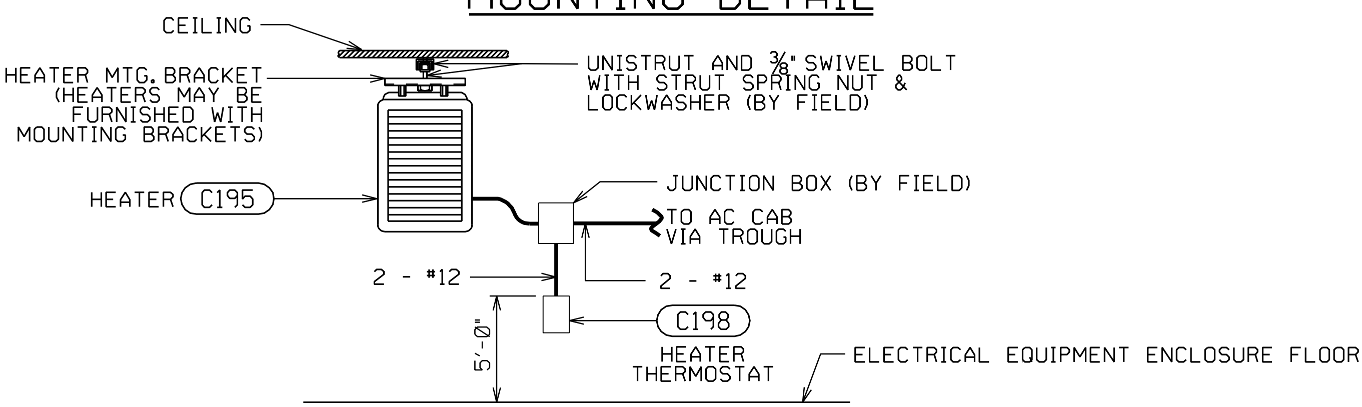
NOTE 3:
20'-0" FOR 50'-59' LONG ELEC. EQUIP. ENCLOSURE
24'-0" FOR 60'-69' LONG ELEC. EQUIP. ENCLOSURE



NOTE 4:
20'-0" FOR 80'-99' LONG ELEC. EQUIP. ENCLOSURE
24'-0" FOR 100'-110' LONG ELEC. EQUIP. ENCLOSURE

NOTE 5:
25'-0" FOR 80'-99' LONG ELEC. EQUIP. ENCLOSURE
35'-0" FOR 100'-110' LONG ELEC. EQUIP. ENCLOSURE

MOUNTING DETAIL



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 3-12
ELECTRICAL EQUIPMENT ENCLOSURE DETAIL
HEATER INSTALLATION

Xcel Energy

SCALE: NONE

NL-200902-3-12

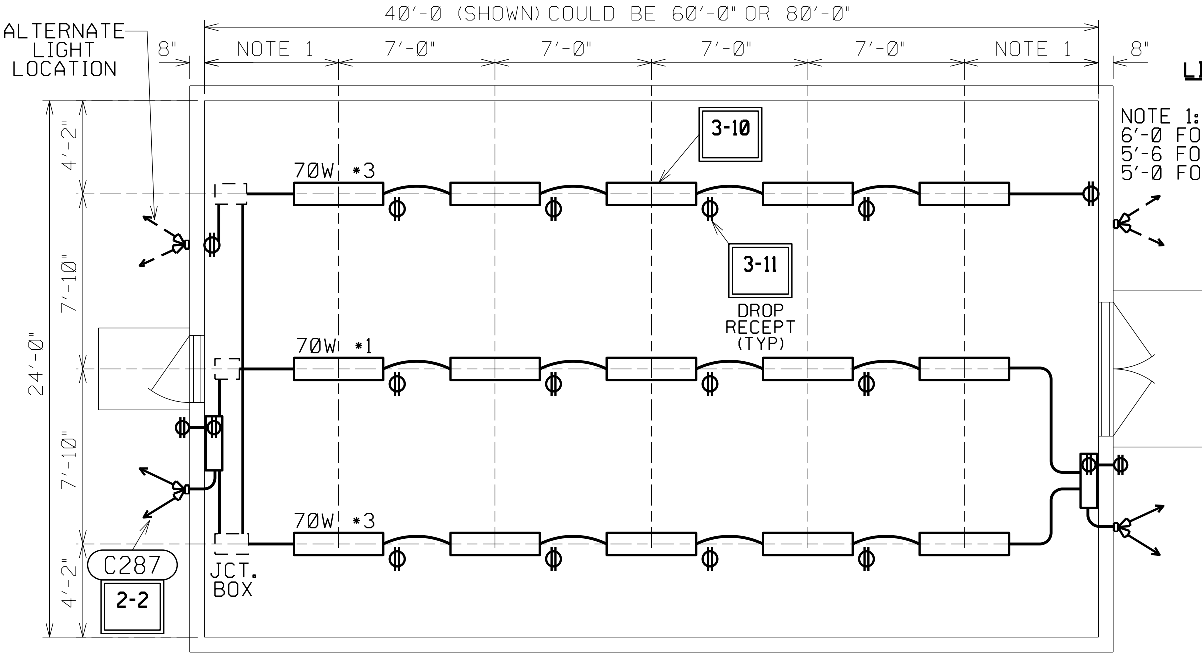
REV: B

$TIME$

02/20/2008

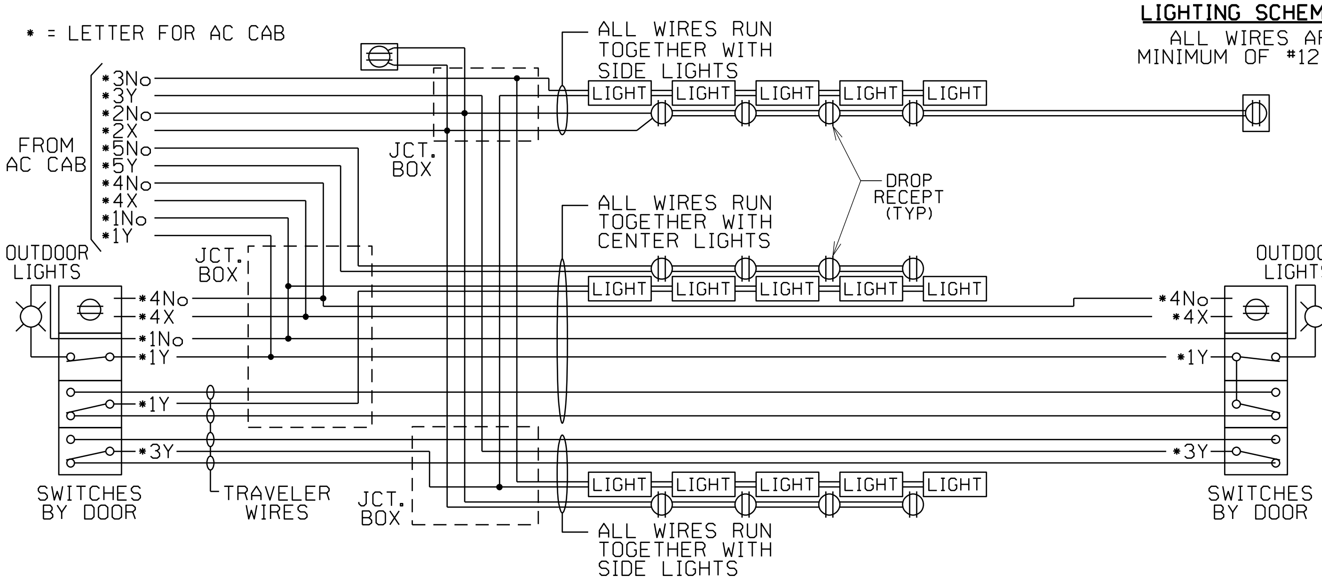
LIGHTING LAYOUT

NOTE 1:
6'-0 FOR 40'-0 ENCLOSURE
5'-6 FOR 60'-0 ENCLOSURE
5'-0 FOR 80'-0 ENCLOSURE



LIGHTING SCHEMATIC

ALL WIRES ARE MINIMUM OF #12 AWG



FIELD NOTE:

- ENCLOSURE SHOWN IS 40'-0", 60'-0" AND 80'-0" ENCLOSURE WIRED THE SAME EXCEPT THERE ARE MORE LIGHTS.
- NUMBER OF LIGHTS REQUIRED: 40'-0 REQUIRES 15, 60'-0" REQUIRES 24 AND 80'-0 REQUIRES 33.

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

[1-5] INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & [1-1E] INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 3-13
ELECTRICAL EQUIPMENT ENCLOSURE DETAIL
LIGHTING LAYOUT AND WIRING

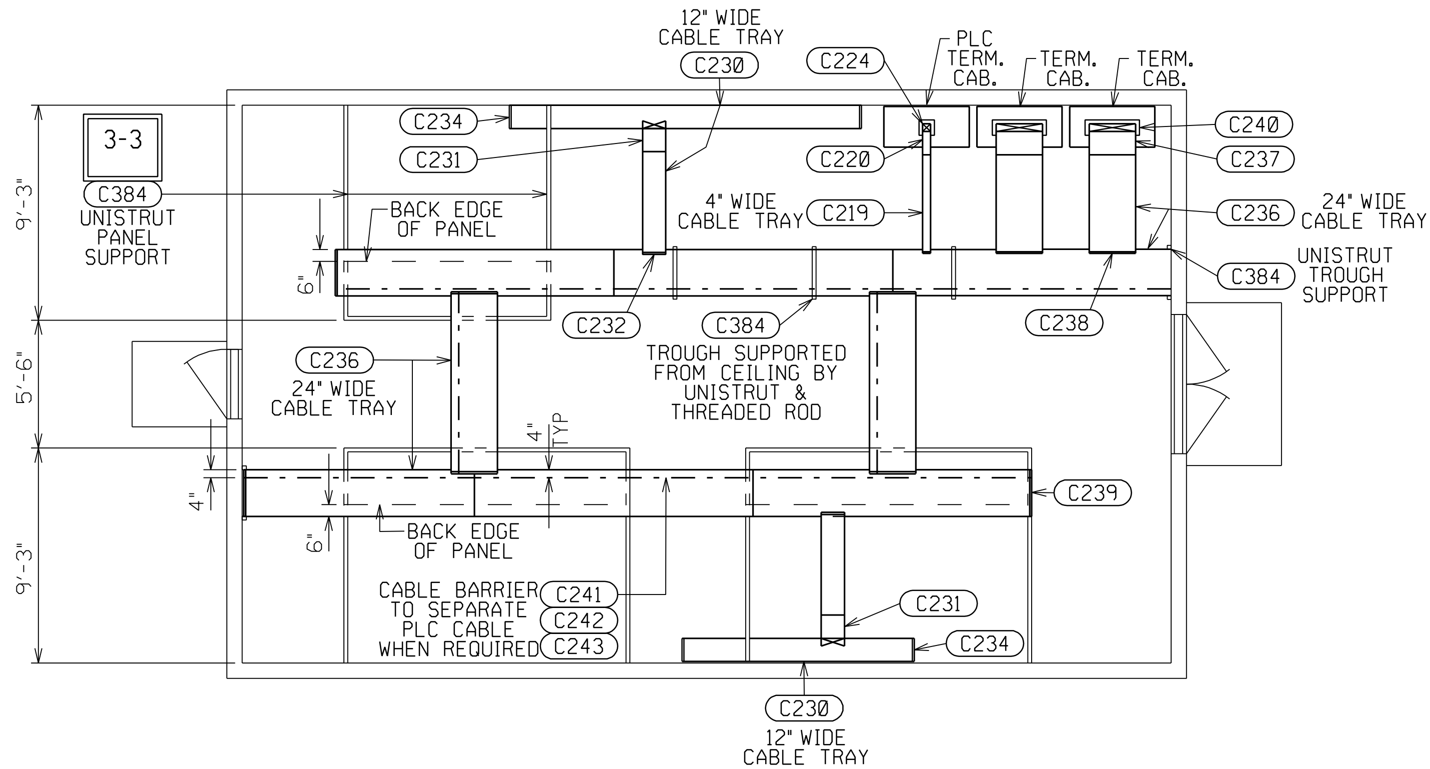
Xcel Energy®

SCALE	DRAWING	REV
NONE	NL-200902-3-13	C

5/20/2011 12:48:52 PM

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C230		12" AL. LADDER CABLE TRAY	C239		BLIND END PLATE FOR 24" CABLE TRAY
C231		90 DEG. ELBOW, FOR 12" WIDE CABLE TRAY	C240		FRAME BOX CONN., FOR 24" CABLE TRAY
C232		END DROP OUT FOR 12" WIDE CABLE TRAY	C241		STRAIGHT SECTION BARRIER
C234		BLIND END PLATE FOR 12" CABLE TRAY	C242		VERTICAL BEND BARRIERS
C236		24" AL. LADDER CABLE TRAY	C243		BARRIER STRIP SPLICE
C237		90 DEG. ELBOW, FOR 24" WIDE CABLE TRAY	C384		GALVANIZED UNISTRUT CHANNEL P-1000
C238		END DROP OUT FOR 24" WIDE CABLE TRAY			



FIELD NOTE:

- MAXIMUM UNSUPPORTED SPAN OF TROUGH SHOULD NOT BE MORE THEN 10'-0"

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

[1-5] INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & [1-1E] INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 3-14
CONTROL HOUSE DETAIL
CONTROL HOUSE EXAMPLE TROUGH LAYOUT

Xcel Energy

SCALE: NONE

NL-200902-3-14

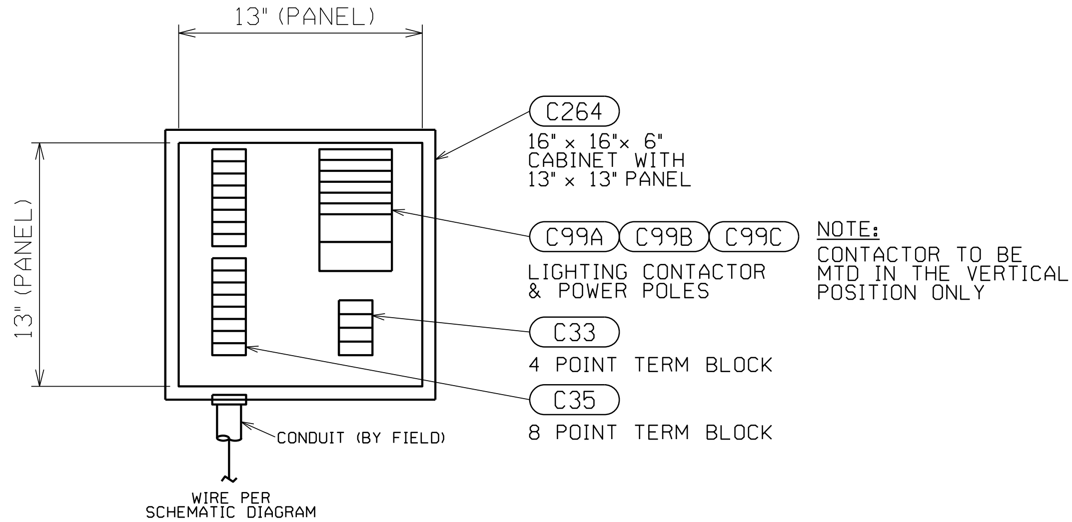
REV: A

05/30/2006 200902-3-14.DGN

200902-3-15.DGN

BILL OF MATERIAL FOR THIS DETAIL

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C33	1	4 POINT TERMINAL BLOCK	C99B	4	SINGLE CIRCUIT POWER POLES
C35	2	8 POINT TERMINAL BLOCK	C99C	2	DOUBLE CIRCUIT POWER POLES
C99A	1	LIGHTING CONTACTOR	C264	1	16" x 16" x 6" CAB. WITH BACK PANEL



THIS EXAMPLE IS TYPICAL FOR EACH LIGHTING CONTACTOR REQUIRED.

Design Notes:

Circuit breakers in the AC lighting cabinet in the Electrical Equipment Enclosure are not to be used for switching yard lights on and off.

A toggle switch(es) shall be installed in the Electrical Equipment Enclosure to operate the substation yard lighting. The switches shall be mounted near the main door helping to provide the operators with immediate access to yard lighting during a system emergency. (Switches will be labeled to indicate which area of the yard they operate).

Receptacles will be provided at each outdoor light location and are to be connected to separate circuits in the AC lighting cabinet.

The standard cable configuration used for yard lighting and receptacles is 4/C #10.

The maximum length of a lighting circuit is the distance from the AC cabinet to the last light on the circuit. The maximum voltage drop allowed is 5% or 6 volts on a 120 volt circuit.

The following table gives the maximum length that #10 AWG conductor can be run, when loaded as noted, withhout exceeding the allowed voltage drop:

# of lights	Watts	Amps	Maximum Length of Circuit
Four	1600	13	188 feet
Three	1200	10	250 feet
Two	800	7	375 feet
One	400	3	750 feet

For yard lighting installations falling outside these parameters, work with the project engineer for a site specific design.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 3-15
ELECTRICAL EQUIPMENT ENCLOSURE DETAIL
WIRING OF OUTDOOR LIGHTING

Xcel Energy

SCALE NONE

NL-200902-3-15

REV C

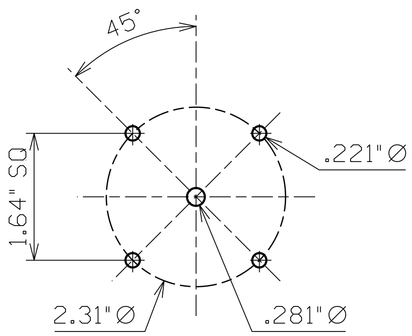
GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

7/27/2012 2:08:49 PM

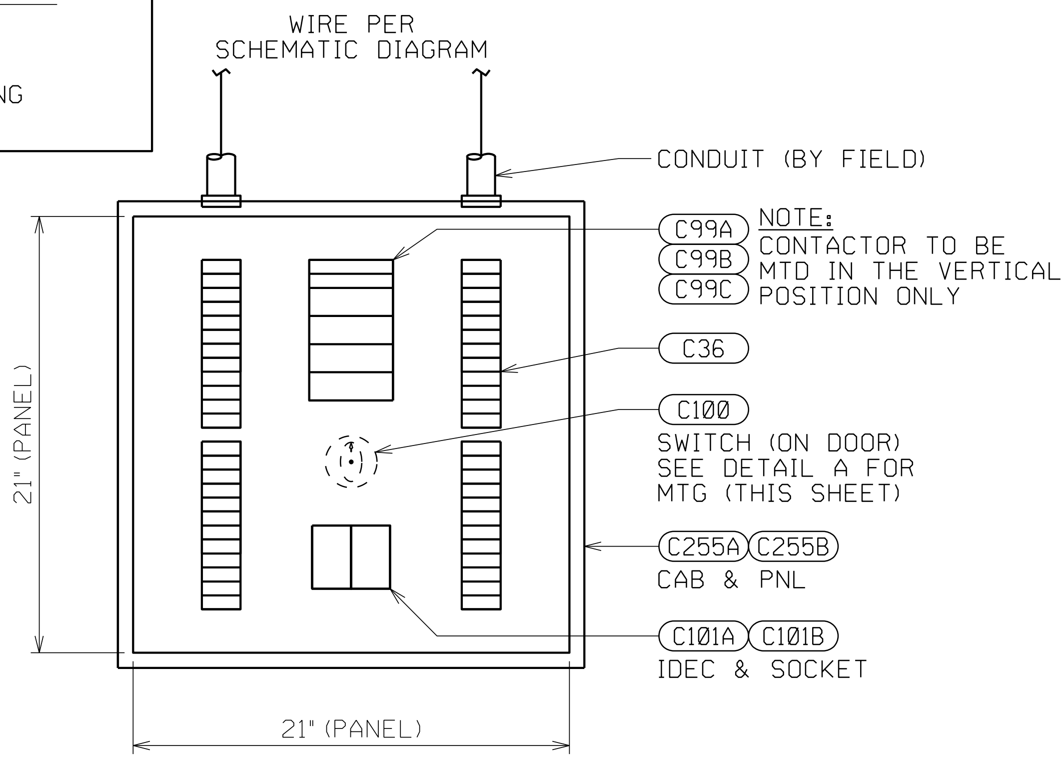
BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C36	4	12 POINT TERMINAL BLOCK	C101A	2	IDEC RELAY, 120VAC SELF RESET
C99A	1	LIGHTING CONTACTOR	C101B	2	11 BLADE SQUARE SOCKET
C99B	2	SINGLE CIRCUIT POWER POLES	C255A	1	24" x 24" x 8" CAB.
C99C	4	DOUBLE CIRCUIT POWER POLES	C255B	1	BACK PANEL, 21" x 21" (FOR ITEM C255A)
C100	1	SWITCH, SELECTOR, MANUAL-OFF AUTO			

200902-3-16.DGN



DETAIL A
SWITCH DRILLING DIMENSIONS



LEGEND:
(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.
[1-5] INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & [1-1E] INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS.YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 3-16
ELECTRICAL EQUIPMENT ENCLOSURE DETAIL
VENT FAN CONTROL CABINET

Xcel Energy

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

SCALE NONE

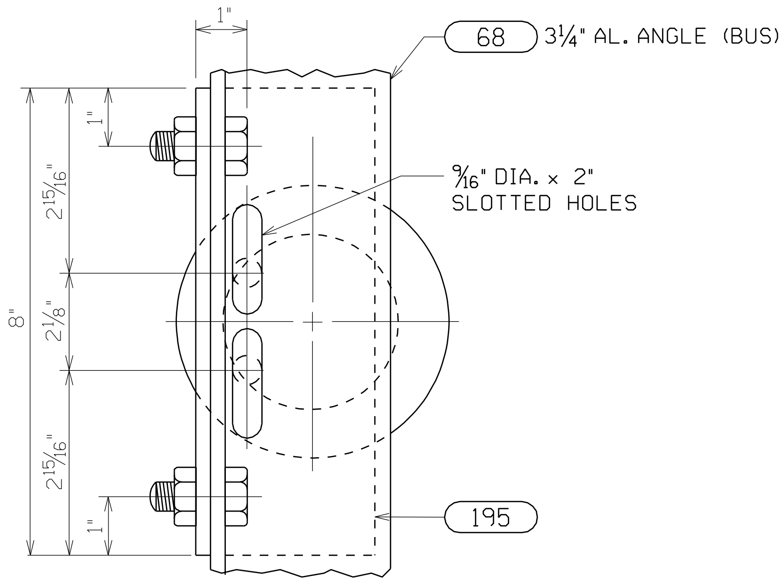
NL-200902-3-16

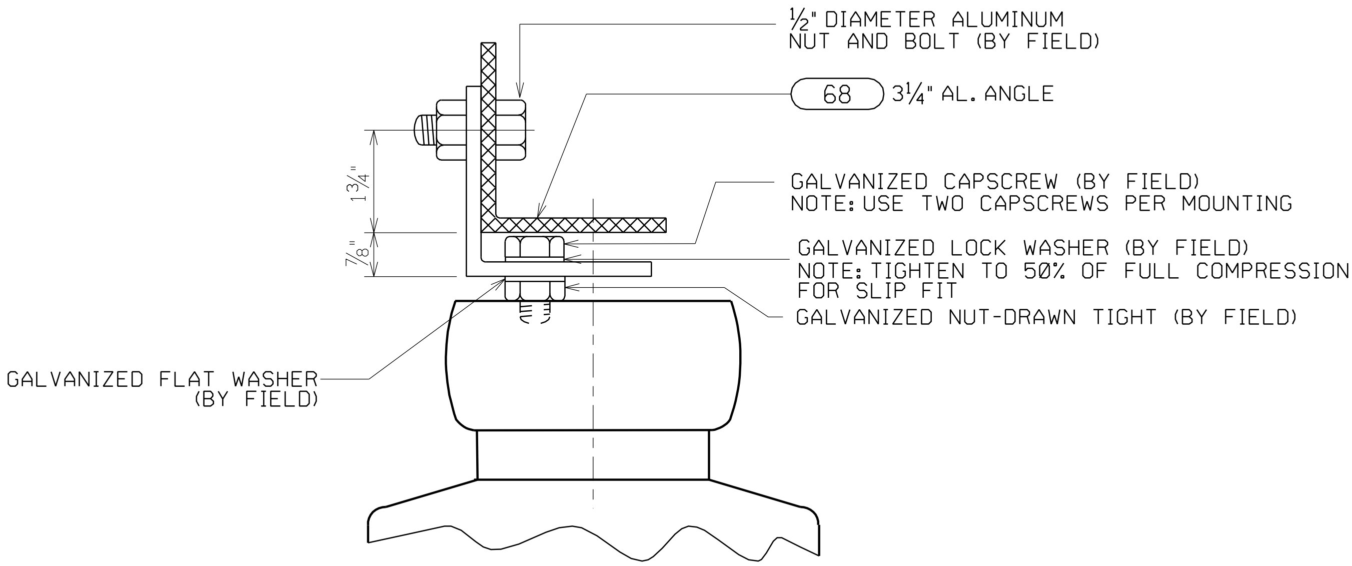
REV B

5/3/2013 9:59:10 AM

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
68		3¼" x 3¼" x ¼" x 25' LONG AL. ANGLE			
195	1	MOUNTING CLIP FOR 3¼" AL ANGLE			





LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

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ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-1

ELECTRICAL CONNECTION DETAIL

BUS MOUNTING FOR ALUMINUM ANGLE

Xcel Energy

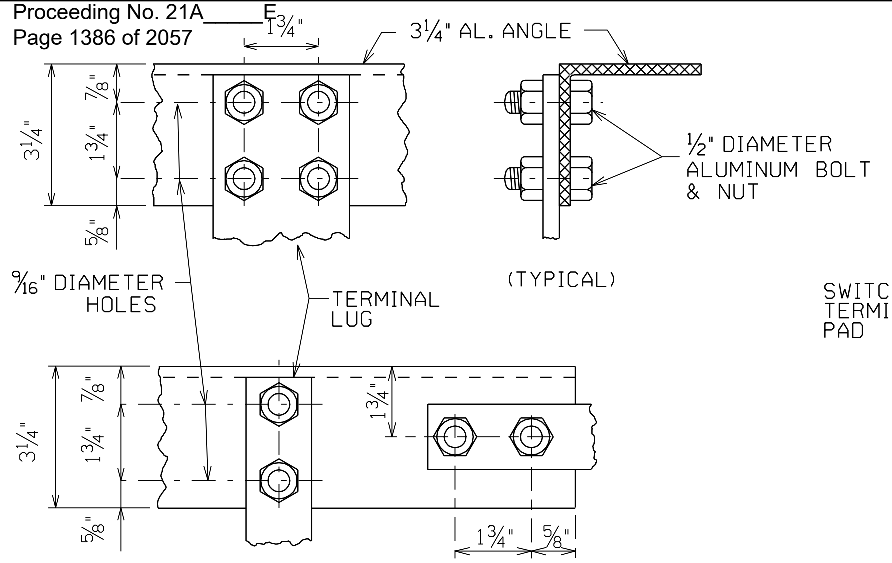
SCALE: NONE

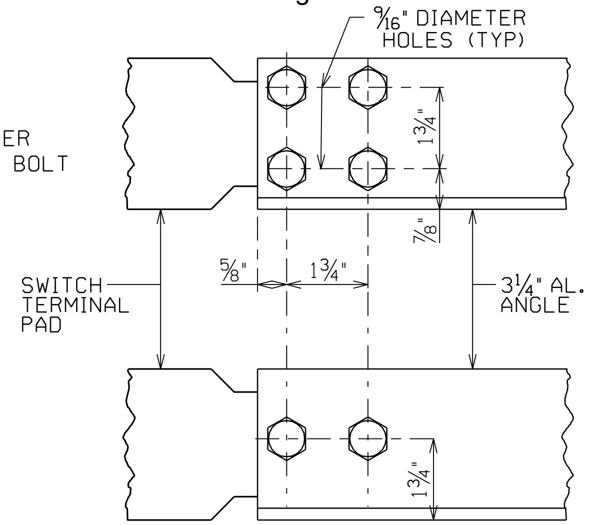
NL-200902-4-1

REV: A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

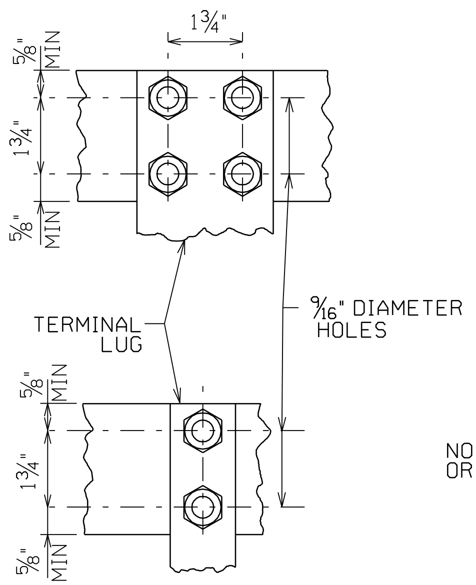
10/19/2005 200902-4-1.DGN

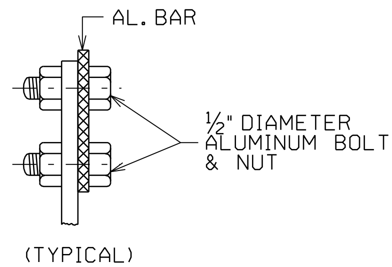


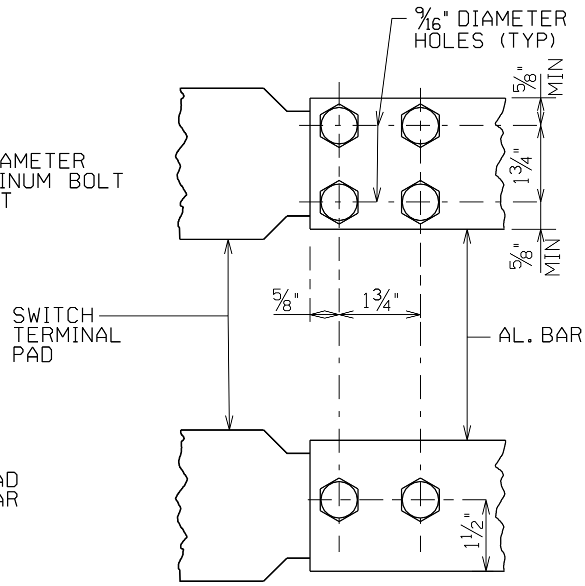


AL. ANGLE TERMINAL LUG DRILLING

AL. ANGLE SWITCH DRILLING







NOTE: CENTER SWITCH PAD OR TERMINAL LUG ON BAR WHEN POSSIBLE.

AL. BAR TERM LUG DRILLING

AL. BAR SWITCH DRILLING

LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-2

ELECTRICAL CONNECTION DETAIL

TERMINAL LUG & SWITCH DRILLING FOR ALUMINUM ANGLE AND BAR

Xcel Energy

SCALE: NONE

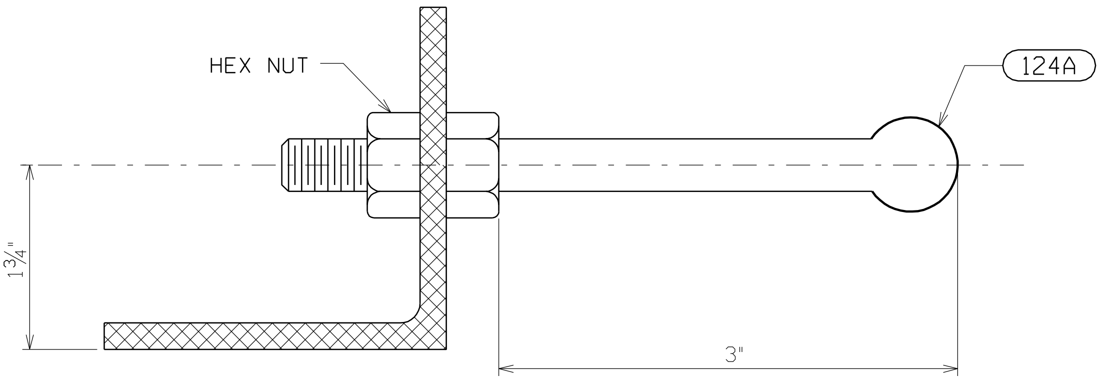
NL-200902-4-2

REV: B

04/05/2006 200902-4-2.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
124A	1	GROUNDING STUD, ½" DIA × 7" LONG			



LEGEND:
INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-3
ELECTRICAL CONNECTION DETAIL
PROVISION FOR HOT LINE CLAMP

Xcel Energy

SCALE: NONE

NL-200902-4-3

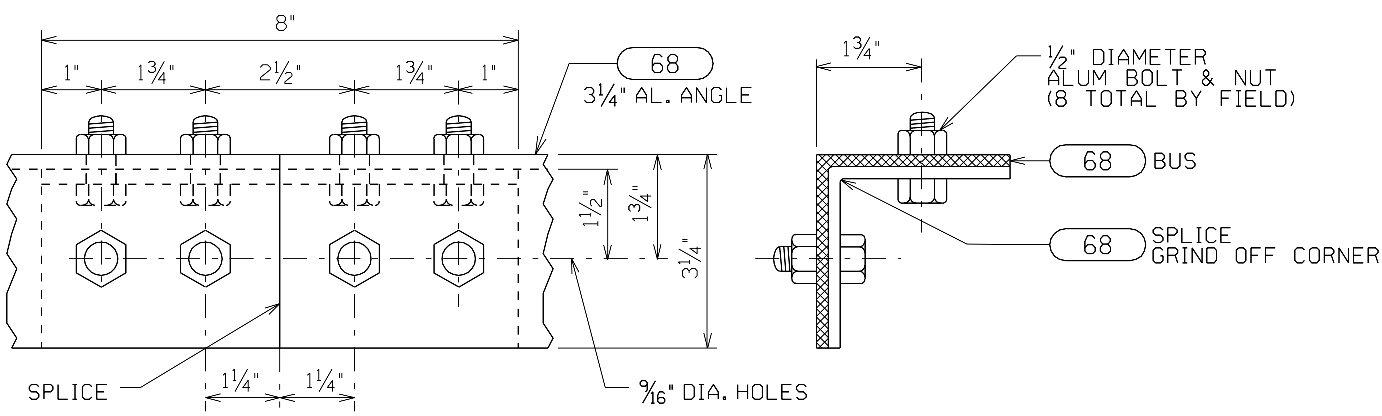
REV: A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-3.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
68	8"	$3\frac{1}{4}$" × $3\frac{1}{4}$" × $\frac{1}{4}$" × 25' LONG AL. ANGLE			



LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-4
ELECTRICAL CONNECTION DETAIL
ALUMINUM ANGLE SPLICE

Xcel Energy

SCALE: NONE

NL-200902-4-4

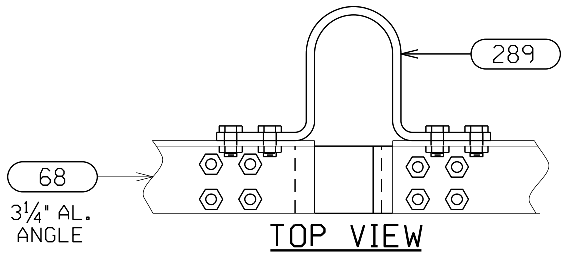
REV: B

11/29/2006 200902-4-4.DGN

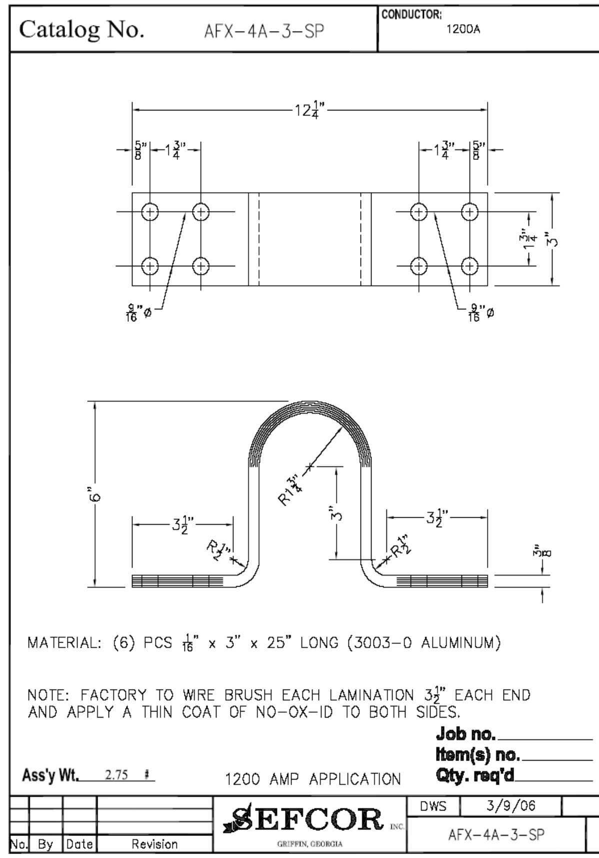
BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

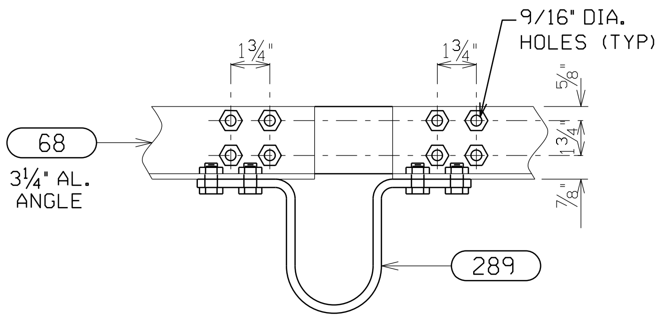
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
68		3¼" x 3¼" x ¼" x 25' AL. ANGLE	289	*	ALUM. FLEX CONNECTOR

* 1 CONNECTOR REQUIRED FOR 1200 AMPS AND 2 CONNECTORS REQUIRED FOR FULL AMP OF ANGLE

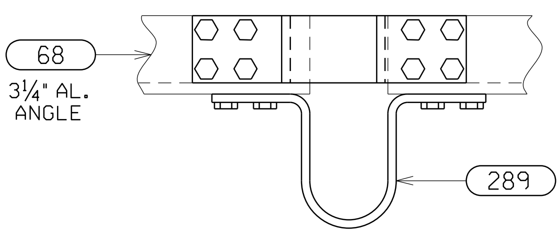


TOP VIEW

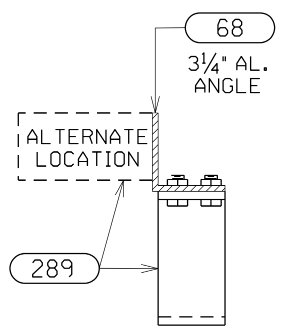




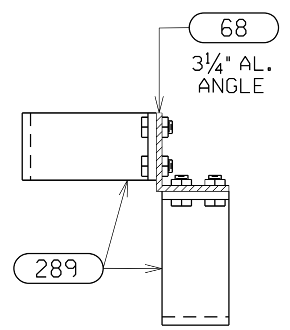
SIDE VIEW



BOTTOM VIEW



END VIEW
SINGLE CONNECTION



END VIEW
DOUBLE CONNECTION

LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-5
ELECTRICAL CONNECTION DETAIL
ANGLE BUS EXPANSION JOINT

Xcel Energy®

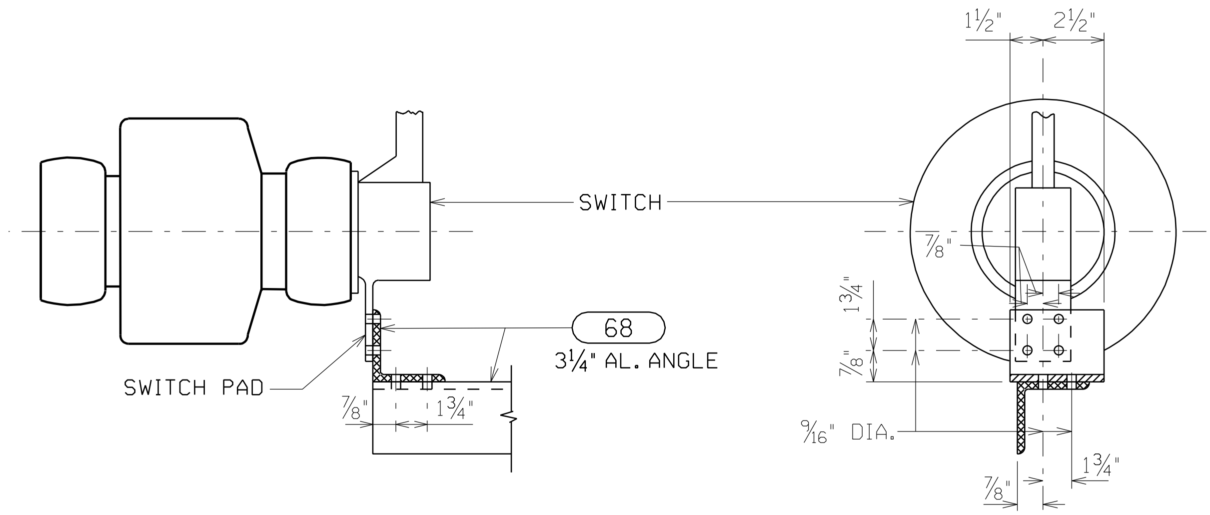
SCALE	DRAWING NO.	REV
NONE	NL-200902-4-5	C

200902-4-5.DGN

5/20/2011 12:43:52 PM

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
68		3¼" x 3¼" x¼" x 25' LONG AL. ANGLE			



LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-6
ELECTRICAL CONNECTION DETAIL
ALUMINUM ANGLE TO SWITCH 90 DEGREE CONNECTION - 900 AMPS MAX

Xcel Energy

SCALE: NONE

NL-200902-4-6

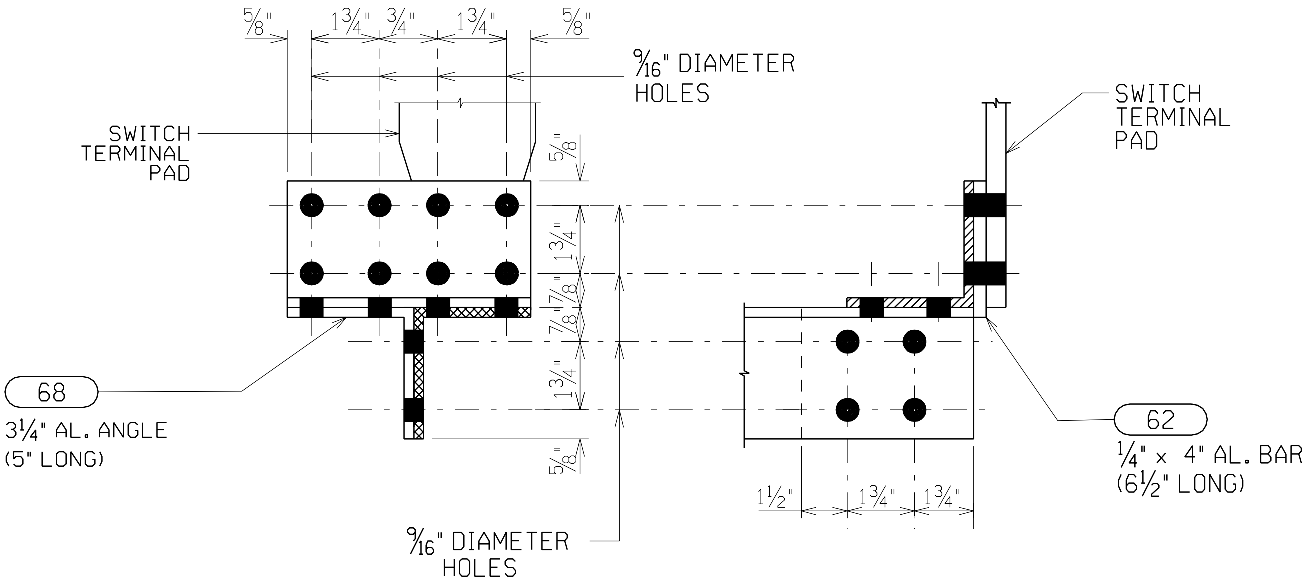
REV: A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-6.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
62		1/4" x 4" x 20' LONG AL. BAR			
68		3 1/4" x 3 1/4" x 1/4" x 25' LONG AL. BAR			



LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-7
ELECTRICAL CONNECTION DETAIL
ALUMINUM ANGLE BUS TO SWITCH 90 DEGREE CONN. - 1800 AMPS MAX.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy

SCALE: NONE

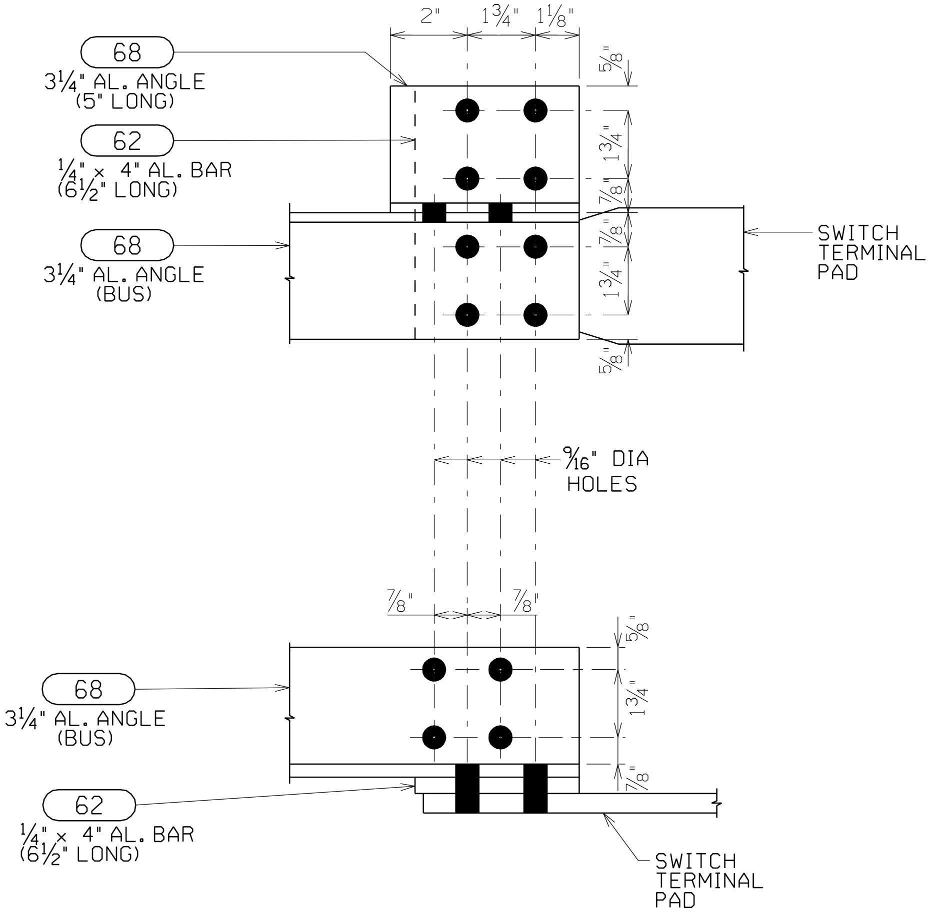
NL-200902-4-7

REV: A

10/19/2005 200902-4-7.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
62		1/4" x 4" x 20' LONG AL. BAR			
68		3 1/4" x 3 1/4" x 1/4" x 25' LONG AL. BAR			



LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-8
ELECTRICAL CONNECTION DETAIL
ALUMINUM ANGLE TO SWITCH - 1800 AMPS MAX

Xcel Energy

SCALE: NONE

NL-200902-4-8

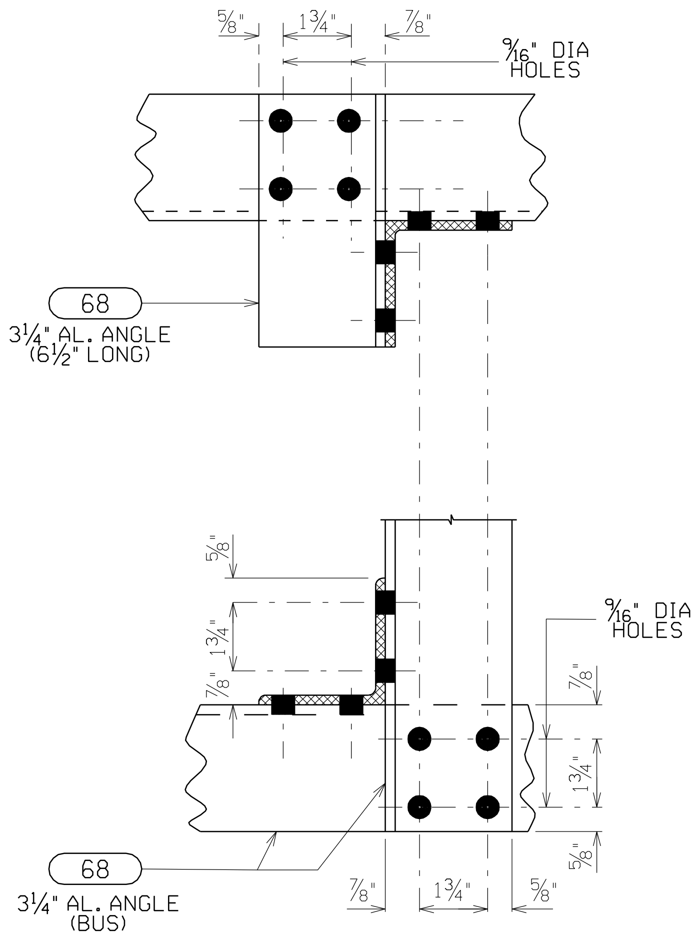
REV: A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-8.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
68		3¼" × 3¼" × ¼" × 25' LONG AL. BAR			



LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

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GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-9

ELECTRICAL CONNECTION DETAIL

ALUMINUM ANGLE TO ALUMINUM ANGLE 90 DEGREE CONN. - 1800AMP MAX

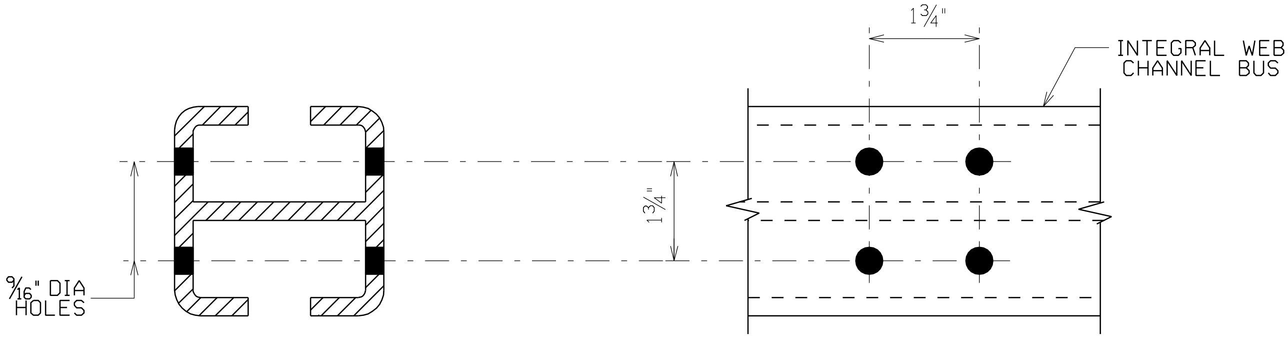
Xcel Energy

SCALE: NONE

NL-200902-4-9

REV: A

10/19/2005 200902-4-9.DGN



LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-10

ELECTRICAL CONNECTION DETAIL

DRILLING FOR TERMINAL LUG CONNECTION TO INTEGRAL WEB CHANNEL BUS

Xcel Energy™

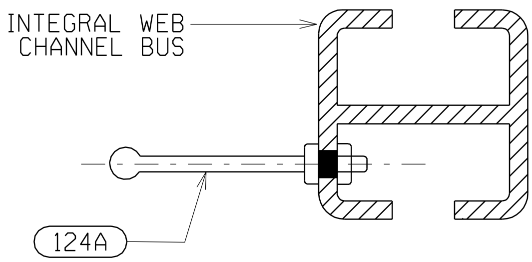
SCALE	DRAWING	REV
NONE	NL-200902-4-10	A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-10.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
124A	1	GROUNDING STUD, ½" DIA x 7" LONG			



LEGEND:
( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-11
ELECTRICAL CONNECTION DETAIL
PROVISION FOR HOT LINE CLAMP CONN. TO INTEGRAL WEB CHANNEL BUS

Xcel Energy

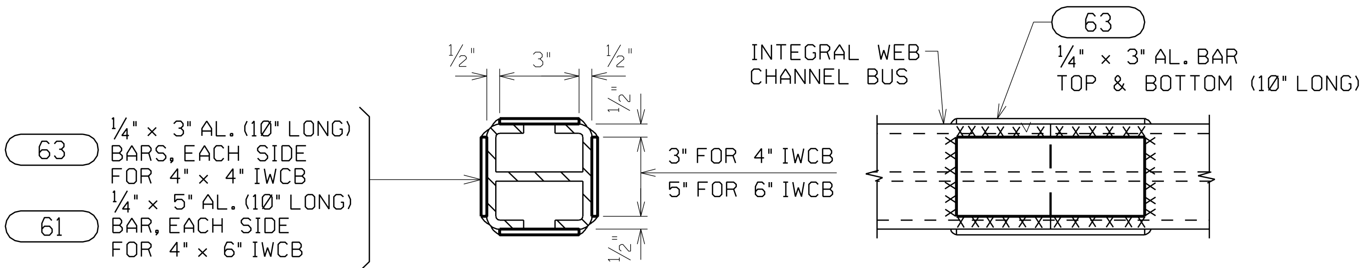
SCALE		REV
NONE	NL-200902-4-11	A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

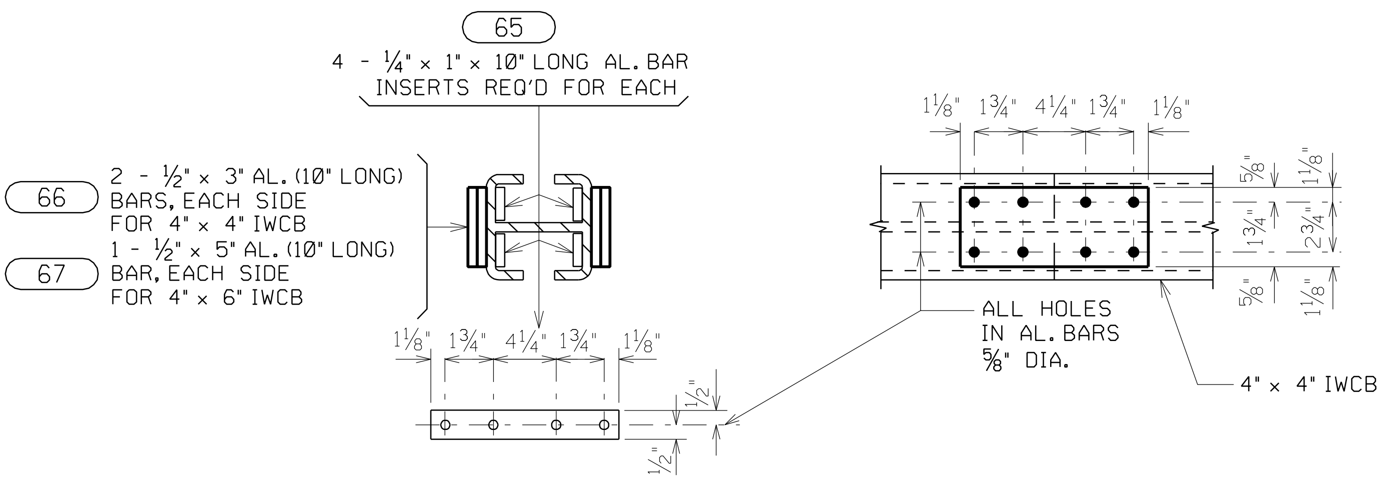
10/19/2005 200902-4-11.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
61		1/4" x 5" x 12' LONG RECT. AL. BAR			
63		1/4" x 3" x 20' LONG RECT. AL. BAR			
65		1/4" x 1" x 12' LONG RECT. AL. BAR			
66		1/2" x 3" x 12' LONG RECT. AL. BAR			
67		1/2" x 5" x 12' LONG RECT. AL. BAR			



WELDED SPLICE



BOLTED SPLICE

FIELD NOTE:

- ALL HOLES DRILLED IN INTERGAL WEB CHANNEL, 9/16" DIAMETER

LEGEND:

INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-12

ELECTRICAL CONNECTION DETAIL

WELDED OR BOLTED SPLICE FOR INTEGRAL WEB CHANNEL BUS

Xcel Energy

SCALE NONE

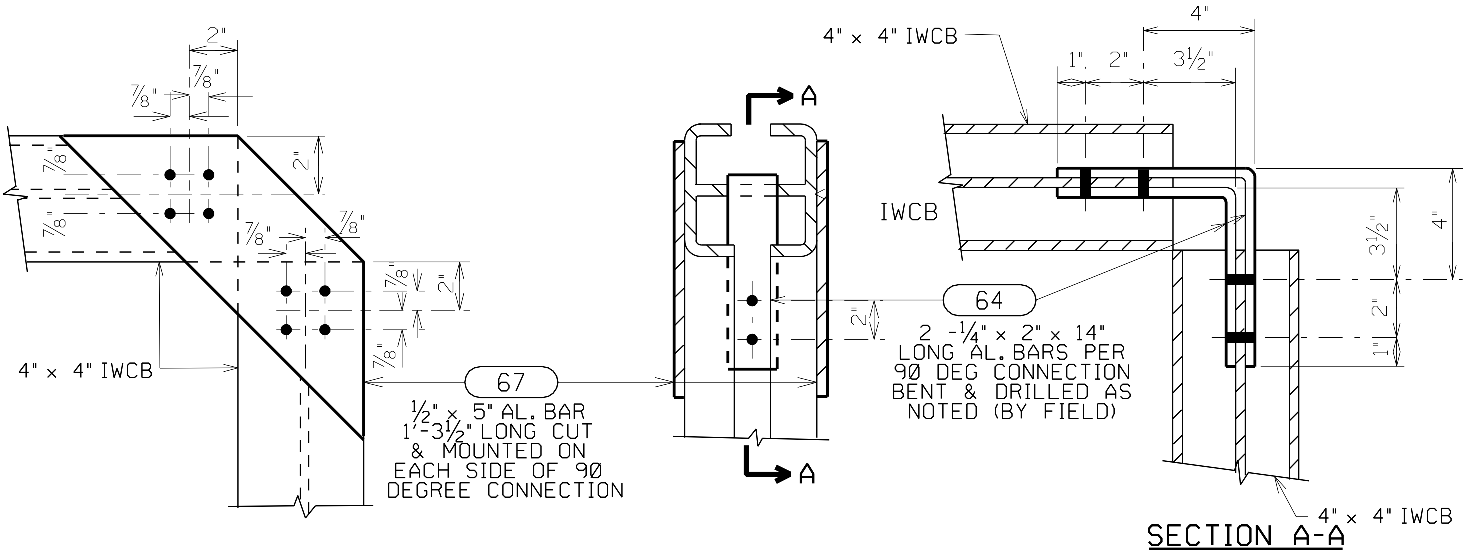
NL-200902-4-12

REV A

10/19/2005 200902-4-12.DGN

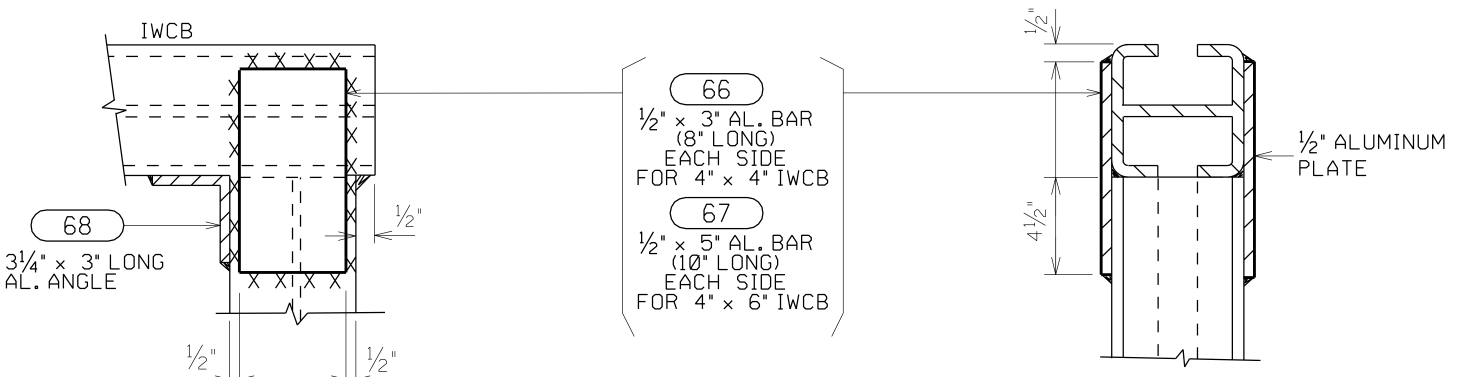
BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
64		1/4" × 2" × 20' LONG RECT. AL. BAR			
66		1/2" × 3" × 12' LONG RECT. AL. BAR			
67		1/2" × 5" × 12' LONG RECT. AL. BAR			
68		3 1/4" × 3 1/4" × 1/4" × 25' LONG AL. ANGLE			



BOLTED

(FOR 4×4 IWCB ONLY)



WELDED

FIELD NOTE:
- ALL HOLES DRILLED IN INTEGRAL WEB CHANNEL 9/16" DIAMETER

LEGEND:
( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-13
ELECTRICAL CONNECTION DETAIL
WELDED-BOLTED 90 DEGREE ANGLE CONN. FOR INTEGRAL WEB CHANNEL BUS

Xcel Energy

SCALE: NONE

NL-200902-4-13

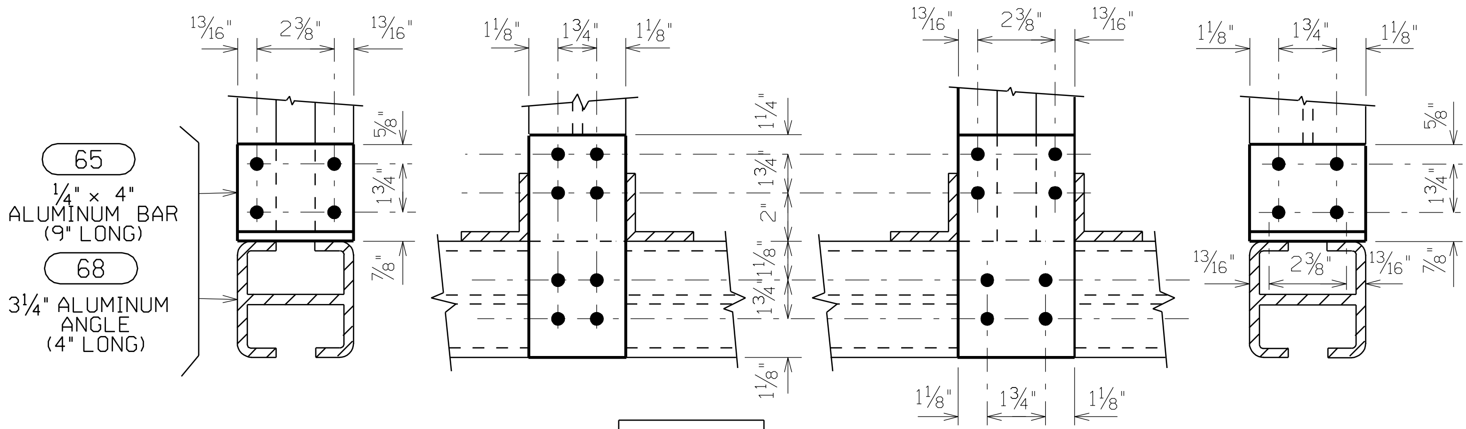
REV: A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-13.DGN

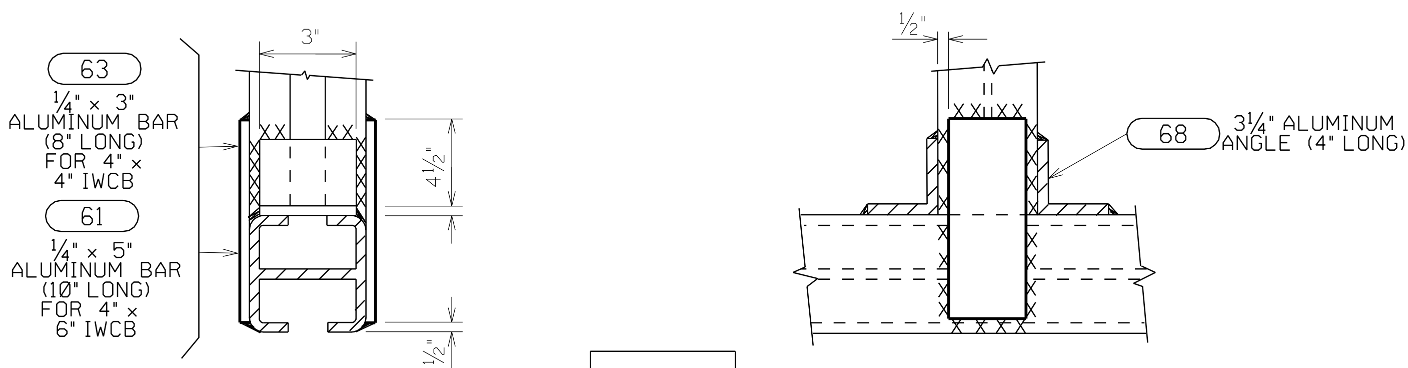
BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
61		1/4" x 5" x 12' LONG RECT. AL. BAR			
63		1/4" x 3" x 20' LONG RECT. AL. BAR			
65		1/4" x 1" x 12' LONG RECT. AL. BAR			
68		3 1/4" x 3 1/4" x 1/4" x 25' LONG RECT. AL BAR.			



BOLTED

(FOR 4" x 4" IWCB TURNED EITHER DIRECTION)



WELDED

FIELD NOTE:

- ALL HOLES DILLED IN INTEGRAL WEB CHANNEL 9/16" DIAMETER

LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

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ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-14
ELECTRICAL CONNECTION DETAIL
WELDED OR BOLTED TEE TAP FOR INTEGRAL WEB CHANNEL BUS

Xcel Energy

SCALE: NONE

NL-200902-4-14

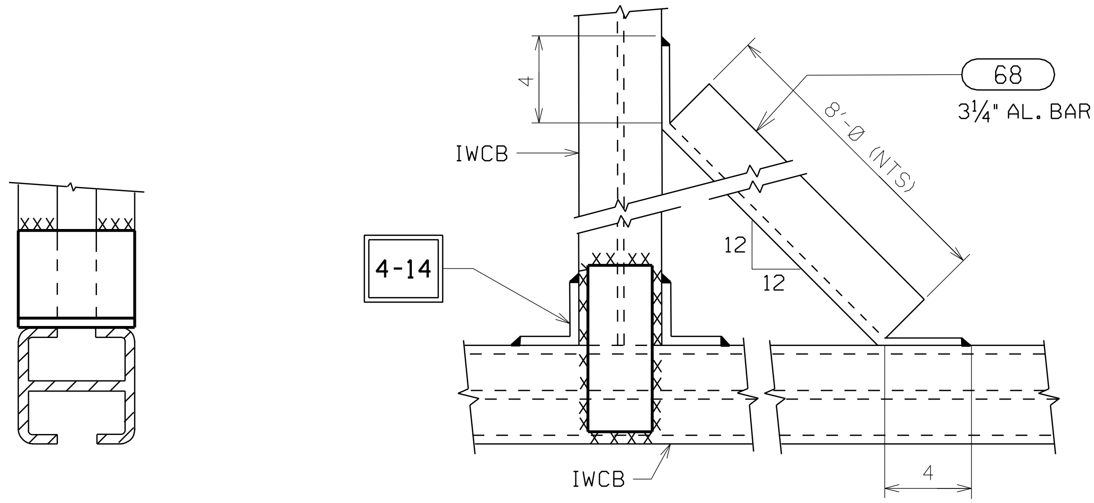
REV: A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-14.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
68		3¼" x 3¼" x ¼" x 25' LONG RECT. AL. BAR			



LEGEND:

INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

4-14 INDICATES DETAIL SHOWN ON DWG NL-200902-4-14

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-15
ELECTRICAL CONNECTION DETAIL
WELDED ANGLE BRACE FOR INTEGRAL WEB CHANNEL BUS

Xcel Energy

SCALE NONE

NL-200902-4-15

REV A

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-15.DGN

MATERIAL REQUIRED FOR DETAIL "A"

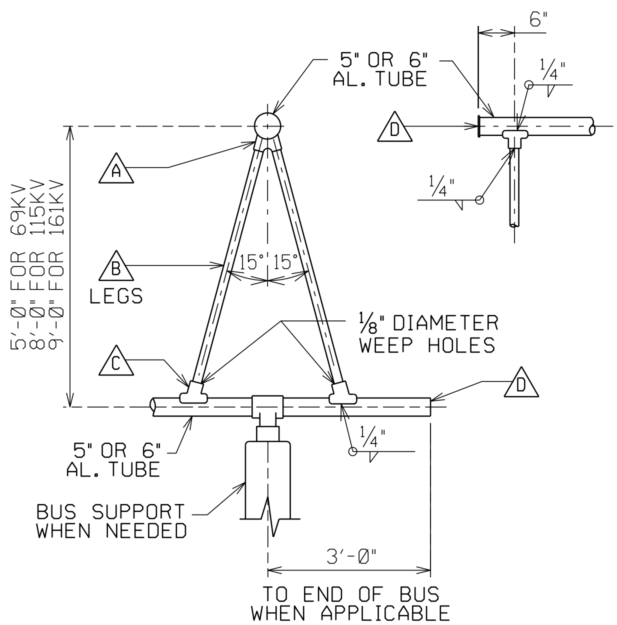
	ITEM NO.	QTY	DESCRIPTION
A	564	1	VEE CONN., 5" IPS TUBE TO 2½" TUBE
A	568		VEE CONN., 6" IPS TUBE TO 4" TUBE
B	55	20 FT	2½" IPS ALUMINUM TUBE
B	58		4" IPS ALUMINUM TUBE
C	516	2	TEE CONN., 5" IPS TUBE TO 2½" TUBE
C	518		TEE CONN., 6" IPS TUBE TO 2½" TUBE
C	513		TEE CONN., 5" IPS TUBE TO 4" TUBE
D	640	1	END CAP, DRIVE FIT, 5" IPS AL. TUBE
D	641		END CAP, WELDED, 6" IPS AL. TUBE

NOTES: 1. ONLY ORDER ONE OF THE ITEM NUMBERS FROM EACH SECTION. QUANTITY LISTED IS PER PHASE.
2. IF TOP BUS IS: 5" USE 2½" LEGS
6" USE 4" LEGS

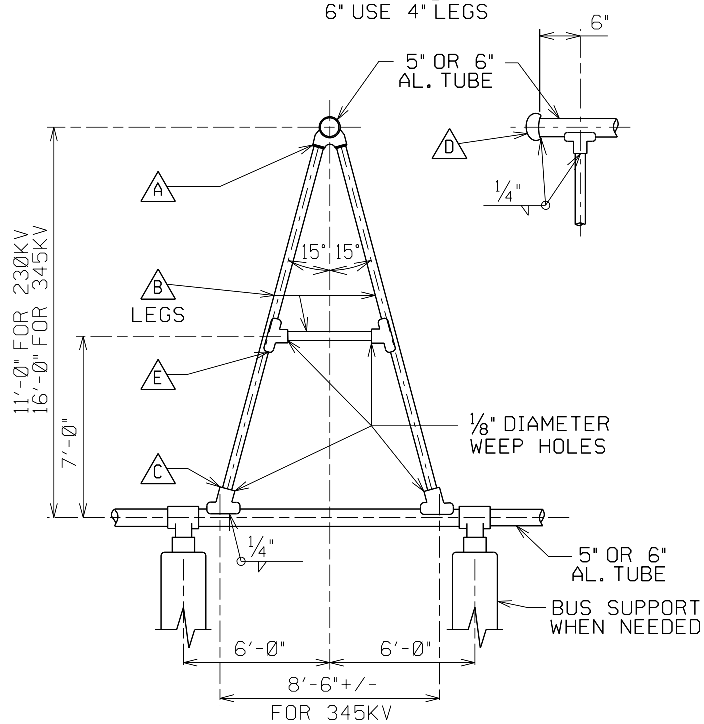
MATERIAL REQUIRED FOR DETAIL "B"

	ITEM NO.	QTY	DESCRIPTION
A	564	1	VEE CONN., 5" IPS TUBE TO 2½" TUBE
A	568		VEE CONN., 6" IPS TUBE TO 4" TUBE
B	55	40 FT	2½" IPS ALUMINUM TUBE
B	58		4" IPS ALUMINUM TUBE
C	516	2	TEE CONN., 5" IPS TUBE TO 2½" TUBE
C	518		TEE CONN., 6" IPS TUBE TO 2½" TUBE
C	513		TEE CONN., 5" IPS TUBE TO 4" TUBE
D	826	1	END BELL, WELDED FOR 5" AL. TUBE
D	827		END BELL, WELDED FOR 6" AL. TUBE
E	503	2	TEE CONN., 2½" IPS TUBE TO 2½" TUBE
E	512A		TEE CONN., 4" IPS TUBE TO 4" TUBE

NOTES: 1. ONLY ORDER ONE OF THE ITEM NUMBERS FROM EACH SECTION. QUANTITY LISTED IS PER PHASE.
2. IF TOP BUS IS: 5" USE 2½" LEGS
6" USE 4" LEGS



DETAIL "A"
69, 115 AND 161KV



DETAIL "B"
230 & 345KV

LEGEND:
( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-16
ELECTRICAL CONNECTION DETAIL
TUBING BUS "A" FRAME TAP

Xcel Energy

SCALE: NONE

NL-200902-4-16

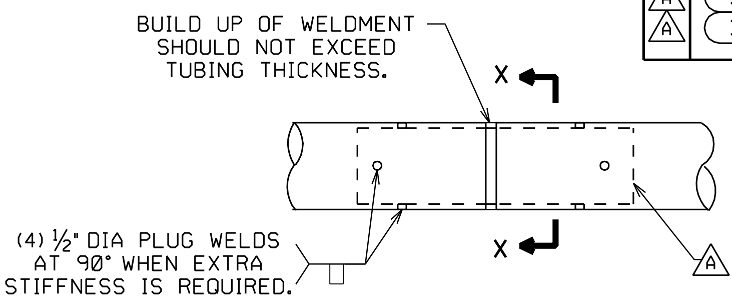
REV: G

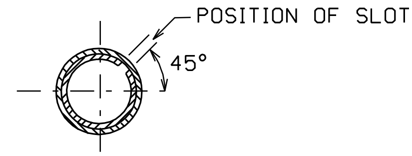
200902-4-16.DGN

10/29/2013 9:32:06 AM

MATERIAL FOR PREFABRICATED SPLICE

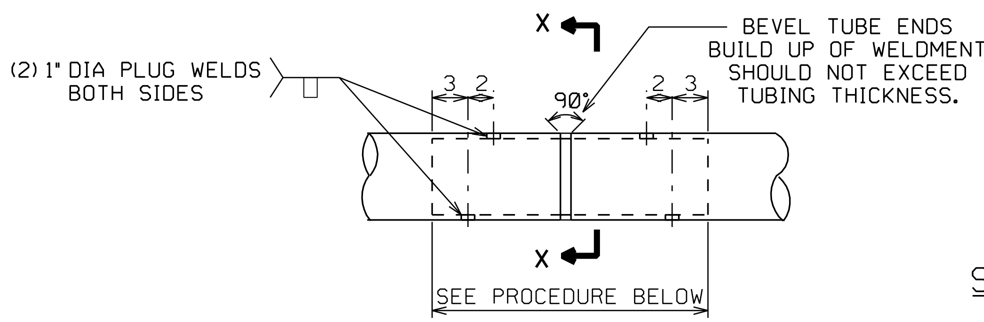
	ITEM NO.	QTY	DESCRIPTION
A	326	1 EA PER PHASE	COUPLER SPLICE, SCHED 40 2" AL TUBE
A	327		COUPLER SPLICE, SCHED 40 2½" AL TUBE
A	328		COUPLER SPLICE, SCHED 40 3" AL TUBE
A	329		COUPLER SPLICE, SCHED 40 3½" AL TUBE
A	330		COUPLER SPLICE, SCHED 40 4" AL TUBE
A	331		COUPLER SPLICE, SCHED 40 5" AL TUBE
A	332		COUPLER SPLICE, SCHED 80 6" AL TUBE
A	333		COUPLER SPLICE, SCHED 40 6" AL TUBE

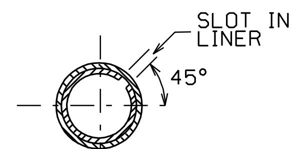




SECTION X-X

PREFABRICATED WELDED SPLICE





SECTION X-X

CONSTRUCTION PROCEDURE

1. PLACE LINER IN ONE TUBE, CENTER IT AND MAKE ONE PLUG WELD.

   A LINER WILL BE MADE FROM ALUMINUM TUBE THE NEXT SIZE SMALLER OR THE SAME SIZE AND CUT TO PROVIDE A SNUG FIT WHEN INSERTED.

   LENGTH OF LINER APPROXIMATELY 6 TIMES NOMINAL PIPE SIZE (MINIMUM LENGTH 15").

2. MAKE BUTT WELD.
3. MAKE REMAINING PLUG WELDS.

WELDED SPLICE FOR TUBE WHEN PREFABRICATED SPLICE IS NOT AVAILABLE

LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-17
ELECTRICAL CONNECTION DETAIL
WELDED SPLICE FOR TUBE

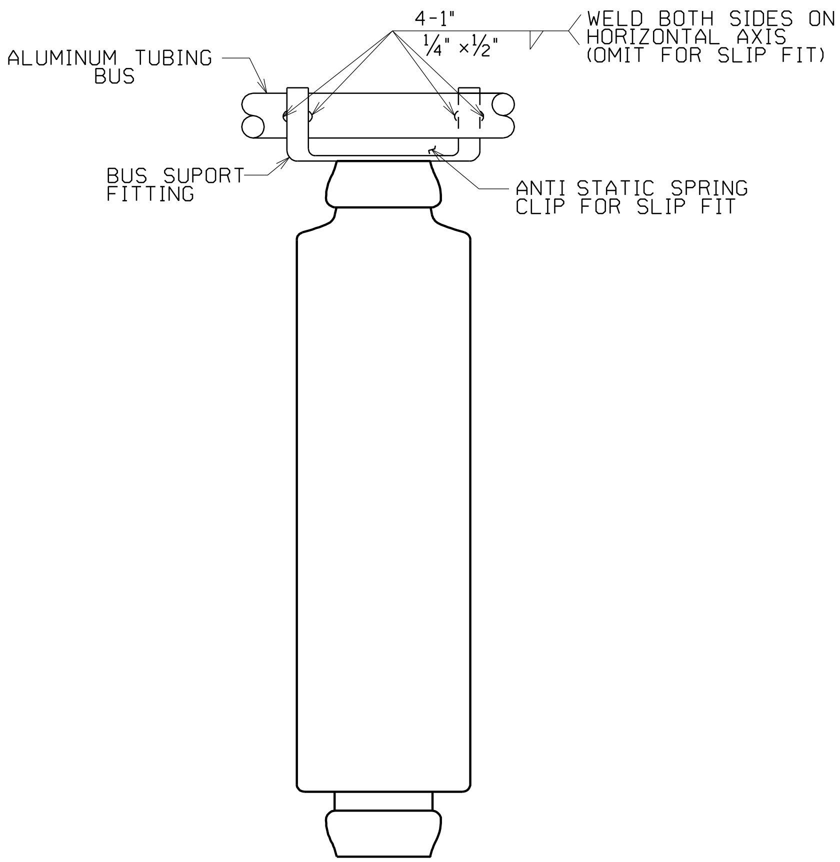
Xcel Energy

SCALE	DRAWING NO.	REV
NONE	NL-200902-4-17	B

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

$TIME$

02/21/2008



LEGEND:

( ) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

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ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-18
ELECTRICAL CONNECTION DETAIL
BUS SUPPORT FIXED & SLIP FITTING FOR ALUMINUM TUBE

Xcel Energy

SCALE		REV
NONE	NL-200902-4-18	A

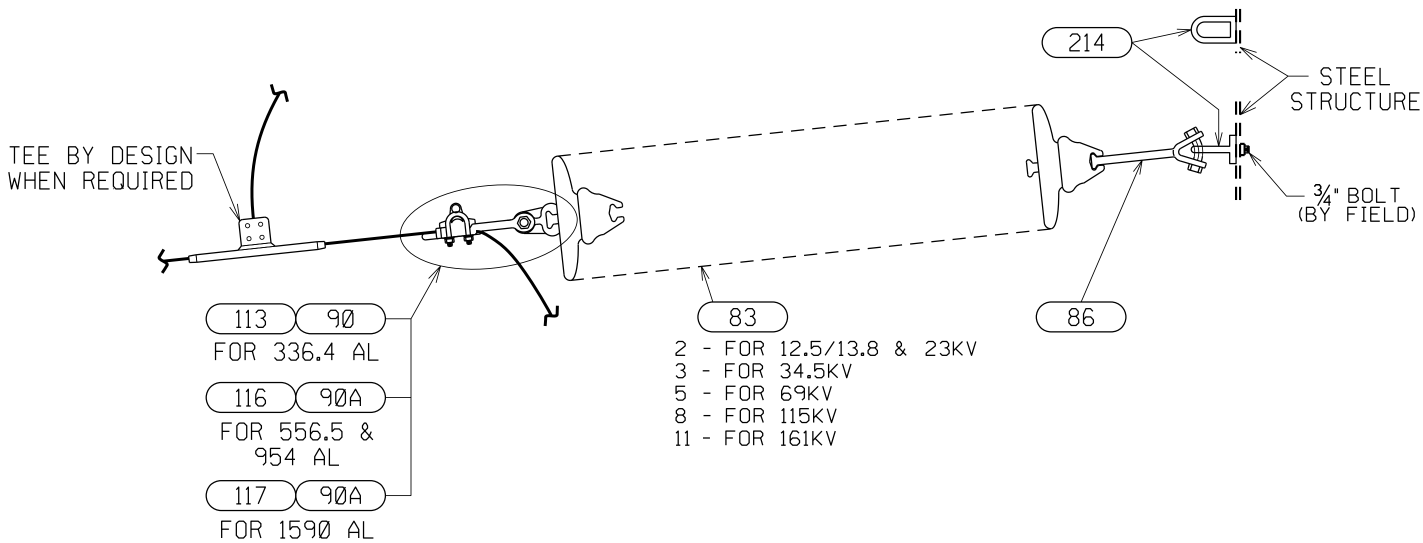
GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

10/19/2005 200902-4-18.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
83		10" SUSPENSION INSULATOR	214		BOLT EYE FOR 3/4" BOLT
86		Y-CLEVIS BALL (30,000 LB)			
90		SOCKET EYE, 1/2" NECK (10,000 LB)			
90A		SOCKET EYE, 3/4" NECK (25,000 LB)			
113		DEAD-END STRAIN CLAMP (1,000 LB)			
116		DEAD-END STRAIN CLAMP (12,000 LB)			
117		DEAD-END STRAIN CLAMP (12,000 LB)			

200902-4-19A.DGN



NOTES:

1. LINE IS HORIZONTAL OR RUNS DOWN HILL
2. CONNECTION TO STRUCTURE CAN BE STEEL CLIP OR ITEM 214 WITH 3/4" BOLT (STEEL CLIP IS PREFERRED).

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-19A

ELECTRICAL CONNECTION DETAIL

STRAIN BUS SUSPENSION INSULATOR ASSEMBLY

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

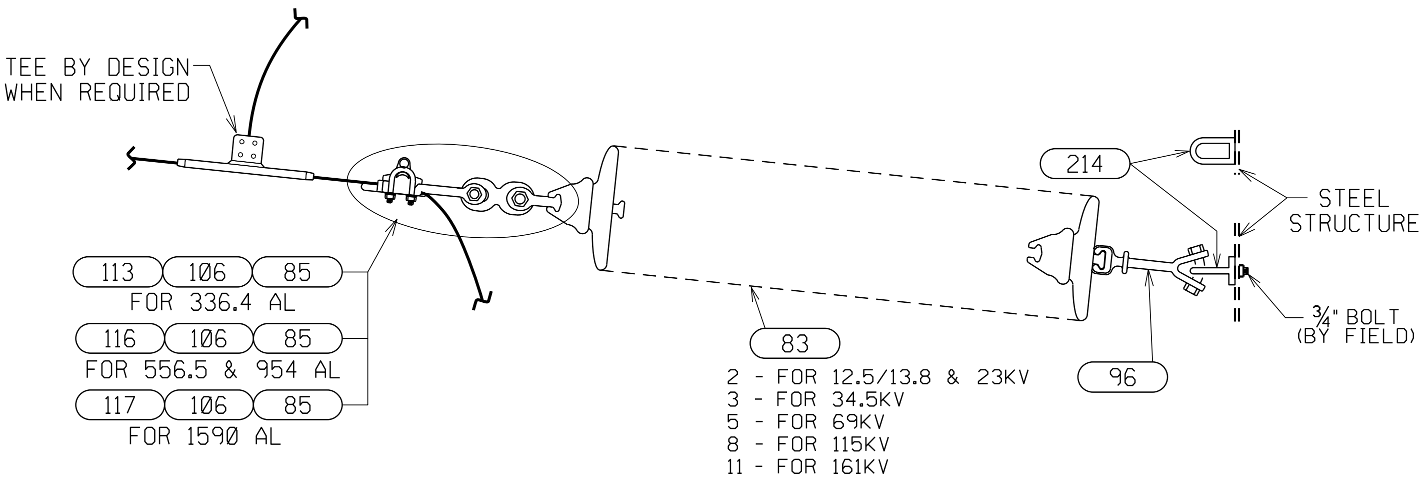
Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-4-19A	G

9:59:55 AM 5/3/2013

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
83		10" SUSPENSION INSULATOR	214		BOLT EYE FOR ¾" BOLT
85		Y-CLEVIS BALL (30,000 LB)			
96		SOCKET Y-CLEVIS (30,000 LB)			
106		FIGURE 8 STRAIGHT LINK (30,000 LB)			
113		DEAD-END STRAIN CLAMP (1,000 LB)			
116		DEAD-END STRAIN CLAMP (12,000 LB)			
117		DEAD-END STRAIN CLAMP (12,000 LB)			



NOTES:

1. LINE RUNS UP HILL
2. CONNECTION TO STRUCTURE CAN BE STEEL CLIP OR ITEM 214 WITH ¾" BOLT (STEEL CLIP IS PREFERRED).

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-19B
ELECTRICAL CONNECTION DETAIL
STRAIN BUS SUSPENSION INSULATOR ASSEMBLY

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-4-19B	G

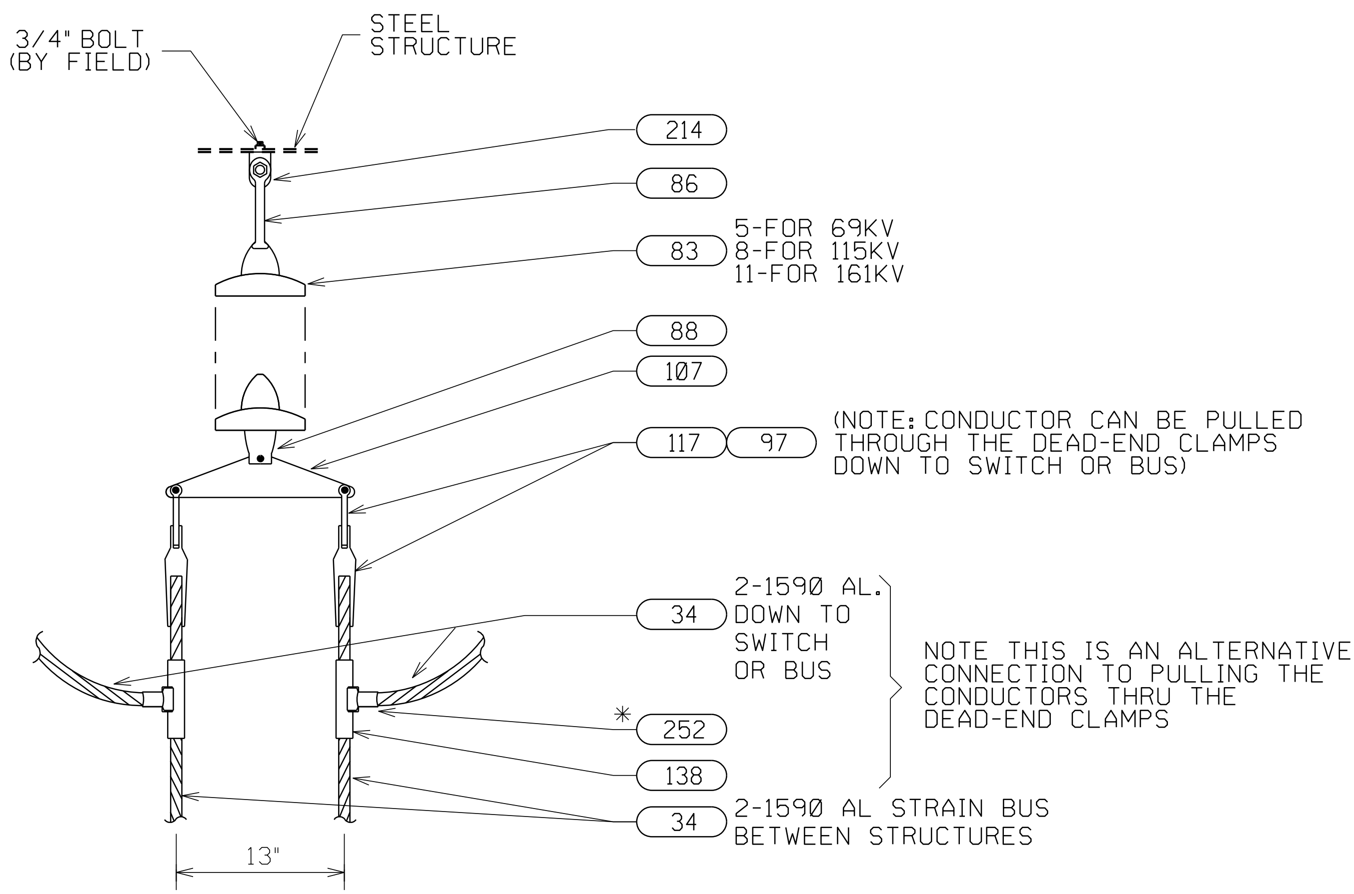
200902-4-19B.DGN

5/3/2013 10:00:14 AM

200902-4-19C.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
83		10" SUSPENSION INSULATOR	214	1	BOLT EYE FOR ¾" BOLT
86	1	BALL Y-CLEVIS (30,000 LB)	138	2	COMPRESION TEE TAP FOR 1590 AL.
88	1	SOCKET CLEVIS (30,000 LB)	✳ 252	2	COMPRESION TERM. LUG FOR 1590 AL.
97	2	Y-CLEVIS EYE (30,000 LB)			
107	1	YOKE PLATE -13" SEPERATION (40,000 LB)			
117	2	DEAD-END STRAIN CLAMP (12,000 LB)			✳ TYPE OF TERMINAL LUG (WELD OR COMP.) TO BE DETERMINED BY FIELD.



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-19C
ELECTRICAL CONNECTION DETAIL
BUNDLED STRAIN BUS SUSPENSION INSULATOR ASSEMBLY

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

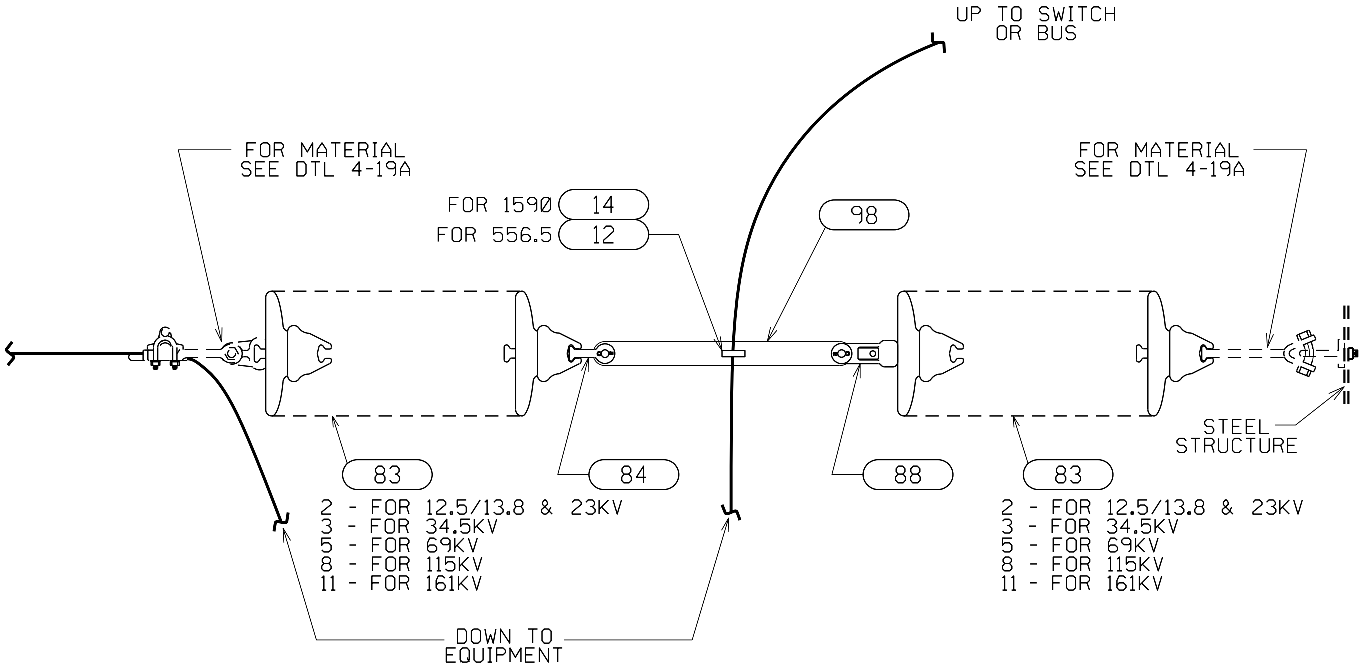
Xcel Energy

SCALE		REV
NONE	NL-200902-4-19C	H

5/3/2013 10:00:57 AM

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
12		U-BOLT FOR 556.5 AL			
14		U-BOLT FOR 1590 AL			
83		10" SUSPENSION INSULATOR, GRAY			
84		BALL CLEVIS (30,000 LB)			
88		SOCKET CLEVIS (30,000 LB)			
98		EXTENSION LINK 1½" W x 18" L (10,000 LB)			



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID	
GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-19D
ELECTRICAL CONNECTION DETAIL
DOUBLE STRAIN BUS SUSPENSION INSULATOR ASSEMBLY

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-4-19D	G

10/26/2012 10:31:54 AM

200902-4-20.DGN

BILL OF MATERIAL FOR 161KV AND BELOW (ORDERED BY DESIGNER)

2-1590 AL (1-ON EACH SIDE)

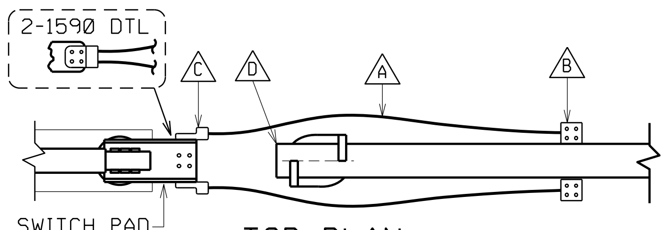
	ITEM NO.	QTY	DESCRIPTION
A	34	15 FT	2-1590 AL CABLE (1-ON EACH SIDE)
B	427	2	TEE CONNECTOR FOR 3"-6" TUBE
B	654	2	TERM LUG, WELDMENT FOR 1-1590 AL
C	674A	1	TERM LUG, WELDMENT FOR 2-1590 AL
D	640	1*	END CAP, DRIVE FIT FOR 5" TUBE
D	641		END CAP, DRIVE FIT FOR 6" TUBE

4-1590 AL (2-ON EACH SIDE)

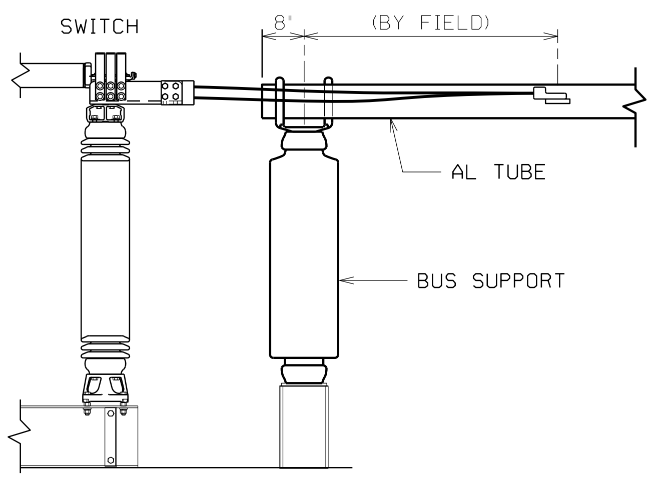
	ITEM NO.	QTY	DESCRIPTION
A	34	30 FT	4-1590 AL CABLE (2 ON EACH SIDE)
B	427	2	TEE CONNECTOR FOR 3"-6" TUBE
B C	674	4	TERM LUG, WELDMENT FOR 2-1590 AL
D	640	1*	END CAP, DRIVE FIT FOR 5" TUBE
D	641		END CAP, DRIVE FIT FOR 6" TUBE

NOTE: MATERIAL LISTED IS PER PHASE

* THIS IS THE QUANTITY REQUIRED FOR ONE OF THE ITEMS. DO YOU HAVE 5" OR 6" TUBE?



TOP PLAN



SIDE VIEW

BILL OF MATERIAL FOR 230KV AND ABOVE (ORDERED BY DESIGNER)

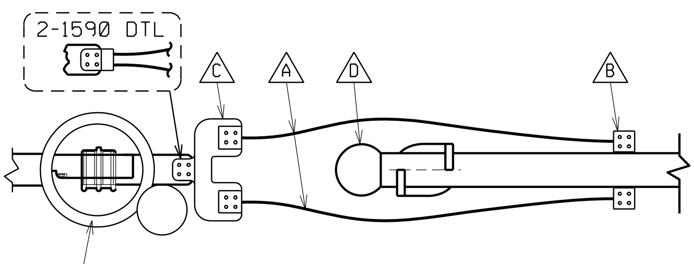
2-1590 AL (1-ON EACH SIDE)

	ITEM NO.	QTY	DESCRIPTION
A	34	15 FT	2-1590 AL CABLE (1-ON EACH SIDE)
B	427	2	TEE CONNECTOR FOR 3"-6" TUBE
B	654	2	TERM LUG, WELDMENT FOR 1-1590 AL
B C	894	5	EHV SHIELD FOR 4 HOLE FLAT PAD
C	674A	1	TERM LUG, WELDMENT FOR 2-1590 AL
D	826	1	EHV END BELL FOR 5" AL TUBE

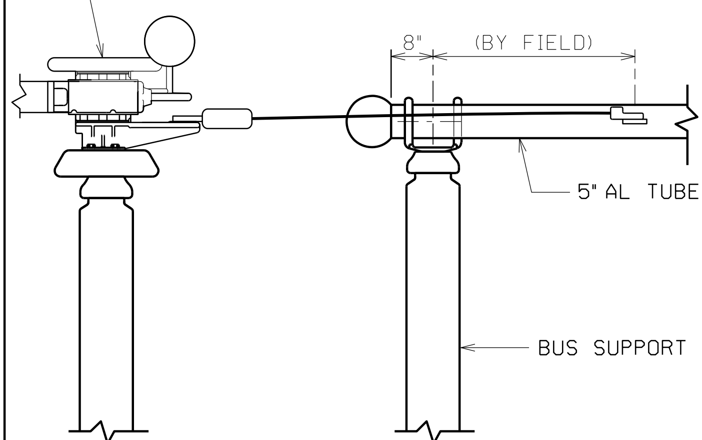
4-1590 AL (2-ON EACH SIDE)

	ITEM NO.	QTY	DESCRIPTION
A	34	30 FT	4-1590 AL CABLE (2 ON EACH SIDE)
A	286	2	CABLE SPACER
B	427	2	TEE CONNECTOR FOR 3"-6" TUBE
B C	674A	4	TERM LUG, WELDMENT FOR 2-1590 AL
B C	894	6	EHV SHIELD FOR 4 HOLE FLAT PAD
C	986	1	EHV BIFURCATING TERMINAL
D	826	1	EHV END BELL FOR 5" AL TUBE

NOTE: MATERIAL LISTED IS PER PHASE



TOP PLAN



SIDE VIEW

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-20

ELECTRICAL CONNECTION DETAIL

SWITCH TO BUS CONNECTION - BUS SUPPORT IS PART OF SWITCH STAND

Xcel Energy®

SCALE		REV
NONE	NL-200902-4-20	B

5/20/2011 12:40:00 PM

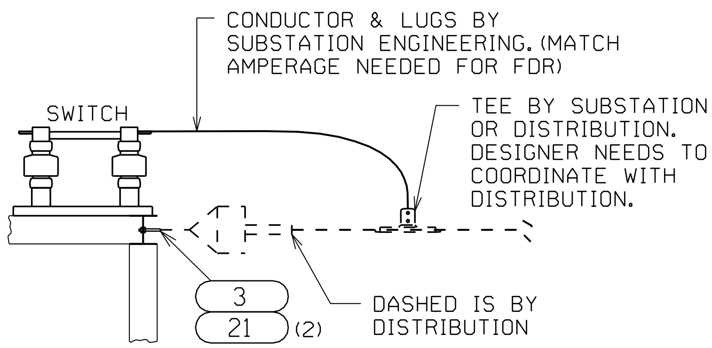
MATERIAL FOR DETAIL "A" & "B"

ITEM NO.	QTY	DESCRIPTION
3	1	EYE BOLT, 5/8" DIA x 8" L
21	2	5/8" DIA. HEX. NUT

MATERIAL FOR DETAIL "C"

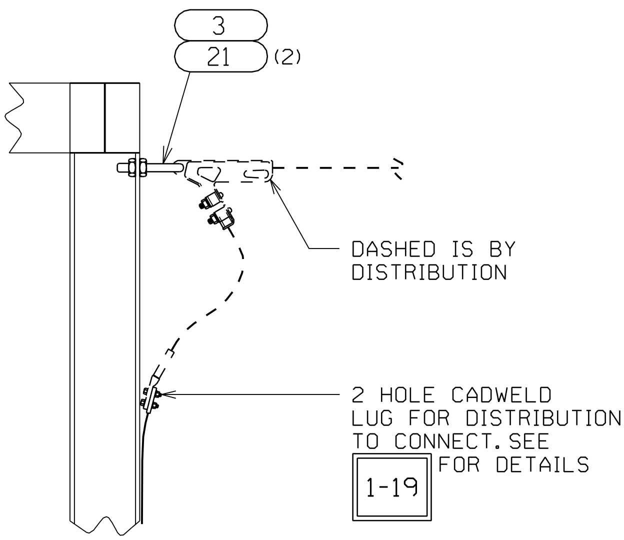
ITEM NO.	QTY	DESCRIPTION
11	1	THREADED ROD, 3/4" DIA x 26" LONG
18	1	NUT, SQUARE FOR 3/4" DIA BOLT
20	4	WASHER NUT, FOR 3/4" DIA BOLT
25	3	LOCKNUT, FOR 3/4" DIA BOLT
214	1	BOLT EYE FOR 3/4" DIA THREADED ROD

NOTE: MATERIAL LISTED IS PER PHASE



DETAIL "A"

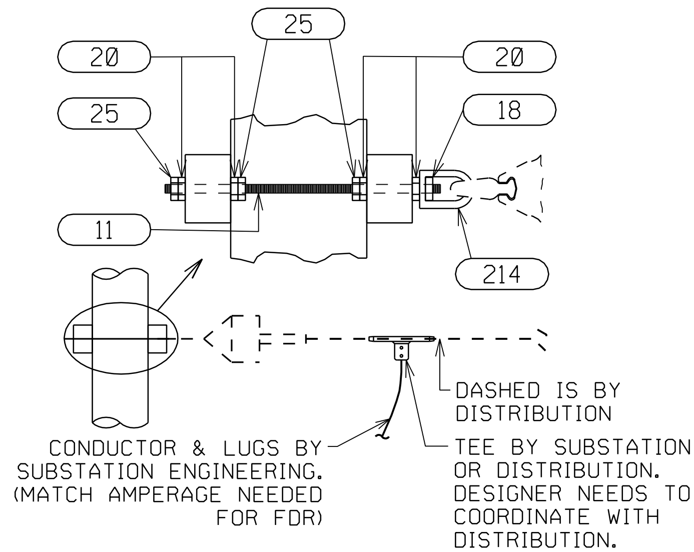
STEEL STRUCTURE
TERMINATION OF LINE



DETAIL "B"

STEEL STRUCTURE
TERMINATION OF NEUTRAL

NOTE: MATERIAL LISTED IS PER PHASE



DETAIL "C"

WOOD POLE STRUCTURE
TERMINATION OF LINE

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

1-5 INDICATES DETAIL SHOWN ON DWG NL-200902-1-5 & 1-1E INDICATES DETAIL "E" SHOWN ON DWG NL-200902-1-1

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-21

ELECTRICAL CONNECTION DETAIL

DISTRIBUTION OVERHEAD TERMINATIONS AT SUBSTATION

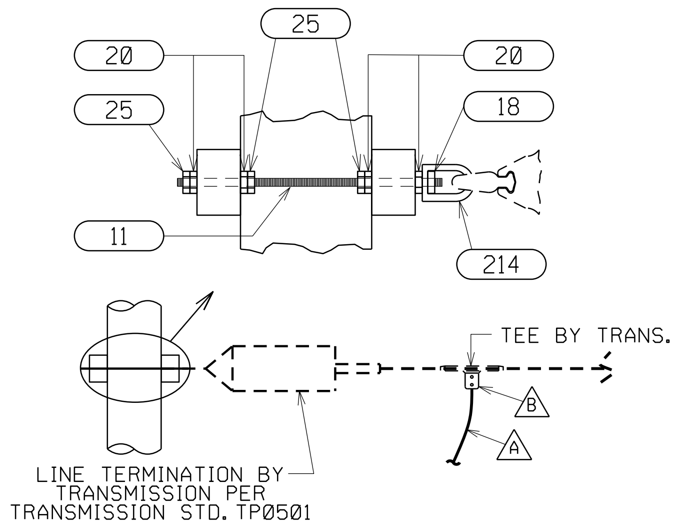
Xcel Energy

SCALE: NONE

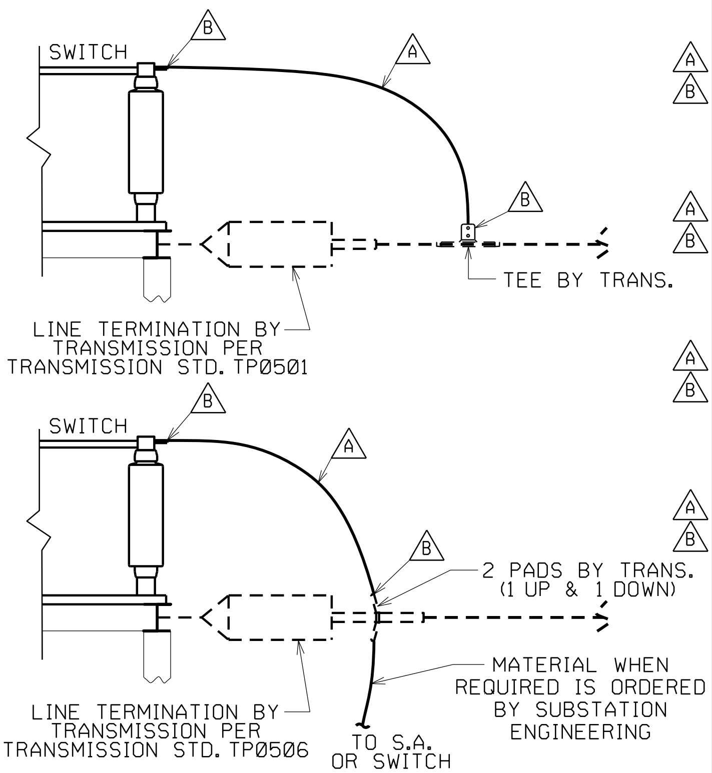
NL-200902-4-21

REV: A

05/25/2006 200902-4-21.DGN



WOOD POLE TERMINATION



STEEL TERMINATIONS

WOOD POLE TERMINATION MATERIAL (ORDERED BY DESIGNER)

ITEM NO.	QTY	DESCRIPTION
11	1	THREADED ROD, ¾" DIA × 26" LONG
18	1	NUT, SQUARE, FOR ¾" DIA BOLT
20	4	WASHER NUT, FOR ¾" DIA BOLT
25	3	LOCKNUT, FOR ¾" DIA BOLT
214	1	BOLT EYE FOR ¾" DIA THREADED ROD

NOTE: MATERIAL LISTED IS PER PHASE

MATERIAL FOR TAP FROM LINE TO EQUIPMENT

556.5 AL

	ITEM NO.	QTY	DESCRIPTION
A	37	10 FT	556.5 AL. CABLE
B	250	2	TERM. LUG FOR 556.5 AL.

954 AL

	ITEM NO.	QTY	DESCRIPTION
A	35	10 FT	954 AL. CABLE
B	251	2	TERM. LUG FOR 954 AL.

1590 AL

	ITEM NO.	QTY	DESCRIPTION
A	34	10 FT	1590 AL. CABLE
B	252	2	TERM. LUG FOR 1590 AL.

2-1590 AL

	ITEM NO.	QTY	DESCRIPTION
A	34	20 FT	(2) - 1590 AL. CABLE
B	674	2	(2) - TERM. LUG FOR 1590 AL.

NOTE: MATERIAL LISTED IS PER PHASE

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-22
ELECTRICAL CONNECTION DETAIL
LINE TERMINATIONS FOR 34.5KV & 69KV

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-4-22	B

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

200902-4-22.DGN
5/20/2011 12:40:45 PM

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

556.5 AL

	ITEM NO.	QTY	DESCRIPTION
A	37	10 FT	556.5 AL. CABLE
B	250	2	TERM. LUG FOR 556.5 AL.

954 AL

	ITEM NO.	QTY	DESCRIPTION
A	35	10 FT	954 AL. CABLE
B	251	2	TERM. LUG FOR 954 AL.

1590 AL

	ITEM NO.	QTY	DESCRIPTION
A	34	10 FT	1590 AL. CABLE
B	252	2	TERM. LUG FOR 1590 AL.

2-1590 AL

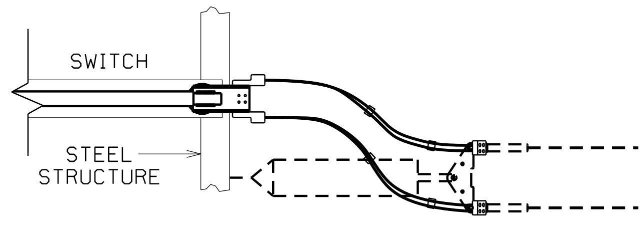
	ITEM NO.	QTY	DESCRIPTION
A	34	20 FT	(2) - 1590 AL. CABLE
B	674	2	TERM. LUG FOR 2-1590 AL.

NOTE: MATERIAL LISTED IS PER PHASE

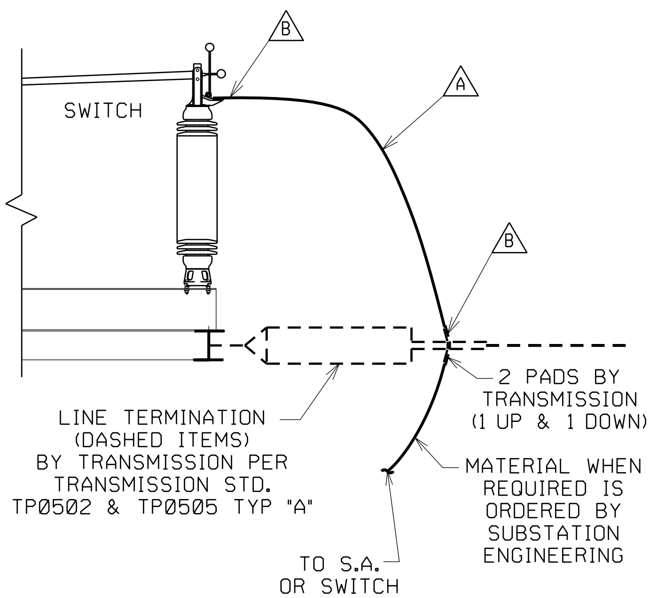
4-1590 AL

ITEM NO.	QTY	DESCRIPTION
34	40 FT	1590 AL. CABLE
286	4	CABLE SPACER FOR 2 OR 3-1590 AL
674	4	TERM. LUG FOR 2-1590 AL.

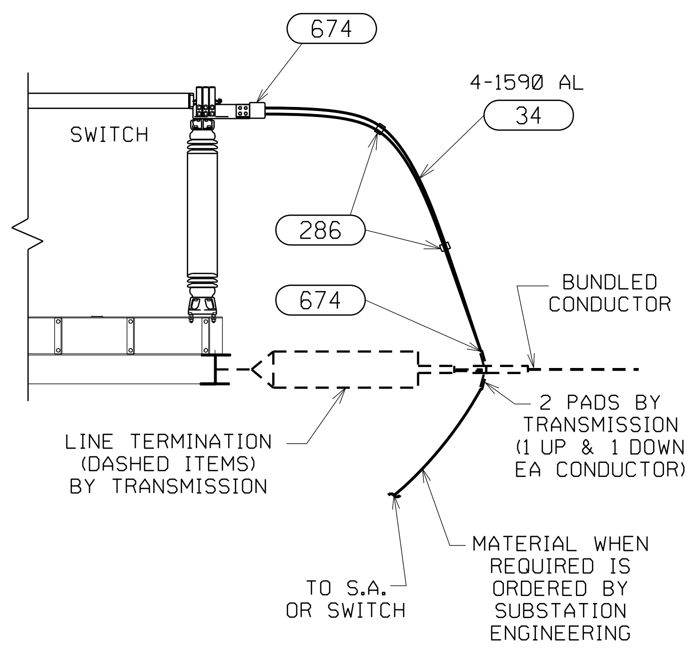
NOTE: MATERIAL LISTED IS PER PHASE



TOP VIEW



2000 AMPS AND BELOW



3000 AMPS

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-23
ELECTRICAL CONNECTION DETAIL
LINE TERMINATION FOR 115KV TO 230KV WITH NO LINE TRAP

Xcel Energy

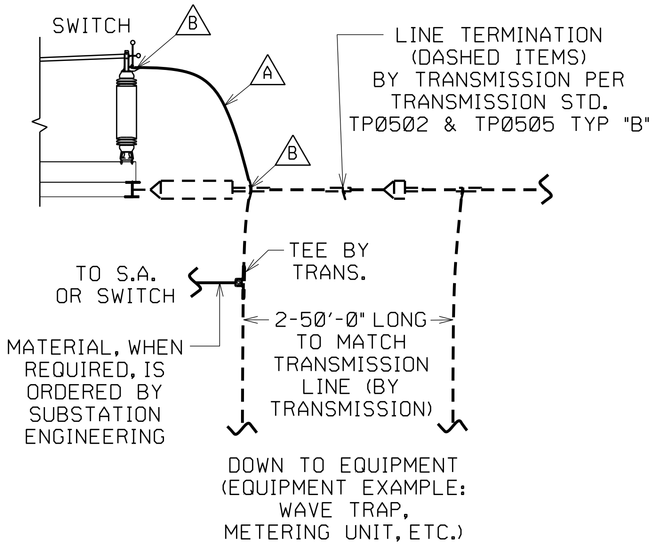
SCALE: NONE

NL-200902-4-23

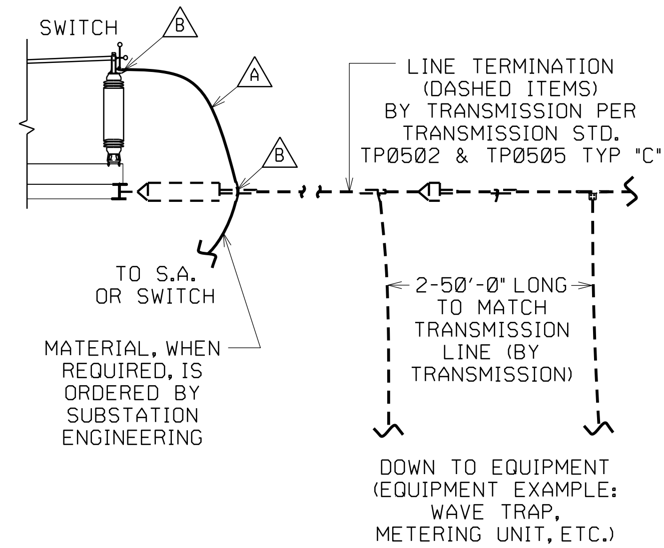
REV: C

200902-4-23.DGN

5/20/2011 12:41:23 PM



EQUIPMENT NEAR STRUCTURE



EQUIPMENT AWAY FROM STRUCTURE

BILL OF MATERIAL FOR THIS DETAIL
(ORDERED BY DESIGNER)

	ITEM NO.	QTY	DESCRIPTION
556.5 AL			
A	37	10 FT	556.5 AL. CABLE
B	250	2	TERM. LUG FOR 556.5 AL.
954 AL			
A	35	10 FT	954 AL. CABLE
B	251	2	TERM. LUG FOR 954 AL.
1590 AL			
A	34	10 FT	1590 AL. CABLE
B	252	2	TERM. LUG FOR 1590 AL.
2-1590 AL			
A	34	20 FT	(2) - 1590 AL. CABLE
B	674	2	(2) - TERM. LUG FOR 1590 AL.

NOTE: MATERIAL LISTED IS PER PHASE

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

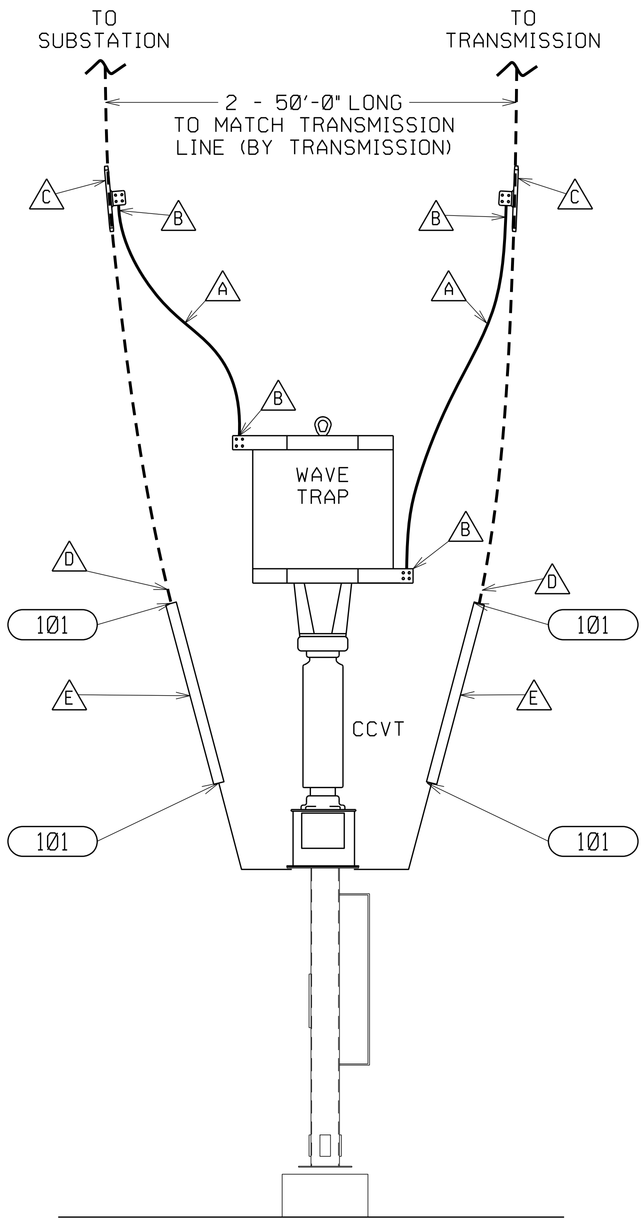
NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-24
ELECTRICAL CONNECTION DETAIL
LINE TERMINATION FOR 115KV TO 230KV - DOWN TO EQUIPMENT

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-4-24	B

200902-4-24.DGN
12:42:02 PM
5/20/2011



NOTE: MATERIAL LISTED IS PER PHASE

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

556.5 AL

	ITEM NO.	QTY	DESCRIPTION
A	37	20 FT	556.5 AL. CABLE
B	250	4	TERM. LUG FOR 556.5 AL.

954 AL

	ITEM NO.	QTY	DESCRIPTION
A	35	20 FT	954 AL. CABLE
B	251	4	TERM. LUG FOR 954 AL.

1590 AL

	ITEM NO.	QTY	DESCRIPTION
A	34	20 FT	1590 AL. CABLE
B	252	4	TERM. LUG FOR 1590 AL.

2-1590 AL

	ITEM NO.	QTY	DESCRIPTION
A	34	40 FT	(2) - 1590 AL. CABLE
B	674	4	(2) - TERM. LUG FOR 1590 AL.

C TEE FOR ACSS & ACSR (2 REQUIRED)

ITEM NO.	QTY	DESCRIPTION
139A	2 EA OF 1 ITEM REQ.	TEE FOR 336.4 26/7
139B		TEE FOR 477 24/7, 26/7, 30/7 & 556.5 26/7
139C		TEE FOR 636 24/7
139D		TEE FOR 795 26/7 & 45/7 & 954 54/7
139E		TEE FOR 2500 KCMIL ALL AL

D DEAD END FOR ACSS & ACSR (2 REQUIRED)

ITEM NO.	QTY	DESCRIPTION
141A	2 EA OF 1 ITEM REQ.	COMP DEAD END FOR 336.4 26/7
141B		COMP DEAD END FOR 477 24/7
141C		COMP DEAD END FOR 477 26/7
141D		COMP DEAD END FOR 477 30/7
141E		COMP DEAD END FOR 556.5 26/7
141F		COMP DEAD END FOR 636 24/7
141G		COMP DEAD END FOR 795 26/7
141H		COMP DEAD END FOR 795 45/7
141J		COMP DEAD END FOR 954 54/7
141K		COMP DEAD END FOR 2500 KCMIL ALL AL

E POLYMER SUSPENSION INSULATOR (2 REQUIRED)

ITEM NO.	QTY	DESCRIPTION
147	2EA OF 1 ITEM REQ.	115KV POLY SUSPENSION INSULATOR
148		161KV POLY SUSPENSION INSULATOR

ITEM NO.	QTY	DESCRIPTION
101	4	ANCHOR SHACKLE

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-25
ELECTRICAL CONNECTION DETAIL
WAVE TRAP CONNECTION TO TRANSMISSION LINE

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

Xcel Energy®

SCALE		REV
NONE	NL-200902-4-25	C

200902-4-25.DGN

5/20/2011 12:42:37 PM

MATERIAL FOR DETAIL BELOW

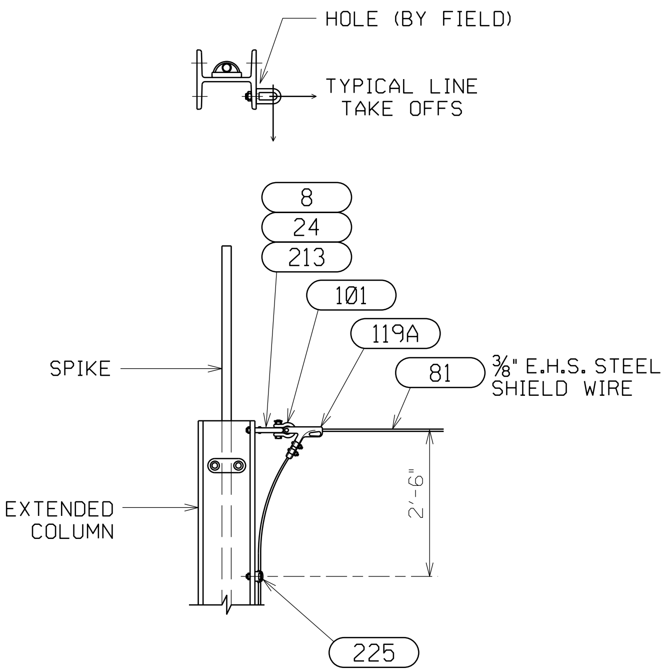
ITEM NO.	QTY	DESCRIPTION
8	1	MACHINE BOLT, GALV., 5/8" DIA × 1½" L
24	1	LOCK NUT, GALV., FOR 5/8" DIA BOLT
81	*	3/8" GALV. E.H.S. SHIELD WIRE
101	1	ANCHOR SHACKLE, GALV., 30,000 LB
119A	1	DEAD-END STRAIN CLAMP
213	1	BOLT EYE FOR 5/8" DIA BOLT
225	1	AL. TOWER CLAMP, SINGLE GROOVE

* VARIES

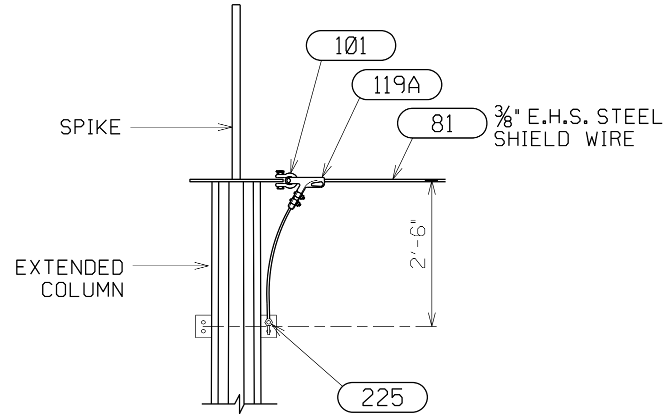
MATERIAL FOR DETAIL BELOW

ITEM NO.	QTY	DESCRIPTION
81	*	3/8" GALV. E.H.S. SHIELD WIRE
101	1	ANCHOR SHACKLE, GALV., 30,000 LB
119A	1	DEAD-END STRAIN CLAMP
225	1	AL. TOWER CLAMP, SINGLE GROOVE

* VARIES



SHIELD WIRE TO ROLLED STEEL



SHIELD WIRE TO TUBULAR STEEL

NOTE:

THESE DETAILS ARE USED FOR SHIELD WIRES THAT STAY WITHIN A SUBSTATION. TRANSMISSION SHIELD WIRE DETAILS ARE SHOWN ON TRANSMISSION STANDARD TP0504.

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-26
ELECTRICAL CONNECTION DETAIL
SHIELD WIRE ATTACHMENT

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-4-26	B

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

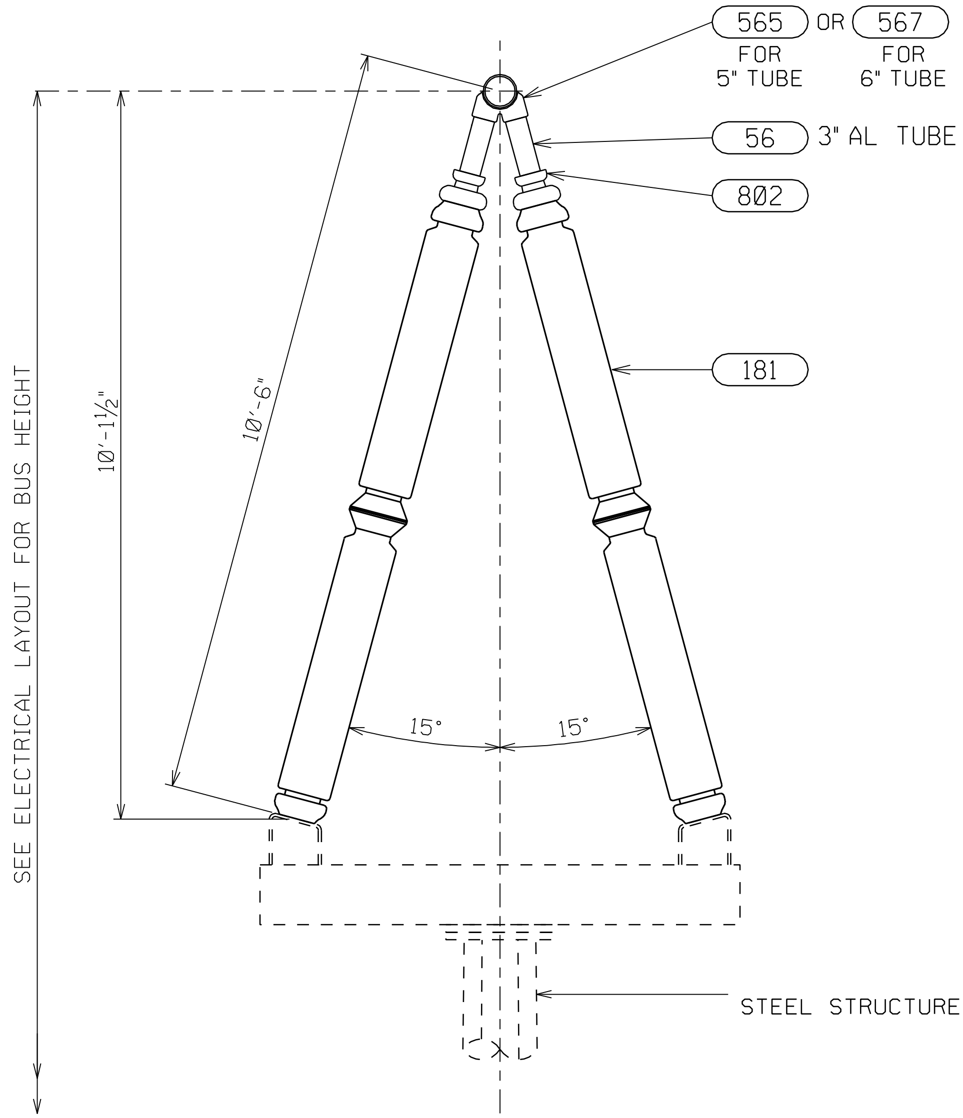
200902-4-26.DGN

5/20/2011 12:43:12 PM

MATERIAL REQUIRED FOR ONE TRIANGULAR BUS SUPPORT

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
56	2FT	3" IPS ALUMINUM TUBE			
181	2	345KV BUS SUPPORT 8'-10" HIGH			
565	1 ✱	VEE CONN., 5" IPS TUBE TO 2-3" TUBE			
567		VEE CONN., 6" IPS TUBE TO 2-3" TUBE			
802	2	B.S. FTG, VERT TUBE SUPP FOR 3" TUBE			

✱ THIS IS THE QUANTITY REQUIRED FOR ONE OF THE ITEMS. DO YOU HAVE 5" OR 6" TUBE?



LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS, MANUALS AND SPARS.

GRP	SIGNIFICANT NUMBER
1	
2	
3	
4	
5A	
5B	DETAIL
6	
CL	

ENGINEERING DEPARTMENT
MINNEAPOLIS, MN

SUBSTATION PHYSICAL DETAIL 4-27
ELECTRICAL CONNECTION DETAIL
345KV TRIANGULAR BUS SUPPORT

Xcel Energy

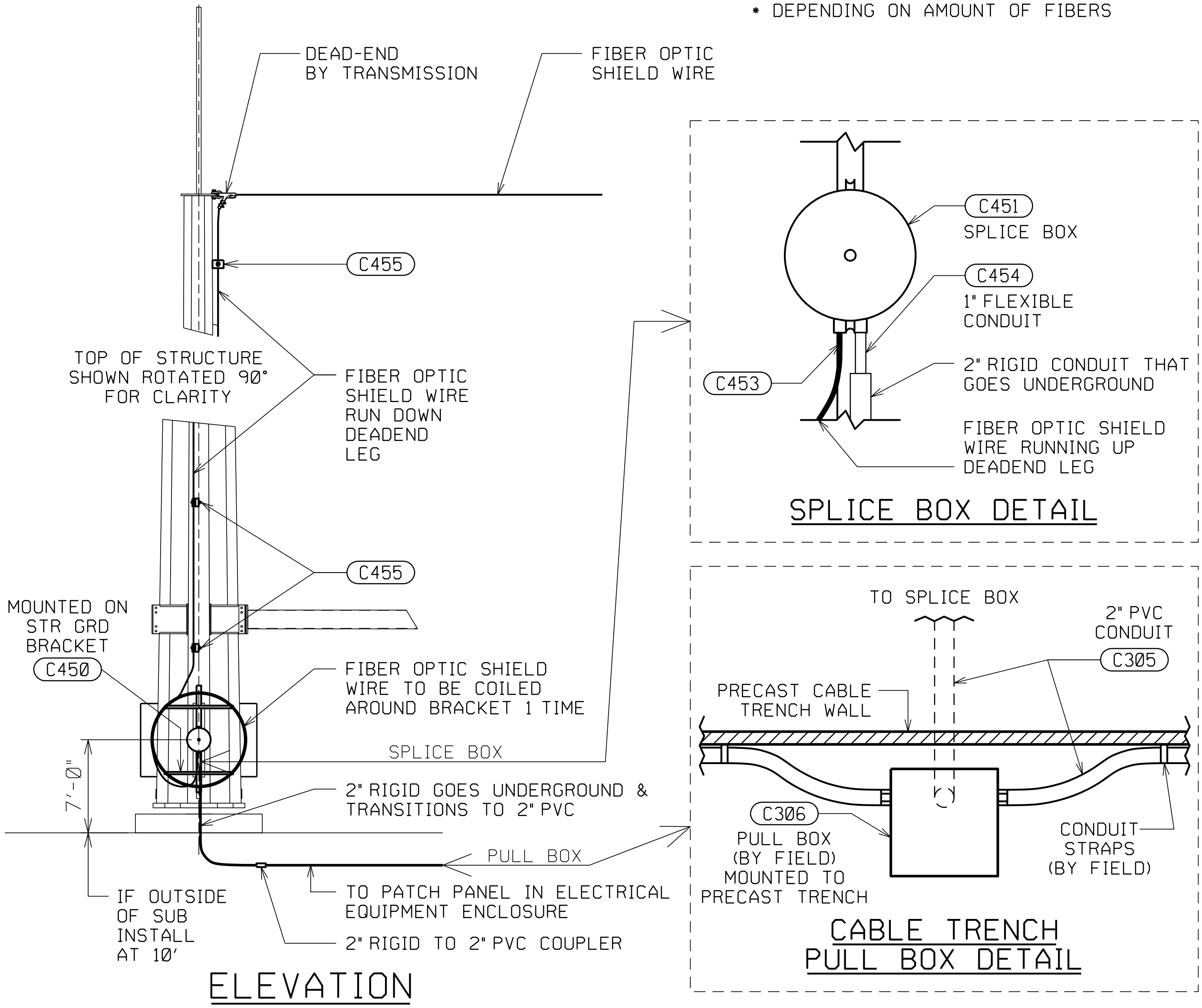
SCALE		REV
NONE	NL-200902-4-27	A

08/16/2006 200902-4-27.DGN

MATERIAL REQUIRED FOR ONE SPLICE

ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
C305	FIELD	2" RIGID PVC CONDUIT, 20' LENGTHS	C453	1 EA	FIBER OPTIC CONNECTOR KIT
C306	1 EA	CONDUIT JCT. BOX, W/COVER 1' x 1' x 6"	C454	1 EA	LOOSE TUBE CABLE CONNECTION KIT
C450	1 EA	EXTERNAL COIL BRACKET	C455	8 EA	FIBER OPTIC DOWN LEAD CLAMP
C451	1 EA	FIBER OPTIC SPLICE BOX ENCLOSURE	C459	5 PG*	FIBER OPTIC SPLICE PROTECTION SLEEVE

* DEPENDING ON AMOUNT OF FIBERS



LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST. (ORDERED BY DESIGNER)

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-28
ELECTRICAL CONNECTION DETAIL
FIBER OPTIC SHIELD WIRE, OVERHEAD TO UNDERGROUND SPLICE

Xcel Energy®

SCALE: NONE

NL-200902-4-28

REV: C

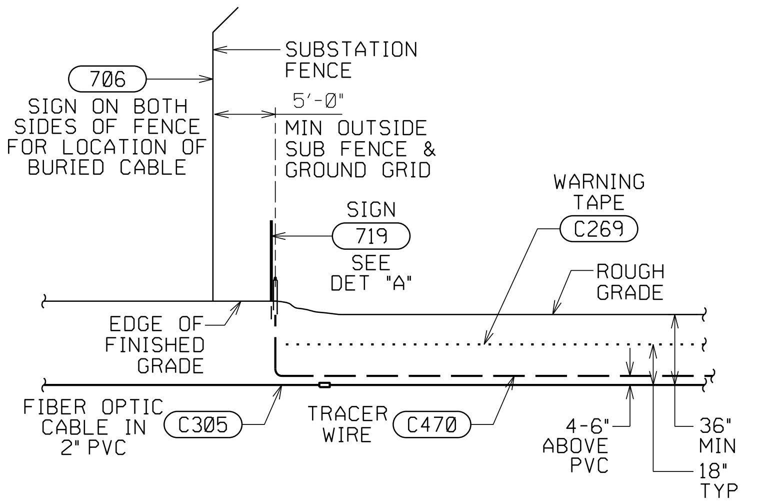
200902-4-28.DGN

10/26/2012 10:32:24 AM

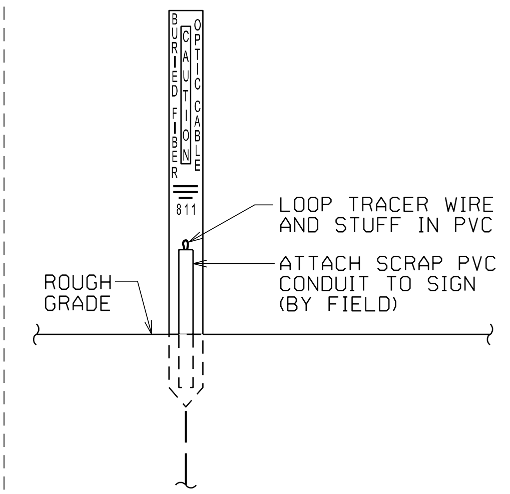
200902-4-29.DGN

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

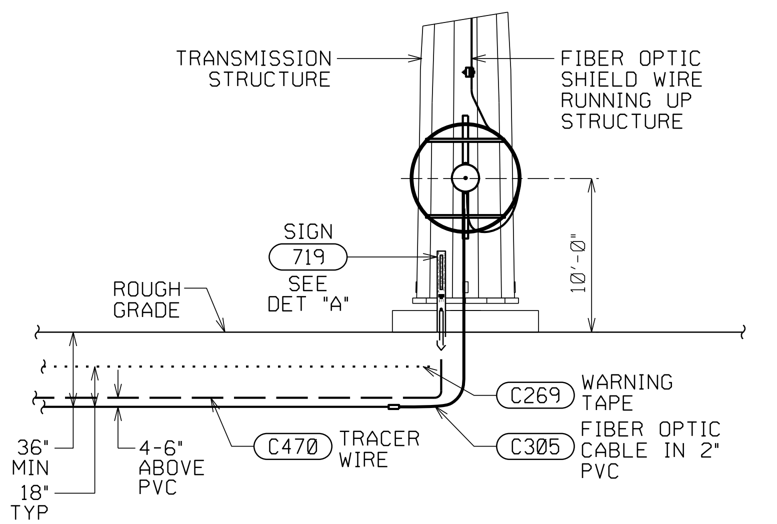
ITEM NO.	QTY	DESCRIPTION	ITEM NO.	QTY	DESCRIPTION
706	2	SIGN, "WARNING BURIED CABLE BELOW"	C305	FIELD	2" RIGID PVC CONDUIT, 20' LENGTHS
719	2 EA	SIGN, "BURIED FIBER OPTIC CABLE"	C470	*	TRACER WIRE, 12 GAUGE, BLACK
C269	*	6" WIDE WARNING TAPE			* DEPENDING ON RUN LENGTH



TRACER WIRE OUTSIDE SUB FENCE



SIGN DETAIL "A"



TRACER WIRE AT STRUCTURE

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 4-29
ELECTRICAL CONNECTION DETAIL
TRACER WIRE FOR FIBER OPTIC LOCATED OUTSIDE SUBSTATION

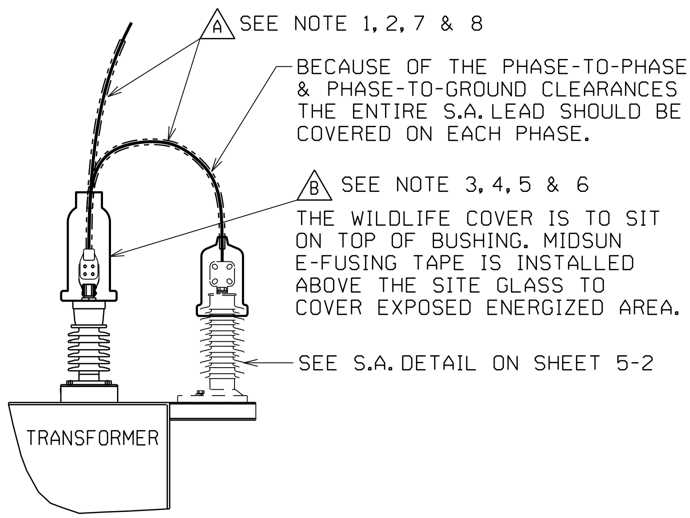
Xcel Energy

SCALE
NONE

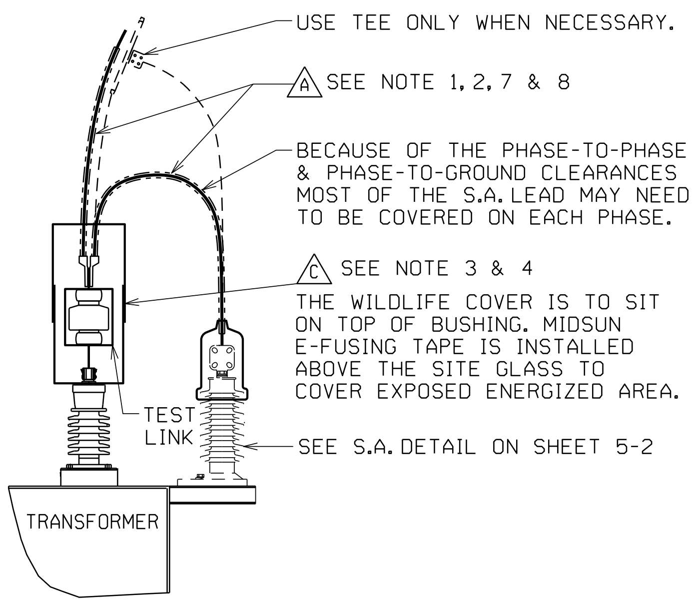
NL-200902-4-29

REV
A

9/19/2013 8:27:06 AM



LOW SIDE TRANSFORMER BUSHING
AND TERTIARY BUSHINGS
35KV AND BELOW



LOW SIDE TRANSFORMER BUSHING
WITH TEST LINK
35KV AND BELOW

BILL OF MATERIAL FOR THIS DETAIL
(ORDERED BY DESIGNER)

WILDLIFE CONDUCTOR COVER

	ITEM NO.	QTY	DESCRIPTION
A	W30	*	COND. COVER FOR #4-2/Ø
A	W31	*	COND. COVER FOR #3/Ø-336.4
A	W32	*	COND. COVER FOR 397.5-636
A	W33	*	COND. COVER FOR 666.6-954
A	W34	*	COND. COVER FOR 1Ø33-2167
A	W6Ø	*	TAPE, SILICONE, SELF-FUSING, 2½" WIDE NOTE: USE TAPE SPARINGLY SEE NOTE 8

* DESIGNER TO DETERMINE WHAT IS NEEDED

WILDLIFE COVERS

	ITEM NO.	QTY	DESCRIPTION
B	W1	1 EA	THERM-O-GUARD COVER, 19" H
C	W2Ø	1 AY	TEST LINK COVER, RAYCHEM

NEED EITHER ITEM B OR C (NOT BOTH).

NOTE: MATERIAL LISTED IS PER PHASE

NOTES:

1. INSULATION SHOULD BE INSTALLED ON EACH PHASE FROM INSIDE THE COVER TO A POINT WHERE THE PHASE-TO-GROUND CLEARANCE IS 18" OR GREATER. INSULATION SHOULD ALSO BE INSTALLED ON THE CENTER PHASE TO A POINT WHERE A PHASE SPACING OF 36" IS REACHED.
2. INSULATION SHALL BE USED ON THE OUTSIDE PHASES WHEN 18" PHASE-TO-GROUND CLEARANCE CAN NOT BE ACHIEVED.
3. A BUSHING COVER SHOULD ALWAYS ALLOW FOR THE OIL INDICATORS TO BE VISIBLE FROM THE GROUND.
4. IF OIL INDICATORS DO NOT EXIST, THE BUSHING COVER IS INSTALLED BETWEEN THE FIRST AND SECOND SKIRT FROM THE TOP OF THE BUSHING. NEVER COVER MORE THAN THE FIRST SKIRT.
5. THERM-A-GUARD RECOMMENDS A MINIMUM OF 1" CLEARANCE FROM THE ENERGIZED CONNECTOR TO THE INSIDE SURFACE OF THE GUARD.
6. THERM-A-GUARD BUSHING COVERS CAN BE TRIMMED TO ACCOMMODATE CONDUCTOR EXITS OTHER THAN THE TOP. TRIM CAREFULLY SO THE OPENING DOES NOT GET OVERSIZED AND DO NOT REMOVE MORE THAN ONE HINGE.
7. FOR THE INSULATING HOSE TO COVER THE BARREL OF THE LUG, PURCHASE HOSE THAT IS ONE SIZE LARGER THAN THE HOSE SIZE RECOMMENDED FOR THE ACTUAL CONDUCTOR SIZE.
8. INSULATING TAPE CAN BE USED IN SMALL AREAS WHERE A BUSHING COVER OR OTHER INSULATING MATERIAL CANNOT BE USED. THE TAPE HAS A DESIGN LIFE OF ONLY 1Ø YEARS AND ALL OTHER ITEMS HAVE A DESIGN LIFE OF 2Ø-4Ø YEARS.

LEGEND:
153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 5-1
WILDLIFE PROTECTION DETAIL
TRANSFORMER BUSHINGS - 35KV AND BELOW

Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-2ØØ9Ø2-5-1	C

GRP	SIGNIFICANT NUMBER
LOC ID	
GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

2ØØ9Ø2-5-1.DGN
11:1Ø:43 AM
11/2Ø/2Ø13

200902-5-2.DGN

BILL OF MATERIAL FOR THIS DETAIL
(ORDERED BY DESIGNER)

WILDLIFE CONDUCTOR COVER

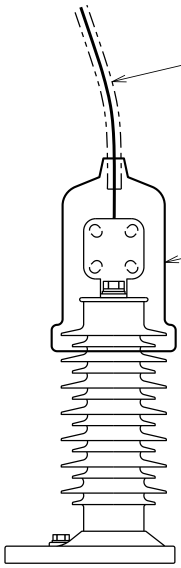
	ITEM NO.	QTY	DESCRIPTION
A	W30	*	COND. COVER FOR #4-2/0
A	W31	*	COND. COVER FOR #3/0-336.4
A	W32	*	COND. COVER FOR 397.5-636
A	W33	*	COND. COVER FOR 666.6-954
A	W34	*	COND. COVER FOR 1033-2167
A	W60	*	TAPE, SILICONE, SELF-FUSING, 2½" WIDE NOTE: USE TAPE SPARINGLY SEE NOTE 3

* DESIGNER TO DETERMINE WHAT IS NEEDED

WILDLIFE SURGE ARRESTER COVER

	ITEM NO.	QTY	DESCRIPTION
B	W2	1 EA	THERM-O-GUARD COVER, 14" H

NOTE: MATERIAL LISTED IS PER PHASE



A
COVER CONDUCTOR AS NECESSARY.
SEE NOTE 1, 2 & 7

B
WILDLIFE COVER SITS ON TOP OF THE SURGE ARRESTER. TO PREVENT ANIMALS FROM LIFTING THE COVER A SMALL AMOUNT OF SILICONE CAULK CAN BE USED TO GLUE THE COVER TO THE TOP SKIRT. SEE NOTE 3, 4 & 5

SURGE ARRESTER - 35KV AND BELOW

NOTES:

1. INSULATION SHOULD BE INSTALLED ON EACH PHASE FROM INSIDE THE COVER TO A POINT WHERE THE PHASE-TO-GROUND CLEARANCE IS 18" OR GREATER. INSULATION SHOULD ALSO BE INSTALLED ON THE CENTER PHASE TO A POINT WHERE A PHASE SPACING OF 36" IS REACHED.
2. INSULATION SHALL BE USED ON THE OUTSIDE PHASES WHEN 18" PHASE-TO-GROUND CLEARANCE CAN NOT BE ACHIEVED.
3. THE BUSHING COVER IS INSTALLED BETWEEN THE FIRST AND SECOND SKIRT FROM THE TOP OF THE BUSHING. NEVER COVER MORE THAN THE FIRST SKIRT.
4. THERM-A-GUARD RECOMMENDS A MINIMUM OF 1" CLEARANCE FROM THE ENERGIZED CONNECTOR TO THE INSIDE SURFACE OF THE GUARD.
5. THERM-A-GUARD BUSHING COVERS CAN BE TRIMMED TO ACCOMMODATE CONDUCTOR EXITS OTHER THAN THE TOP. TRIM CAREFULLY SO THE OPENING DOES NOT GET OVERSIZED AND DO NOT REMOVE MORE THAN ONE HINGE.
6. FOR THE INSULATING HOSE TO COVER THE BARREL OF THE LUG, PURCHASE HOSE THAT IS ONE SIZE LARGER THAN THE HOSE SIZE RECOMMENDED FOR THE ACTUAL CONDUCTOR SIZE.
7. INSULATING TAPE CAN BE USED IN SMALL AREAS WHERE A BUSHING COVER OR OTHER INSULATING MATERIAL CANNOT BE USED. THE TAPE HAS A DESIGN LIFE OF ONLY 10 YEARS AND ALL OTHER ITEMS HAVE A DESIGN LIFE OF 20-40 YEARS.

LEGEND:
(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

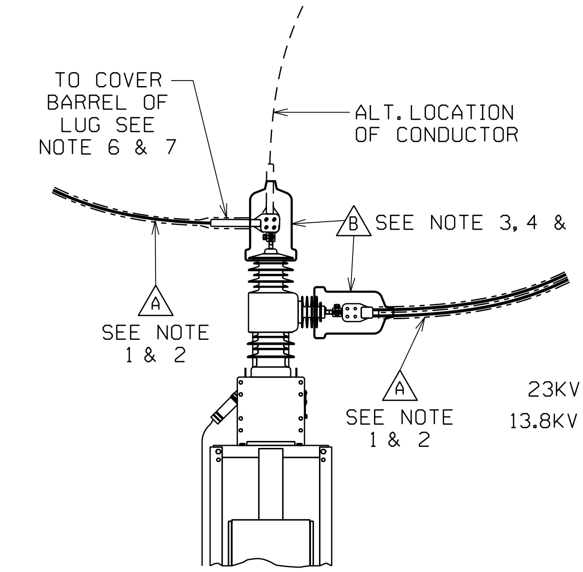
NSP OPERATING AREA ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 5-2
WILDLIFE PROTECTION DETAIL
SURGE ARRESTERS - 35KV AND BELOW

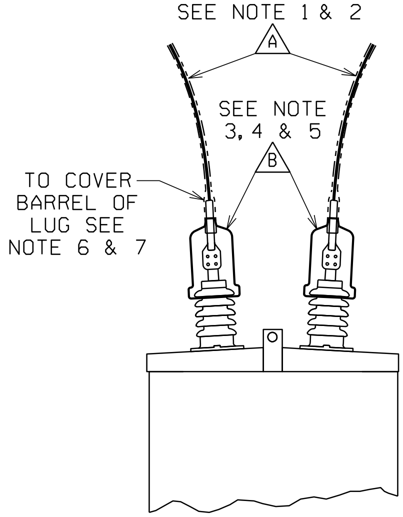
Xcel Energy®

SCALE	DRAWING NO.	REV
NONE	NL-200902-5-2	C

11/20/2013 11:11:56 AM



NOVA RECLOSER
35KV AND BELOW



TYPICAL CIRCUIT BREAKER
OR RECLOSER
35KV AND BELOW

BILL OF MATERIAL FOR THIS DETAIL (ORDERED BY DESIGNER)

WILDLIFE CONDUCTOR COVER

	ITEM NO.	QTY	DESCRIPTION
A	W30	*	COND. COVER FOR #4-2/0
A	W31	*	COND. COVER FOR #3/0-336.4
A	W32	*	COND. COVER FOR 397.5-636
A	W33	*	COND. COVER FOR 666.6-954
A	W34	*	COND. COVER FOR 1033-2167
A	W60	*	TAPE, SILICONE, SELF-FUSING, 2½" WIDE NOTE: USE TAPE SPARINGLY SEE NOTE 7

* DESIGNER TO DETERMINE WHAT IS NEEDED

WILDLIFE BUSHING COVER

	ITEM NO.	QTY	DESCRIPTION
23KV & ABOVE B	W1	6 EA OF 1 ITEM REQ.	THERM-O-GUARD COVER, 19" H
13.8KV & BELOW B	W2		THERM-O-GUARD COVER, 14" H

NOTE: MATERIAL LISTED IS PER BREAKER

NOTES:

1. INSULATION SHOULD BE INSTALLED ON EACH PHASE FROM INSIDE THE COVER TO A POINT WHERE THE PHASE-TO-GROUND CLEARANCE IS 18" OR GREATER. INSULATION SHOULD ALSO BE INSTALLED ON THE CENTER PHASE TO A POINT WHERE A PHASE SPACING OF 36" IS REACHED.
2. INSULATION SHALL BE USED ON THE OUTSIDE PHASES WHEN 18" PHASE-TO-GROUND CLEARANCE CAN NOT BE ACHIEVED.
3. THE BUSHING COVER IS INSTALLED BETWEEN THE FIRST AND SECOND SKIRT FROM THE TOP OF THE BUSHING. NEVER COVER MORE THAN THE FIRST SKIRT.
4. THERM-A-GUARD RECOMMENDS A MINIMUM OF 1" CLEARANCE FROM THE ENERGIZED CONNECTOR TO THE INSIDE SURFACE OF THE GUARD.
5. THERM-A-GUARD BUSHING COVERS CAN BE TRIMMED TO ACCOMMODATE CONDUCTOR EXITS OTHER THAN THE TOP. TRIM CAREFULLY SO THE OPENING DOES NOT GET OVERSIZED AND DO NOT REMOVE MORE THAN ONE HINGE.
6. FOR THE INSULATING HOSE TO COVER THE BARREL OF THE LUG, PURCHASE HOSE THAT IS ONE SIZE LARGER THAN THE HOSE SIZE RECOMMENDED FOR THE ACTUAL CONDUCTOR SIZE.
7. INSULATING TAPE CAN BE USED IN SMALL AREAS WHERE A BUSHING COVER OR OTHER INSULATING MATERIAL CANNOT BE USED. THE TAPE HAS A DESIGN LIFE OF ONLY 10 YEARS AND ALL OTHER ITEMS HAVE A DESIGN LIFE OF 20-40 YEARS.

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

NSP OPERATING AREA ENGINEERING
Minneapolis, MN

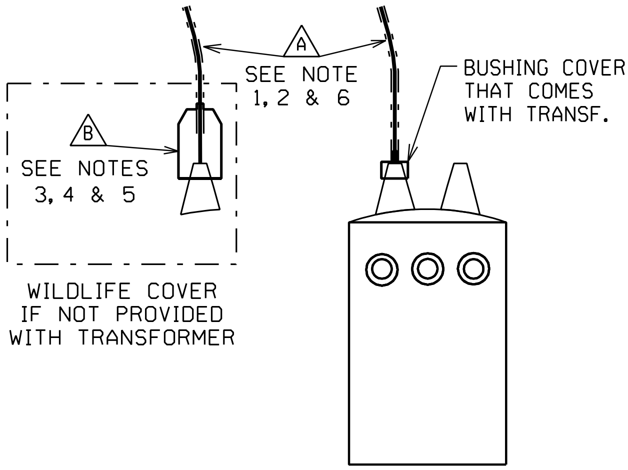
SUBSTATION PHYSICAL DETAIL 5-3
WILDLIFE PROTECTION DETAIL
CIRCUIT BREAKERS OR RECLOSERS - 35KV AND BELOW

Xcel Energy®

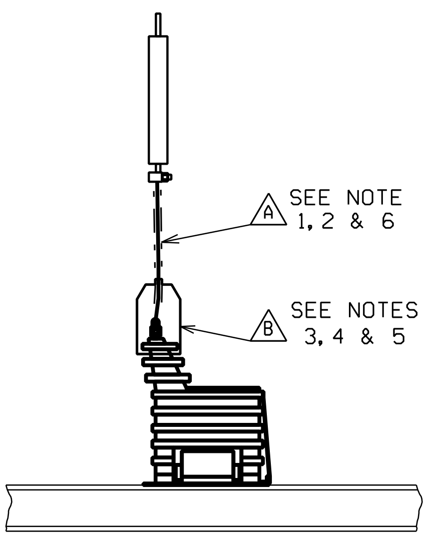
SCALE	DRAWING NO.	REV
NONE	NL-200902-5-3	C

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

200902-5-3.DGN
11/20/2013 11:14:09 AM



TYPICAL AUX TRANSFORMER
35KV AND BELOW



TYPICAL POT TRANSFORMER
35KV AND BELOW

BILL OF MATERIAL FOR THIS DETAIL
(ORDERED BY DESIGNER)

WILDLIFE CONDUCTOR COVER

	ITEM NO.	QTY	DESCRIPTION
A	W30	*	COND. COVER FOR #4-2/0
A	W31	*	COND. COVER FOR #3/0-336.4
A	W32	*	COND. COVER FOR 397.5-636
A	W33	*	COND. COVER FOR 666.6-954
A	W34	*	COND. COVER FOR 1033-2167
A	W60	*	TAPE, SILICONE, SELF-FUSING, 2½" WIDE NOTE: USE TAPE SPARINGLY SEE NOTE 6

* DESIGNER TO DETERMINE WHAT IS NEEDED

WILDLIFE BUSHING COVER

	ITEM NO.	QTY	DESCRIPTION
B	W4	1 EA	THERM-O-GUARD COVER, 8" H

NOTE: MATERIAL LISTED IS PER PHASE

NOTES:

1. INSULATION SHOULD BE INSTALLED FROM INSIDE THE COVER TO THE FUSE OR FUSE DISCONNECT.
2. WHEN MORE THAN ONE TRANSFORMER IS USED ALL LEADS BETWEEN THE FUSE DISCONNECTS AND THE TRANSFOMERS SHALL BE COVERED.
3. THE BUSHING COVER IS INSTALLED BETWEEN THE FIRST AND SECOND SKIRT FROM THE TOP OF THE BUSHING. NEVER COVER MORE THAN THE FIRST SKIRT.
4. THERM-A-GUARD RECOMMENDS A MINIMUM OF 1" CLEARANCE FROM THE ENERGIZED CONNECTOR TO THE INSIDE SURFACE OF THE GUARD.
5. THERM-A-GUARD BUSHING COVERS CAN BE TRIMMED TO ACCOMMODATE CONDUCTOR EXITS OTHER THAN THE TOP. TRIM CAREFULLY SO THE OPENING DOES NOT GET OVERSIZED.
6. INSULATING TAPE CAN BE USED IN SMALL AREAS WHERE A BUSHING COVER OR OTHER INSULATING MATERIAL CANNOT BE USED. THE TAPE HAS A DESIGN LIFE OF ONLY 10 YEARS AND ALL OTHER ITEMS HAVE A DESIGN LIFE OF 20-40 YEARS.

LEGEND:

(153) INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 5-4
WILDLIFE PROTECTION DETAIL
STATION AUX AND POT TRANSFOMERS - 35KV AND BELOW

Xcel Energy

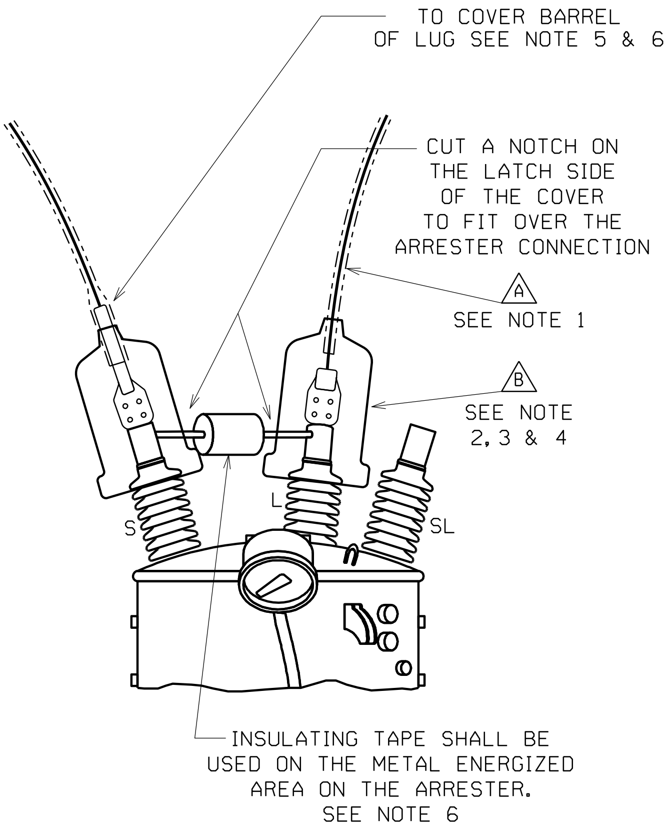
SCALE: NONE

NL-200902-5-4

REV: A

$TIME$

01/07/2008



REGULATOR
35KV AND BELOW

BILL OF MATERIAL FOR THIS DETAIL
(ORDERED BY DESIGNER)

WILDLIFE CONDUCTOR COVER

	ITEM NO.	QTY	DESCRIPTION
A	W30	*	COND. COVER FOR #4-2/0
A	W31	*	COND. COVER FOR #3/0-336.4
A	W32	*	COND. COVER FOR 397.5-636
A	W33	*	COND. COVER FOR 666.6-954
A	W34	*	COND. COVER FOR 1033-2167
A	W60	*	TAPE, SILICONE, SELF-FUSING, 2½" WIDE NOTE: USE TAPE SPARINGLY SEE NOTE 6

* DESIGNER TO DETERMINE WHAT IS NEEDED

WILDLIFE BUSHING COVER

	ITEM NO.	QTY	DESCRIPTION
B	W2	2 EA	THERM-O-GUARD COVER, 14" H

NOTE: MATERIAL LISTED IS PER PHASE

NOTES:

1. INSULATION SHALL BE INSTALLED ON EACH PHASE FROM INSIDE THE COVER TO THE FIRST POINT OF ATTACHMENT. THIS WILL BE DONE FOR BOTH THE SOURCE AND LOAD BUSHINGS ON THE REGULATOR BECAUSE OF MINIMAL CLEARANCES.
2. THE BUSHING COVER IS INSTALLED BETWEEN THE FIRST AND SECOND SKIRT FROM THE TOP OF THE BUSHING. NEVER COVER MORE THAN THE FIRST SKIRT.
3. THERM-A-GUARD RECOMMENDS A MINIMUM OF 1" CLEARANCE FROM THE ENERGIZED CONNECTOR TO THE INSIDE SURFACE OF THE GUARD.
4. THERM-A-GUARD BUSHING COVERS CAN BE TRIMMED TO ACCOMMODATE CONDUCTOR EXITS OTHER THAN THE TOP. TRIM CAREFULLY SO THE OPENING DOES NOT GET OVERSIZED AND DO NOT REMOVE MORE THAN ONE HINGE.
5. FOR THE INSULATING HOSE TO COVER THE BARREL OF THE LUG, PURCHASE HOSE THAT IS ONE SIZE LARGER THAN THE HOSE SIZE RECOMMENDED FOR THE ACTUAL CONDUCTOR SIZE.
6. INSULATING TAPE CAN BE USED IN SMALL AREAS WHERE A BUSHING COVER OR OTHER INSULATING MATERIAL CANNOT BE USED. THE TAPE HAS A DESIGN LIFE OF ONLY 10 YEARS AND ALL OTHER ITEMS HAVE A DESIGN LIFE OF 20-40 YEARS.

LEGEND:

153 INDICATES ITEM NUMBER SHOWN ABOVE AND ON PHYSICAL MATERIAL LIST.

GRP	SIGNIFICANT NUMBER
LOC ID GRP 1	
3	
4	
5A	
5B	DETAIL
6	
CL	

NSP OPERATING AREA
ENGINEERING
Minneapolis, MN

SUBSTATION PHYSICAL DETAIL 5-5
WILDLIFE PROTECTION DETAIL
REGULATORS - 35KV AND BELOW

Xcel Energy®

SCALE NONE

NL-200902-5-5

REV B

200902-5-5.DGN

12:45:34 PM 5/20/2011

Xcel Energy

PHYSICAL DETAIL INDEX AND REVISION LEGEND

NL-INDEX Page 1 of 2

This Map/Document is a tool to assist employees in the performance of their jobs. Your personal safety is provided for by using safety practices, procedures and equipment as described in safety training programs, manuals and SPAR's

REVISION "F"

Revised?	DRAWING NUMBER		REV	DESCRIPTION 1	DESCRIPTION 2	What Changed on the revision above?
	NL	200902-1-1	D	SUBSTATION GROUNDING DETAIL	CADWELD MOLD TYPES AND SHOT REQUIRED FOR EACH MOLD	
	NL	200902-1-10	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR CAPACITOR BANK STAND	
	NL	200902-1-11	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR SINGLE CAPACITOR BANK	
	NL	200902-1-12	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR CAPACITOR BANK SINGLE POINT CONNECTION	
	NL	200902-1-13	C	SUBSTATION GROUNDING DETAIL	GROUND WELL	
	NL	200902-1-14	A	SUBSTATION GROUNDING DETAIL	FENCE GROUND ISOLATION	
	NL	200902-1-15	A	SUBSTATION GROUNDING DETAIL	GROUNDING FOR SURGE ARRESTER	
	NL	200902-1-16	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR SHIELD SPIKE ON WOOD POLE	
	NL	200902-1-17	A	SUBSTATION GROUNDING DETAIL	GROUNDING FOR GUARD POST	
	NL	200902-1-18	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR OUTDOOR UNDERGROUND FEEDER NEUTRAL	
	NL	200902-1-19	B	SUBSTATION GROUNDING DETAIL	OVERHEAD FEEDER NEUTRAL CONNECTION TO GROUND GRID	
	NL	200902-1-2	C	SUBSTATION GROUNDING DETAIL	GROUNDING FOR SUBSTATION STEEL STRUCTURES	
	NL	200902-1-20	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR PAINTED CABINETS	
	NL	200902-1-21	A	SUBSTATION GROUNDING DETAIL	SWITCH OPERATING PIPE GRD'G & OPERATING CRANK MOUNTING HEIGHT	
	NL	200902-1-3	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR FENCE AND GATE	
	NL	200902-1-4	D	SUBSTATION GROUNDING DETAIL	GROUNDING FOR TRANSFORMER	
	NL	200902-1-5	D	SUBSTATION GROUNDING DETAIL	GROUNDING FOR BREAKERS	
	NL	200902-1-6	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR NOVA RECLOSER	
	NL	200902-1-7	C	SUBSTATION GROUNDING DETAIL	GROUNDING FOR RECLOSER	
	NL	200902-1-8	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR REGULATOR	
	NL	200902-1-9	B	SUBSTATION GROUNDING DETAIL	GROUNDING FOR P.T. AND C.C.V.T.	
	NL	200902-2-1	C	SUBSTATION CONTROL AND LIGHTING DETAIL	CONDUIT RISER DETAIL "A", DETAIL "B", DETAIL "C" & DETAIL "D"	
	NL	200902-2-10	A	SUBSTATION CONTROL AND LIGHTING DETAIL	POTENTIAL TRANSFORMER MOUNTING AND CONDUIT LAYOUT	
	NL	200902-2-2	A	SUBSTATION CONTROL AND LIGHTING DETAIL	FLOODLAMP LIGHTING FIXTURE MOUNTING	
	NL	200902-2-3	C	SUBSTATION CONTROL AND LIGHTING DETAIL	400W HIGH PRESSURE SOIDUM LIGHT FIXTURE MOUNTING	
	NL	200902-2-4	B	SUBSTATION CONTROL AND LIGHTING DETAIL	FUSE CABINET FOR SINGLE PHASE P.T. OR CCVT AND DIST. BUS PT'S	
	NL	200902-2-5	B	SUBSTATION CONTROL AND LIGHTING DETAIL	FUSE CABINET FOR THREE SINGLE PHASE PT'S OR CCVT'S	
	NL	200902-2-6	B	SUBSTATION CONTROL AND LIGHTING DETAIL	CONTROL CABLE CONNECTION FOR PT'S OR CCVT'S	
	NL	200902-2-7	B	SUBSTATION CONTROL AND LIGHTING DETAIL	CONTROL CABLE CONNECTION FOR THREE SINGLE PHASE CCVT'S	
	NL	200902-2-8	A	SUBSTATION CONTROL AND LIGHTING DETAIL	CABLE TRENCH DETAIL "A", DETAIL "B", DETAIL "C" & DETAIL "D"	
	NL	200902-2-9	B	SUBSTATION CONTROL AND LIGHTING DETAIL	TRANSFORMER CABLE TERMINATION CABINET	
	NL	200902-3-1	C	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	CABLE ENTRANCE FOR PRE-CAST PULL BOX	
	NL	200902-3-10	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	FLUORESCENT LIGHT FIXTURE HANGER	
	NL	200902-3-11	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	MOUNTING DETAIL FOR PANEL DROP CORD RECEPTACLES	
	NL	200902-3-12	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	HEATER INSTALLATION	
	NL	200902-3-13	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	LIGHTING LAYOUT AND WIRING	
	NL	200902-3-14	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	EXAMPLE TROUGH LAYOUT	
	NL	200902-3-15	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	WIRING OF OUTDOOR LIGHTING	
	NL	200902-3-2	C	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	CABLE ENTRANCE FOR BURIED CABLE	
	NL	200902-3-3	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	TYPICAL PANEL AND CABLE TRAY MOUNTING	
	NL	200902-3-4	C	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	GROUND BUS ENTRANCE	
	NL	200902-3-5	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	MOBILE TRANSFORMER CONTROL CABLE ENTRANCE	
	NL	200902-3-6	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	TELEPHONE CABLE ENTRANCE	
	NL	200902-3-7	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	TYP GRD'G FOR ALL CAB., BOXES, SAF. SW., BATT. RACK & CHARGER	
	NL	200902-3-8	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	MOUNTING FOR HEAVY EQUIPMENT	
	NL	200902-3-9	B	ELECTRICAL EQUIPMENT ENCLOSURE DETAIL	TYPICAL MOUNTING OF BATTERY RACK TO WALL	
	NL	200902-4-1	A	ELECTRICAL CONNECTION DETAIL	BUS MOUNTING FOR ALUMINUM ANGLE	
	NL	200902-4-10	A	ELECTRICAL CONNECTION DETAIL	DRILLING FOR TERMINAL LUG CONNECTION TO INTEGRAL WEB CHANNEL BUS	
	NL	200902-4-11	A	ELECTRICAL CONNECTION DETAIL	PROVISION FOR HOT LINE CLAMP CONN. TO INTEGRAL WEB CHANNEL BUS	
	NL	200902-4-12	A	ELECTRICAL CONNECTION DETAIL	WELDED OR BOLTED SPLICE FOR INTEGRAL WEB CHANNEL BUS	

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PHYSICAL DETAIL INDEX AND REVISION LEGEND

NL-INDEX Page 2 of 2

This Map/Document is a tool to assist employees in the performance of their jobs. Your personal safety is provided for by using safety practices, procedures and equipment as described in safety training programs, manuals and SPAR's

REVISION "F"

Revised?	DRAWING NUMBER		REV	DESCRIPTION 1	DESCRIPTION 2	What Changed on the revision above?
	NL	200902-4-13	A	ELECTRICAL CONNECTION DETAIL	WELDED-BOLTED 90 DEGREE ANGLE CONN. FOR INTEGRAL WEB CHANNEL BUS	
	NL	200902-4-14	A	ELECTRICAL CONNECTION DETAIL	WELDED OR BOLTED TEE TAP FOR INTEGRAL WEB CHANNEL BUS	
	NL	200902-4-15	A	ELECTRICAL CONNECTION DETAIL	WELDED ANGLE BRACE FOR INTEGRAL WEB CHANNEL BUS	
	NL	200902-4-16	E	ELECTRICAL CONNECTION DETAIL	TUBING BUS "A" FRAME TAP	
	NL	200902-4-17	B	ELECTRICAL CONNECTION DETAIL	WELDED SPLICE FOR TUBE	
	NL	200902-4-18	A	ELECTRICAL CONNECTION DETAIL	BUS SUPPORT FIXED & SLIP FITTING FOR ALUMINUM TUBE	
Y	NL	200902-4-19A	F	ELECTRICAL CONNECTION DETAIL	STRAIN BUS SUSPENSION INSULATOR ASSEMBLY	Updated Material
Y	NL	200902-4-19B	F	ELECTRICAL CONNECTION DETAIL	STRAIN BUS SUSPENSION INSULATOR ASSEMBLY	Updated Material
Y	NL	200902-4-19C	F	ELECTRICAL CONNECTION DETAIL	BUNDLED STRAIN BUS SUSPENSION INSULATOR ASSEMBLY	Updated Material
Y	NL	200902-4-19D	F	ELECTRICAL CONNECTION DETAIL	DOUBLE STRAIN BUS SUSPENSION INSULATOR ASSEMBLY	New Detail
	NL	200902-4-2	B	ELECTRICAL CONNECTION DETAIL	TERMINAL LUG & SWITCH DRILLING FOR ALUMINUM ANGLE AND BAR	
	NL	200902-4-20	A	ELECTRICAL CONNECTION DETAIL	SWITCH TO BUS CONNECTION - BUS SUPPORT IS PART OF SWITCH STAND	
	NL	200902-4-21	A	ELECTRICAL CONNECTION DETAIL	DISTRIBUTION OVERHEAD TERMINATIONS AT SUBSTATION	
	NL	200902-4-22	A	ELECTRICAL CONNECTION DETAIL	LINE TERMINATIONS FOR 34.5KV & 69KV	
	NL	200902-4-23	B	ELECTRICAL CONNECTION DETAIL	LINE TERMINATION FOR 115KV TO 230KV WITH NO LINE TRAP	
	NL	200902-4-24	A	ELECTRICAL CONNECTION DETAIL	LINE TERMINATION FOR 115KV TO 230KV - DOWN TO EQUIPMENT	
	NL	200902-4-25	B	ELECTRICAL CONNECTION DETAIL	WAVE TRAP CONNECTION TO TRANSMISSION LINE	
	NL	200902-4-26	A	ELECTRICAL CONNECTION DETAIL	SHIELD WIRE ATTACHMENT	
	NL	200902-4-27	A	ELECTRICAL CONNECTION DETAIL	345KV TRIANGULAR BUS SUPPORT	
	NL	200902-4-3	A	ELECTRICAL CONNECTION DETAIL	PROVISION FOR HOT LINE CLAMP	
	NL	200902-4-4	B	ELECTRICAL CONNECTION DETAIL	ALUMINUM ANGLE SPLICE	
	NL	200902-4-5	B	ELECTRICAL CONNECTION DETAIL	ANGLE BUS EXPANSION JOINT	
	NL	200902-4-6	A	ELECTRICAL CONNECTION DETAIL	ALUMINUM ANGLE TO SWITCH 90 DEGREE CONNECTION - 900 AMPS MAX	
	NL	200902-4-7	A	ELECTRICAL CONNECTION DETAIL	ALUMINUM ANGLE BUS TO SWITCH 90 DEGREE CONN. - 1800 AMPS MAX.	
	NL	200902-4-8	A	ELECTRICAL CONNECTION DETAIL	ALUMINUM ANGLE TO SWITCH - 1800 AMPS MAX	
	NL	200902-4-9	A	ELECTRICAL CONNECTION DETAIL	ALUMINUM ANGLE TO ALUMINUM ANGLE 90 DEGREE CONN. - 1800AMP MAX	
	NL	200902-5-1	A	WILDLIFE PROTECTION DETAIL	TRANSFORMER BUSHINGS - 35KV AND BELOW	
	NL	200902-5-2	A	WILDLIFE PROTECTION DETAIL	SURGE ARRESTERS - 35KV AND BELOW	
	NL	200902-5-3	A	WILDLIFE PROTECTION DETAIL	CIRCUIT BREAKERS OR RECLOSERS - 35KV AND BELOW	
	NL	200902-5-4	A	WILDLIFE PROTECTION DETAIL	STATION AUX AND POT TRANSFORMERS - 35KV AND BELOW	
	NL	200902-5-5	A	WILDLIFE PROTECTION DETAIL	REGULATORS - 35KV AND BELOW	
	NL	200902-5-3	A	WILDLIFE PROTECTION DETAIL	CIRCUIT BREAKERS OR RECLOSERS - 35KV AND BELOW	
	NL	200902-5-4	A	WILDLIFE PROTECTION DETAIL	STATION AUX AND POT TRANSFORMERS - 35KV AND BELOW	
	NL	200902-5-5	A	WILDLIFE PROTECTION DETAIL	REGULATORS - 35KV AND BELOW	

Preface

P.1. Scope and Purpose

The purpose of the criteria is to provide a general instruction for the civil/structural design for Xcel Energy substations. The criteria apply to the structures that support electrical equipment and rigid bus and other conductors, foundations and all civil work within Xcel Energy substations.

P.2. Responsibilities

The Substation Engineering and Design department of Xcel Energy and all consulting firms involved in the substation civil/structural design shall follow these criteria for the design and analysis of new and expanded electrical substation facilities. Exceptions to the following criterion need to be requested in writing to the sponsoring engineer and approved by the director of engineering.

Users of the criteria shall notify the Xcel Energy Standards Department of errors and other opportunities for improvements.

P.3. Work Flow

P.3.1 Approval

The Xcel Energy Standards Council Sponsors has approved this document.

Date	Name
7/12/2017	Philpott, Lester W
7/14/2017	Harvey, Brian D
5/25/2017	Gragg, Jim
5/16/2017	Hui, Ming-Wa
5/12/2017	Jensen, Mike C
5/15/2017	Foster, Perry D
5/12/2017	Gutzmann, Mark G
5/26/2017	Munsell, Kenny
7/26/2017	Newton, Jeremy H

P.3.2 Creation

The following committee updated this document.

Name	Title
Troy Livgard	Engineer, NSP
Mark Lavanish	Engineer, PSCo
Don Simpson	Engineer, PSCo
Kyle Vriesman	Engineer, Standards

P.3.3 Version History

The personnel listed above have approved the following changes.

Date	Version Number	Change
02/21/2003	TSD-4	Initial Version
03/31/2014	1.0	Release
1/22/2015	3.0	Added Sections 4.3-4.6 to address grading
2/18/2015	4.0	Addressed comments from Open Review and finalized
8/18/2015	4.1	Section 2.2.5 redirected to new standard XEL-STD-Structural Design of Tubular Bus
8/18/2015	5.0	Released
1/18/2017	6.2	Updated Grading Design Criteria - Open Review
2/8/2017	6.3	Updated to current template
4/17/17	6.4	Updated Grading Design Criteria
5/12/2017	6.5	Out for Council Approval
7/26/2017	7.0	Published

Table of Contents

1 Overview

1.1. Philosophy

The purpose of the criteria is to provide a general instruction for the civil/structural design for Xcel Energy substations. The criteria apply to the structures that support electrical equipment and rigid bus and other conductors, foundations and all civil work within Xcel Energy substations.

This document addresses four main sections. Section 2 addresses structural performance criteria, including load cases, load factors and combinations, deflection criteria, structure materials, structure connections, and rigid bus design considerations. Section 3 presents requirements for foundations, including design load, factor of safety, bearing capacity, frost heave protection, settlement, shallow foundation, drilled pier foundations. Section 4 is civil performance criteria, including substation treatment, traffic, storm water drainage, oil spill containment, and fencing. Section 5 addresses the geotechnical performance criteria, including soil identification, sampling and testing, soil parameters and design values, water conditions, back fill material qualification, sub-grade treatment, and foundation recommendations. The fifth section presents the requirements for survey, boundary survey, layout standard and topographic survey. The last section presents the requirement for Electrical Equipment Enclosure (EEE)/Switchgear Enclosure performance criteria.

Any engineer wishing to deviate from this standard must fill out an exception request form and submit it for approval. The exception request form can be found in ProjectWise here XEL-FRM-Standards Exception Request

1.2. References

The following codes, standards and guides shall govern the civil and structural activities associated with substation design and are considered a part of this criteria document. All codes and standards shall be applied as amended to date unless otherwise indicated.

- AASHTO GDHS A Policy on Geometric Design of Highways and Streets
- AASHTO Guide for Design of Pavement Structures, 1993, Chapter 4, Aggregate-Surfaced Road provisions
- ACI 211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass concrete
- ACI 301 Specifications for Structural Concrete for Buildings
- ACI 305 Guide to Hot Weather Concreting
- ACI 306 Guide to Cold Weather Concreting
- ACI 318 Building Code Requirements for Structural Concrete and Commentary

- ACI 336.3R Design and Construction of Drilled Piers
- AISC 325 Steel Construction Manual
- AISC 341 Detailing for Steel Construction
- AISC 360 Specifications for Structural Steel for Buildings
- ANSI C2 National Electric Safety Code
- ASCE Manual of Engineering Practice No. 17 -Timber piles and Construction Timbers
- ASCE 113 Substation Structure Design Guide
- ASCE/SEI 7-05 Minimum Design Loads for Buildings and Other Structures
- ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
- ASTM A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
- ASTM A36 Standard Specification for Carbon Structural Steel
- ASTM A500 Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- ASTM A572 Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- ASTM A588 Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
- ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- ASTM A775 Standard Specification for Epoxy-Coated Steel Reinforcing Bars
- ASTM A871 Standard Specification for High-Strength Low-Alloy Structural Steel Plate with Atmospheric Corrosion Resistance
- ASTM A992 Standard Specification for Structural Steel Shapes
- ASTM D1586 Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

- ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
- ASTM D2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
- ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- ASTM D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
- ASTM D4546 Standard Test Methods for One-Dimensional Swell or Collapse of Cohesive Soils
- ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3))
- ASTM F1554 Standard Specification for Anchor Bolts
- ASTM F1852 Standard Specification for “Twist Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
- ASTM F567 Standard Practice for Installation of Chain-Link Fence
- AWS D1.1 Structural Welding Code-Steel
- AWS D1.2 Structure Welding Code-Aluminum
- IEEE 605 IEEE Guide for Bus Design in Air Insulated Substations
- IEEE 693 IEEE Recommended Practices for Seismic Design of Substations
- IEEE 979 IEEE Guide for Substation Fire Protection
- IEEE 980 IEEE Guide for Containment and Control of Oil Spills In Substations
- WLG 2445 Wind Load Guide for the Selection of Line Post Spacing

2 Structural Design Criteria

2.1. Design Requirements

2.1.1. Overview

Structure applications include termination structures, switch stands, bus and equipment supports, rigid frame box structures and shield poles. Engineers shall design substation structures and their components with the strength and rigidity to adequately resist maximum stresses resulting from combination of loads. Specific performance criteria for structure types are described below.

Substation structure design shall be per ASCE 113, with specific requirements below.

2.1.2. Design Loads

In addition to dead and equipment loads, design loads must consider normal and extreme climatic conditions to assure the operational performance of the substation while in service. Design loads for substation structures shall include the following:

- NESC Heavy
  NESC Heavy loading providing for a 4 psf horizontal wind pressure with 0.5" radial thickness of ice at 0°F on wire-loaded structures, such as dead end structures and wire-loaded box structures. NESC HEAVY load does not apply to other substation structures. The wind load shall be determined using Equation 1. The loading conditions which must be considered in the design of substation structures and supports must require wind load applications longitudinal, perpendicular and at 45-degrees to the line or bus

Extreme Wind

Extreme wind loading of 3-second gust wind speed of 90 mph at 60°F shall be applied on structures, equipment, and conductors. The 90 mph basic wind speed is applicable to all Xcel Energy service areas (CO, MI, MN, NM, ND, SD, TX, WI, and OK) except where the local conditions are higher. A check with the local authority is required for special wind areas, which exist in the Front Range and mountains of Colorado and Southwest Minnesota. The wind load shall be determined using Equation 2.

The gust response factor, G_{SRF}, for equipment support structures is based on ASCE 113 for rigid structure. Rigid structures not supporting wire for wind response are defined as structures with a fundamental frequency of 1HZ or greater. For these structures, the gust response factor, G_{SRF} can be assumed as a constant value of 0.85.

The loading conditions which must be considered in the design of substation structures and

$$W_{NESC} = 4 \cdot C_f \cdot A$$

Where:
W_{NESC}: NESC Heavy wind load, lbs.
A: projected wind surface area normal to the direction of wind, ft^2.
C_f: Force Coefficient listed in Table 1.

Equation 1: Wind load for NESC Heavy load case.

Member Shape	Force Coefficient, C_f
Circular (including rigid and flexible bus)	1.0
Hexadecagonal	1.0
Dodecagonal	1.0
Octagonal	1.4
Hexagonal	1.4
W, C, and L Shapes	1.6
Rectangle and Square Shapes	2.0

Table 1: Force coefficient based on member shape

supports must require wind load applications longitudinal, perpendicular and at 45-degrees to the line or bus

The following are the URL links to wind maps in the front range and mountains of Colorado:

PSC-STD-WIND SPEED-FRONT RANGE-STATE

PSC-STD-WIND SPEED FRONT RANGE-METRO

- Combined Ice and Wind Load

  Combined ice and wind load shall be applied to structures, equipment, and conductors. Refer to ASCE 7-05 maps for ice thickness and wind speed. The loading conditions which must be considered in the design of substation structures and supports must require wind load applications longitudinal, perpendicular and at 45-degrees to the line or bus

- Line Loads

  Line loads, including conductor and shield wire, shall be based on standard or typical conductor sizes determined by the substation electrical criteria. Tensions and sags at various temperatures and conditions will be determined and selected jointly by the electrical and structural areas to assure cost effective choices of structures. Engineers shall consider tensions for wind and ice load combinations and broken conductor criteria in the design loads. For strain-bus loading, −30°F is recommended for extreme cold temperature.

$$W = Q \cdot k_z \cdot V^2 \cdot I_{FW} \cdot G_{RF} \cdot C_f \cdot A$$

Where
W: wind force in the direction of wind (lb)
Q: air density factor, default value=0.00256
k_z: terrain exposure coefficient, Exposure C, refer to ASCE 113
V: basic wind speed, 3-second gust wind speed (mile/hour), taking 90 mile/hour.
I_{FW}: importance factor for basic wind speed, taking 1.00
G_{RF}: gust response factor (for structure G_{SRF} and wire G_{WRF}), based on Exposure C.
C_f: Force Coefficient, from **Table 1**.

Equation 2: Wind load for Extreme Wind load case.

- Equipment Loads
  The dynamic load supplied by the manufacturer shall be applied for the supported equipment structure.
- Dead Loads
  Gravity loads from bus, insulators, equipment, and structures shall be applied.
- Short Circuit Loads
  The engineer shall consider short circuit forces from fault currents. The electrical substation engineer must provide the ultimate electrical current values for the determination of forces, which occur at the top of the insulator and must be accounted for in the design of the insulator support system. Short circuit forces shall be calculated using Equation 3.
- Seismic Loads
  Seismic loading is an environmental loading condition that – based on the specific site and substation structure characteristics – may govern design in certain regions of Colorado. Seismic design should be considered in areas where the 0.2 second spectral response acceleration is 30% g or higher, the loads shall be developed according to ASCE 113.
- Platform Loads

$$F_{SC} = \frac{5.4 \cdot \Gamma \cdot \left(D_f \cdot \sqrt{2} \cdot I_{SC}\right)^2}{10^7 \cdot D}$$

Where:
F_{sc}: Short circuit load on bus, lb/ft
I_{sc}: Fault current, amps
D: Bus phase spacing, inches
D_f: Decrement factor, 1.6
Γ: constant based on fault type, 1.0

Equation 3: Short Circuit Equation: The horizontal force on the bus due to short circuit force (IEEE Std 605-1998; the existence of IEEE 605-2008 is acknowledged but deprecated).

Load Cases		USD Load Factors and Combinations
Case 1	NESC Heavy	$1.5 \cdot D + 1.5 \cdot I_{NESC} + 1.65 \cdot T_{NESC} + 2.5 \cdot W_{NESC}$
Case 2	Extreme Wind (no ice)	$1.1 \cdot D + 1.2 \cdot W + 0.75 \cdot SC + 1.1 \cdot T_W$
Case 3	Combined Ice + Wind load	$1.1 \cdot D + 1.2 \cdot I_W + 1.2 \cdot W_I + 0.75 \cdot SC + 1.1 \cdot T_W$
Case 4	Short circuit	$1.1 \cdot D + 1.0 \cdot SC + 1.1 \cdot T_W$
Case 5	Earthquake	$1.1 \cdot D + 1.25 \cdot E$

Where
D: Dead load Use 1.0 for D if this causes higher stresses.
I_{NESC}: NESC 0.5" radial ice
T_{NESC}: NESC Line load
W_{NESC}: NESC wind load
I_W: Ice load in combination with wind
W: Wind load
W_I: Wind load in combination with ice.
SC: Short-circuit load
T_W: Wire tension for the appropriate wind and temperature condition
E: Earthquake load

Table 2: Load factors for USD. For allowable stress design, the load factor should equal 1.0.

Stairways and platforms provided as part of any substation structure shall be designed for a live load of 100 pounds per square foot.

2.1.3. Load Factors and Combinations

Allowable stress design (ASD) is a method of proportioning structural members such that elastically computed stresses produced in the members by nominal loads do not exceed specified allowable stress. ASD is also called working stress design.

Ultimate strength design (USD) is a method of proportioning structural members such that the computed forces produced in the members by the factored loads do not exceed the member design strength. USD is also called load and resistance factor design or LRFD.

USD and ASD are both acceptable for design of substation structures.

2.2. Design Requirements

2.2.1. Deflection

Structures are classified for by the sensitivity of supported equipment. Table 3 summarizes the structure classes and associated deflection limits.

- Class A Structures
  Support equipment with mechanical mechanisms where structure deflection could impair or prevent proper operation. Examples are group-operated switches, vertical reach switches, ground switches, circuit-breaker supports, and circuit-interrupting devices.

Member Type	Deflection Direction	Class A	Class B	Class C
Horizontal	Vertical	1/300	1/200	1/200
Horizontal	Horizontal	1/200	1/100	1/100
Vertical	Horizontal	1/200	1/150	1/50

Table 3: Maximum Structure Deflection as a Ratio of Span Length

Switches mounted on dead end structures with no rigid bus connection are classified as Class B.

- Class B Structures
  Support equipment without mechanical mechanisms, but where excessive deflection could result in compromised phase-to-phase or phase-to-ground clearances or unpredicted stresses in equipment, fittings, or bus conductors. Examples are support structures for rigid bus conductors, surge arresters, metering devices (such as CTs, PTs, and CCVTs), station power transformers, hook-stick switches or fuses, and wave traps.
- Class C Structures
  Support equipment relatively insensitive to deflection or are stand-alone structures that do not support any equipment. Examples are structures for flexible (stranded conductor) buses, masts for lightning shielding, and dead end structures for incoming transmissions lines. Deflection limitations for these structures are intended to limit P-delta stress, wind-induced vibrations, and visual impact.

Table 4 lists load cases for deflection limitations. Deflection shall be determined for NESC heavy and extreme wind, combined ice & wind load with load factor 1.0. Loads resulting from bus short circuits and earthquakes should not be considered in deflection analysis.

2.2.2. Tall Lightly Loaded Structures

Wind induced motion and vibration on lightly loaded tall structures must be controlled to assure performance and prevent fatigue of members, bus or accessories.

Dampening devices must be provided on shield poles or other lightly loaded structures, which are typically subject to vibration. Suspended dampening chains shall be provided inside the tubular columns as a minimum.

Deflection Cases		Load Factor and Combinations
Case A	NESC Heavy	$D + I_{NESC} + T_{NESC} + W_{NESC}$
Case B	Extreme Wind (no ice)	$D + W + T_W$
Case C	Combined Ice + Wind load	$D + I_W + W_I + T_W$

Table 4: Load cases for Deflection. Parameter definitions same as Table 2.

	Shape/Section	ASTM Standard	F_y (ksi)
Rolled Steel	W	A992	50
	M, S, C, MC	A36	36
	L	A36	36
	Plate	A36	36
		A572 Grade 50	50
	HSS	A500 Grade B	46
	Pipe	A53 Grade B	35
Tubular Steel	Tapered Tubular	A36	36
		A500, Grade B	46
		A572, Grade 50	50
		A588	50

Table 5: Preferred material grades for rolled and tubular products.

2.2.3. Steel Frame

The box structure designs shall be designed with moment resisting connections to allow for the elimination of all bracing in order to provide flexibility for future additions.

2.2.4. Bolted Connections

Bolted connections shall be specified for field connections using A325 high strength bolts. Bolt patterns and bearing type will follow AISC design and details. Use of welded connections in the field is discouraged.

2.2.5. Rigid Bus

See XEL-STD-Structural Design of Tubular Bus.pdf

2.3. Materials

2.3.1. Steel

Structural steel shapes and plates used for steel frames, materials for tubular steel plates for shafts, base plates, and accessory plates shall conform to Table 5.

All high strength steel structures supporting high wire tension shall meet or exceed minimum Charpy Impact values of 15 ft lbs at -20°F. Documentation of representative Charpy Impact tests shall be received for all high strength steel plate, not for rolled steel.

The flatness of equipment mounting surfaces and flange plates of companion structural members must be maintained to assure correct fit-up and closure of joints and structural

Fastener Type	ASTM Standard
High-Strength Bolts	A325,
Nuts	A563 (Grade DH3) A194 2H
Washers	F436
Threaded Rods	A36
Anchor Bolts	A 307 Grade C F1554 Grade 36,55 and 105

Table 6: Preferred material for fasteners.

integrity throughout the service life of the structures and supports. Tolerance criteria for substation structures shall meet the minimum requirements of ASTM A6.

The preferred protective coating for substation structures is hot-dipped galvanizing per ASTM A123 and ASTM A153. Galvanizing has proven to be highly reliable and has eliminated the need for coating system maintenance in energized substations.

Review of new coating technologies that are also environmentally acceptable should be periodically performed to assure the use of the most reliable and economic choice of protective coating systems.

When paint or other finish is required for permitting, it shall be applied over galvanizing in accordance with an approved coating system intended for use over galvanized surfaces.

2.3.2. Fasteners

Fasteners shall conform to Table 6.

Documentation of representative Charpy Impact tests shall be received for all anchor bolts. All steel shall meet or exceed minimum Charpy Impact values of 15 ft lbs at -20°F.

2.3.3. Wood

Steel is the preferred material for the design of substation structures due to its dependability and performance. Wood structures, although cheaper to install, cannot guarantee the structural performance stated in this document. Wood structures can be used for emergency or temporary use of no more than one year or for retrofit of an existing wood structure substation. NESC criteria shall govern in the design of wood structures.

Wood structures and poles should be designed and constructed in accordance with recommendations in ASCE 113 using either ultimate strength or allowable stress design.

3 Foundations Design Criteria

3.1. Foundation Applications and Equipment Performance

3.1.1. Overview

Performance of foundations for substations, are driven by requirements of the electrical equipment being supported. The types of equipment having specific foundation needs are stated below.

3.1.2. Foundation Reveal

Reveal is defined as the amount of concrete that rises above the surfacing rock. Top of Concrete (TOC) must be coordinated with pad grading and bus height design. Steps in TOC should not be less than 6” and should be located at flexible bus connections whenever possible. If the step is more than 12” coordination with the electrical engineer is required to ensure minimum electrical clearances are met.

Reveal for bus support foundations (not including switches) should be a maximum of 2’-0” and a minimum of 4”.

Reveal for equipment foundations (including switches) should be a maximum of 1’-6” and a minimum of 4”.

3.1.3. Transformers

Transformer performance requires the oil in the transformer to be maintained in a level position. The slab foundation shall meet settlement criteria for long-term differential and total vertical settlement. Design for the eccentricity of the center of gravity, rolling and jacking conditions.

3.1.4. Breakers

Breakers may require dynamic loadings and wind to be considered depending on the type of breaker. Oil type breakers may require mass ratios of two or more to resist dynamic uplift forces. Equipment dynamic forces provided by manufacturer and wind/seismic condition specified here must be considered in foundation design.

3.1.5. Capacitors

Capacitor (large shunt capacitor) performance requires banks to be supported on insulators located at a number of points. Each point of support may not move differentially with respect to other points of support. The foundation must be configured to incorporate all points of support on a rigid foundation element. Capacitor banks typically have high profiles and can accumulate significant wind loads. The design shall consider wind loadings as defined in this document. Series capacitors should be addressed separately.

3.1.6. Reactors

Reactor performance requires insulating the foundation from the effects of magnetic fields. The support steel or reinforcing steel must be isolated from the reactor. This requires insulator supports of appropriate height to isolate the magnetic field with an arrangement of insulators supported by a rigid foundation.

The foundation must provide a rigid configuration to prevent any differential displacement between supports. Movement between points of reactor supports will cause breakage of the insulators supporting the reactor. Where the economics of using larger insulators are not feasible, reactors may require a non-magnetic frame, such as aluminum between the reactor and foundation to provide magnetic field isolation.

Design of the surrounding steel structure or other magnetic materials must provide adequate clearance from the reactor's magnetic field.

3.1.7. Switches

Switches in single or group operating configurations require a rigid mounting surface for the entire switch assembly to assure operating performance and minimize the long-term operating and maintenance problems of the device. This requires support steel and foundations to be designed to perform to strict limits of differential movement where rigid bus ties into switches. The performance of bus and switch accessories such as expansion joints is critical to the performance of the foundation with limits on horizontal and vertical displacements.

3.2. Load Requirements

3.2.1. Design Loads

- Live Loads

  Live loads for substation foundations must include the loading discussed in the structural criteria portion of this document and the additional loads below which are specific to equipment:

- Dead Loads

  Dead Loads shall be applied and must include weight of equipment, insulators, conductor accessories, oil (when applicable), and the weight of foundation and supporting steel.

- Construction Loads

  Construction loads such as jacking and rolling must be considered for the installation and removal of transformers on slab foundations, cable pulling and thermal loads for underground termination structures

3.2.2. Factor of Safety

Foundation bearing capacity and stability shall be checked with all load factors equal to 1.0 (working load). The minimum factors of safety (FS), the ratio of the resisting to applied forces, shall be as Table 7 or as recommended by geotechnical report.

	Factor of Safety
Shallow Foundations	
Bearing Capacity	3.0
Stability (Overturning and Sliding)	1.5
Drilled Pier Foundations	2.0
Slope Stability	1.5
Retaining Wall	
Bearing Capacity	2.0
Stability (Overturning and Sliding):	1.5

Table 7: Factor safety for foundation design.

3.2.3. Bearing Capacity

Minimum Bearing Capacity at the bottom elevation of any type of substation foundation shall be as specified by the geotechnical report. Sub-grades of a lower value must be improved to a value equal to or exceeding the report or a deep foundation type must be considered.

3.3. Design Requirements

3.3.1. Frost Depth/Heave/ Swell

Substation structure vertical loads vary from very light to moderate in magnitude and foundations may be susceptible to significant differential vertical movements where significant frost is present. Specific study of frost susceptible soils shall be provided when present in the frost zone. The minimum frost depth for design consideration shall be governed by the local code.

The presence of groundwater in the frost zone creates potential for excessive frost heave caused by ice lensing. Sub-drains may be provided where it is not economical to cut to the full frost depth and fill with imported and qualified fill.

Where swell is significant, sensitive structures such as masonry buildings, floor slabs etc. shall be designed in accordance with recommendations in the Geotechnical Report.

3.3.2. Settlement

The total settlement of any single foundation shall be limited to 1.0 inch. This limit is established to prevent tilting of slab foundations supporting transformers, switchgear, control houses or other equipment, which may affect operating performance. This limit applies to supports to prevent forces from being imposed on rigid bus and connections within the overall bus arrangement of substations.

Differential settlement across the diagonal of any shallow slab or mat foundation supporting substation equipment shall be limited to ½”. The structural engineer shall collaborate with the geotechnical engineer to insure the subsoil preparation, allowable bearing capacity and the required eccentricity of the equipment loads will not cause the foundation to exceed this criterion.

3.3.3. Durability

Durability of the slab must be assured to reduce the risk of slab deterioration, which could result in taking the transformer or the electrical equipment out of service during its intended service life. Surface flatness, distributed bearing pressure of equipment, and elimination of water on finished surfaces enhance durability of the concrete and enhance service life.

Strength and air content of concrete must be provided to assure adequate service life. Repair of concrete is difficult with equipment in service. Outages and removal of the equipment are usually not acceptable from an operating or cost perspective.

Structural design of concrete foundations must be in accordance with ACI code.

3.4. Foundation Types

3.4.1. Shallow Slab Foundations

Minimum edge distance of equipment base to edge of slab shall be 12 inches for heavy equipment and 9 inches for light equipment. These minimums are provided to minimize soil pressure and allow for future replacement of equipment, which may vary in size and loading.

Sub-grade preparation for slabs should be performed when needed to ensure uniformity and stability for the foundation. The site grading design for new substations should consider sub-grade preparation for slabs and other foundations to avoid duplication.

Sites with cohesive materials in the sub-grade and requiring sub-grade preparation will require cohesionless backfill, or granular material.

3.4.2. Drilled Pier Foundations

Drilled piers are used over a wide range of substation foundation applications and are considered the most flexible and an economical choice for support of light equipment stands or dead end structures. This is due to the minimal forming and absence of backfilling in drilled pier construction. Piers are the most efficient foundation for supporting lateral loads.

The design of drilled piers shall disregard the top layer of soil to account for freeze thaw, erosion, lack of compaction or disturbance. The depth of the ignored layer shall be as recommended in the geotechnical report, but shall in no case be less than 1’-0”.

Drilled pier foundation shall be designed to conform to the requirements of ACI 336.3R-Design and Construction of Drilled Piers.

	Vertical and Horizontal Deflection	Rotation
Switch support structure foundation	0.25 inch	0.5°
All other support structure foundations	0.50 inch	0.5°

Table 8: Deflection limits for drilled pier foundations.

In addition to satisfying strength and stability requirements, the deflection and rotation of the drilled pier foundations shall be limited to those listed in Table 8 under working loads (unfactored loads).

3.4.3. Formed Foundations / Walls

Spread footings, pile caps, grade beams, mat foundations, walls and other cast in place concrete construction may be used as foundation solutions in substations. Standards for minimum dimensions, concrete and reinforcement, finish and durability will be per ACI.

Shallow spread footing foundations are utilized where site specific needs do not allow for drilled piers as standard solutions. Conditions, which result in the consideration of cast-in-place footings, include outage restraints, shallow bedrock, difficult drilling conditions for deep piers, equipment access, existing foundation types at a site or special soil conditions.

ACI 318 shall govern the design and ACI 301 the construction of reinforced concrete foundations and walls.

Retaining or firewalls constructed of reinforced concrete may be required by space or permit requirements. The International Building Code shall govern the design of walls except where electrical equipment is involved, in which case the requirements for design loads and conditions stated in the structures portion of this document will apply. Cast in place concrete retaining walls should be compared with sheet pile retaining walls, masonry, precast walls, nailed earth, mechanically stabilized earth (MSE), concrete cribbing, etc, for determining the most economical solution.

3.4.4. Piling Foundations

Piling foundations may be necessary where poor soils require a deep foundation. This is necessary when shallow foundations are not suitable, or practical, or when the constructability of drilled piers are not favorable.

Piles are primarily used to control settlement on marginal soil sites. Pile sizes are selected based on required cross sectional area, depth of marginal soil and the embedment length into the good soil required to support the loads generated by the above ground structure and equipment. Piles must be designed for bearing, lateral and uplift loads as, determined by structure reactions and pile patterns.

Piling foundations must not exceed the minimum uplift and bearing capacities recommended by the geotechnical engineer. Negative skin friction (downdrag forces) may be significant and must be considered in pile designs.

Typical steel pile sections include pipe pile, H-pile and concrete filled pipe pile. Pipe piles are the standard for most applications in substations. H-piles with heavy compression and uplift loads are used in deep end-bearing applications where structural considerations control selection of the pile. Driving in clay soils where friction forces for displacement piles are excessive may require H-pile as a preferred pile type.

3.4.5. Timber Mat Foundations

Treated Timber foundations for transformers and other equipment may be used for temporary storage or operation. Performance requirements for the equipment or the foundation cannot be met or guaranteed for an extended period of time. Drawings shall note this performance limitation when treated timber foundations are specified.

4 Civil Design Criteria

For definitions of grading terminology, please refer to XEL-PRO-SUB-DESIGN-Contour & Grading Layout - Drawing Function & Instructions.doc

4.1. Geometric Design for Traffic

The substation access road/driveway and circulation areas inside the substation shall, at a minimum, meet the driveway turning templates shown in Figure 1 which are based on the AASHTO Intermediate Semi-Trailer WB-67 design vehicle. Vehicles larger than WB-67 are usually required for equipment such as transformers greater than 100MVA, mobile substations, pre-manfactured medium and large EEE's, or metal clad switchgear. In these cases the designer should obtain specficications from the equipment hauler fore the expected vehicle(s). Specialty software such as Auto Turn should be used to ensure adequate access to and from the large equipment position. Coordinate with the physical engineer to determine the need for oversize vehicles.

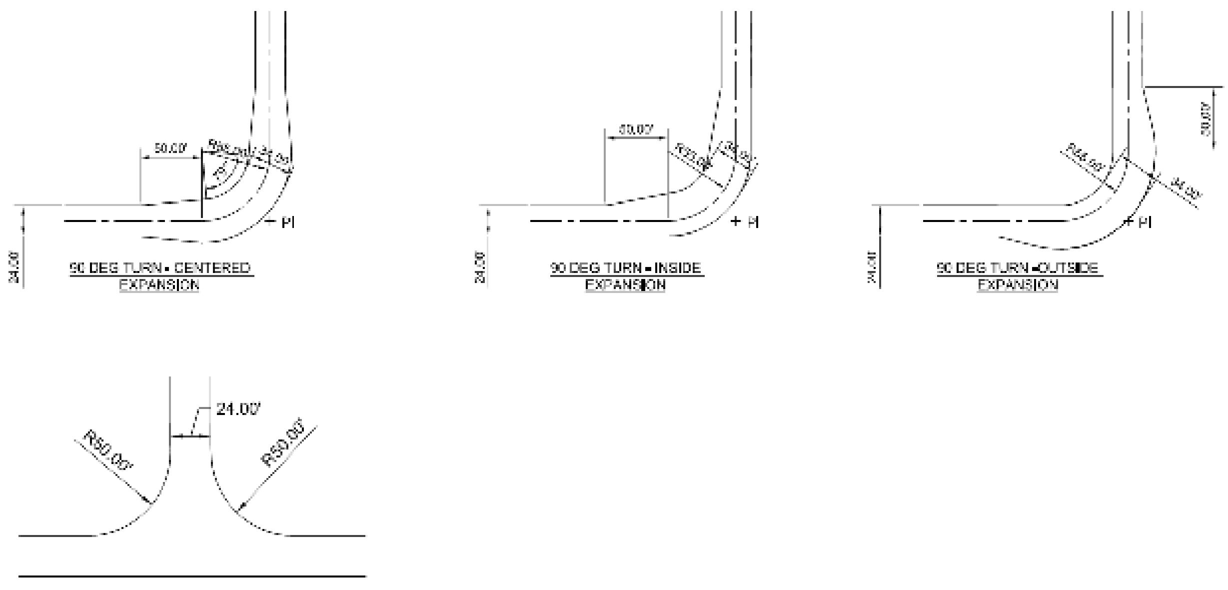


Figure 1

4.1.1. Access Road Geometric Design Criteria

Substation access roads shall conform to the following geometric design criteria.

Cross Section:

- 24' aggregate base width
- 3% cross slope for road base (standard design)
- 2% cross slope for asphalt/concrete (only if required by jurisdiction)
- Aggregate Road base thickness to match substation pad design

- Ditches – 1.5' minimum depth measured from edge of roadway
- Ditch side slope - 3:1 maximum – 4:1 (or flatter) preferred

Horizontal Alignment:

- Minimum centerline radius - 55'
- Roadway widening for small curve radius:
  55' Radius = 4'
  100' radius = 0'
  Linear interpolate widening for curves between 55' and 100'

Vertical Alignment:

- Maximum grade = 6%. Up to 8% (with approval of an exception request) for straight alignments only
- Minimum grade = 0.5%
- Grade breaks are allowed up to a maximum algebraic difference of 4% without a vertical curve design
- For vertical curves: minimum K factor at crest = 20, minimum K factor at sag = 30

4.2. Pad Grading

The substation pad is the area inside and outside the fence that has, at a minimum, been improved with a layer of base material as designed per Section 4.3 of this document. Substation pad grading design is complex and based on numerous factors, including, but not limited to: geotechnical conditions, existing topography, earthwork balance, erosion prevention, site drainage, vehicle access and adjacent properties.

- Pad size - The pad should be constructed to a full depth 8' outside the fence when possible. This is the preferred size and allows for installation of the fence and ground grid as well as ease of access, once construction is complete, for repairs and vegetation management. For ground grid design and personnel safety in the event of an electrical fault, the pad shall not be less than 5' outside the fence unless approved by the standard exception request. There are existing sites with space constraints that necessitate less than 5' outside the fence. These situations need to be reviewed and coordinated with the engineer responsible for the substation grounding design and all options explored prior to making this deviation.

- Pad Slope - Coordination with the foundation and physical engineer is critical when designing the slope of the pad. Pads that are too flat may not drain properly and result in soft areas or standing water, pads that are too steep may cause erosion problems or require stepping of top of foundations. If this can be minimized or eliminated, it would be preferred. Additional guidance on foundation reveal can be found in section 3.1.2 of this document.

  - Preferred pad slope should be between 1.0% and 1.5%. Pad slope shall be no greater than 3.0% or less than 0.5% unless approved via the standard exception process.

- Special attention is required on pad side slopes and other drainage features to prevent erosion. When large pads are needed the grading engineer shall utilize all tools available to collect and direct stormwater in a way that long term maintenance is minimized due to water runoff. Some possible methods are reinforced swales/slopes, seed and mulch, fiber blankets, drain tile (underdrain), curb and gutter systems, drainage pipes, stepping of the pad and bus, etc. If possible, a slope of 6:1 or flatter is recommended to minimize erosion problems, slopes of up to 3:1 can be used if site conditions necessitate.

4.3. Pad Strength Design

Substation pads and associated parking and access roads shall be designed with an aggregate base course layer and, if required, a subbase or stabilized subgrade, to assure the surface will support traffic loads up to 18,000 ESAL without producing rutting under wet conditions.

Factors that need to be considered in designing the pad section to provide the desired surface performance include:

- Traffic Loading – Equivalent Single Axle Load (ESAL)
- Subgrade Strength – Soil Resilient Modulus (M_R) in PSI
- Climate – Region I – VI
- Drainage – Surface and subsurface
- Frost Susceptible Soils
- Swelling Soils

Required thickness of the aggregate base course shall be determined using the AASHTO Guide for Design of Pavement Structures, 1993, Chapter 4, Aggregate-Surfaced Road provisions. Either the Design Chart, Section 4.1.2, or the Design Catalog, Section 4.2.3, method may be used. Table 1 and Exhibit 11.4.2 B&C can be used for the Design Catalog method.

In using either method **all** of the following conditions shall apply:

1. Traffic Loading: Use the Medium Traffic Level. This is based on 30,000 to 60,000 ESAL. The reasons for requiring the Medium Traffic Levels are, when comparing to a typical low volume road design that the catalog is based on; a) design life of the substation pad should be much longer, b) very high axle loads are experienced while moving heavy equipment into substations, and c) substation pad surface drainage is much worse than a crowned roadway.
2. Subgrade Strength: Relative Quality of the Subgrade/Subbase Soil must be at least fair. For poor or very poor soils, imported subbase or improved subgrade by moisture and density treatment is required. See Exhibit 11.4.2.B&C for correlation of AASHTO/ASTM Soil Class to Relative Quality of Subgrade Soil for use in the Catalog method.
3. Climate: Use the appropriate U.S. Climatic Region. Xcel Energy operates in regions III, V and VI. See Exhibit 11.4.2-D
4. Drainage: Flatter slopes and long sheet flow distances will increase the moisture content of the base and subgrade decreasing the support strength. Consider increasing the aggregate base thickness for slopes < 1.0% and sheet flow lengths > 300 feet.
5. Frost Susceptible Soils: Aggregate base course and subbase materials meeting specification requirements may be placed in the frost zone. Common backfill determined to be frost susceptible may only be placed at depths below average frost penetration or on slopes outside the limits of the substation and access road.
6. Swelling Soils: If the average swell of the top 4.0 feet of the subgrade soils is greater than 4%, the Geotechnical Report shall provide a recommendation for subgrade moisture treatment and subgrade stabilization. Swell, % shall be determined at 200 psf surcharge on natural soil from liner samples. Ref.: Metropolitan Government Pavement Engineers Council (MGPEC)-Volume 1- Pavement Design Standards (4/15/11 draft)

TABLE 1 - AGGREGATE SURFACED SUBSTATION DESIGN CATALOG
RECOMMENDED MINUMUM AGGREGATE BASE THICKNESS IN INCHES

Relative Quality of Subgrade/Subbase Soil	Traffic Level	U.S. Climatic Region		
		III	V	VI
Very Good	Medium	11	7	11
Good	Medium	12	9	12
Fair	Medium	12	10	12
Poor	N/A	Not Allowed (See Condition #2 Above)		
Very Poor	N/A	Not Allowed (See Condition #2 Above)		

This table is based on Table 4.10 in AASHTO Guide for Design of Pavement Structures, 1993, Chapter 4, Aggregate-Surfaced Road provisions and may be used to determine the minimum required aggregate base course thickness. In no case shall the aggregate base course be less than 7 inches thick.

Manholes, trench covers, or other substructures shall be designed for a minimum of HS20 loads where subject to substation truck traffic.

Exhibit 11.4.2.B&C - CORRELATION OF AASHTO/ASTM SOIL CLASS TO RELATIVE

Exhibit 11.4.2.B
AASHTO and ASTM Soil Classification

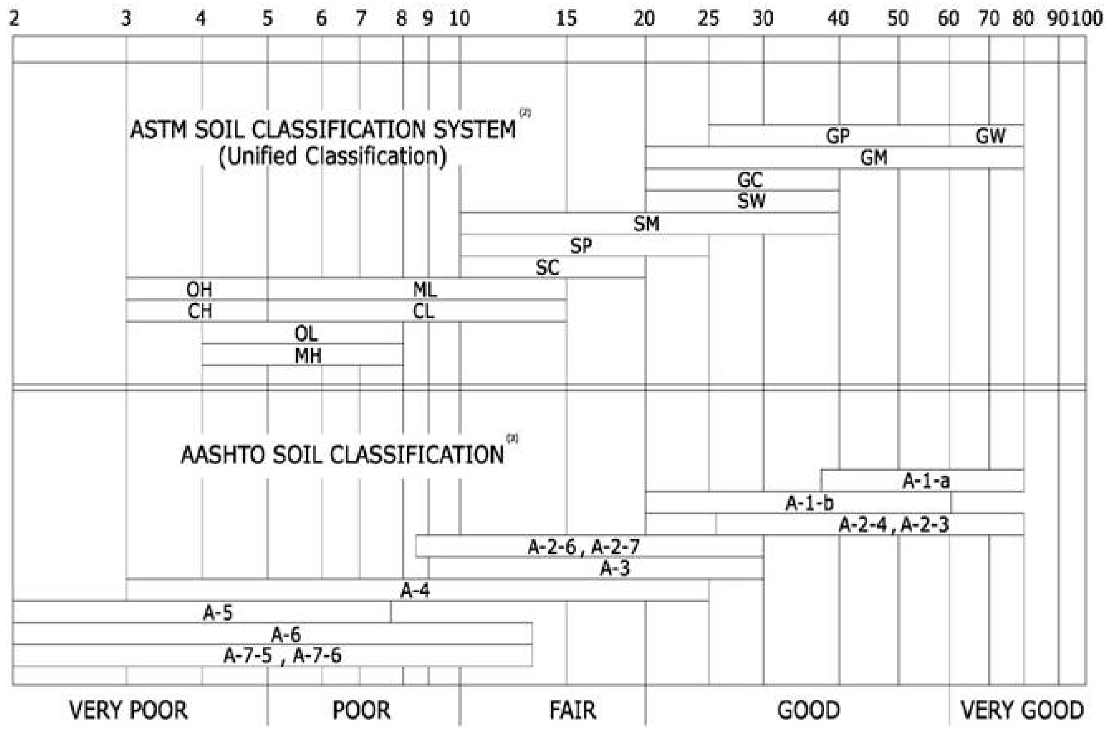


Exhibit 11.4.2.C
Roadbed Soil Strength

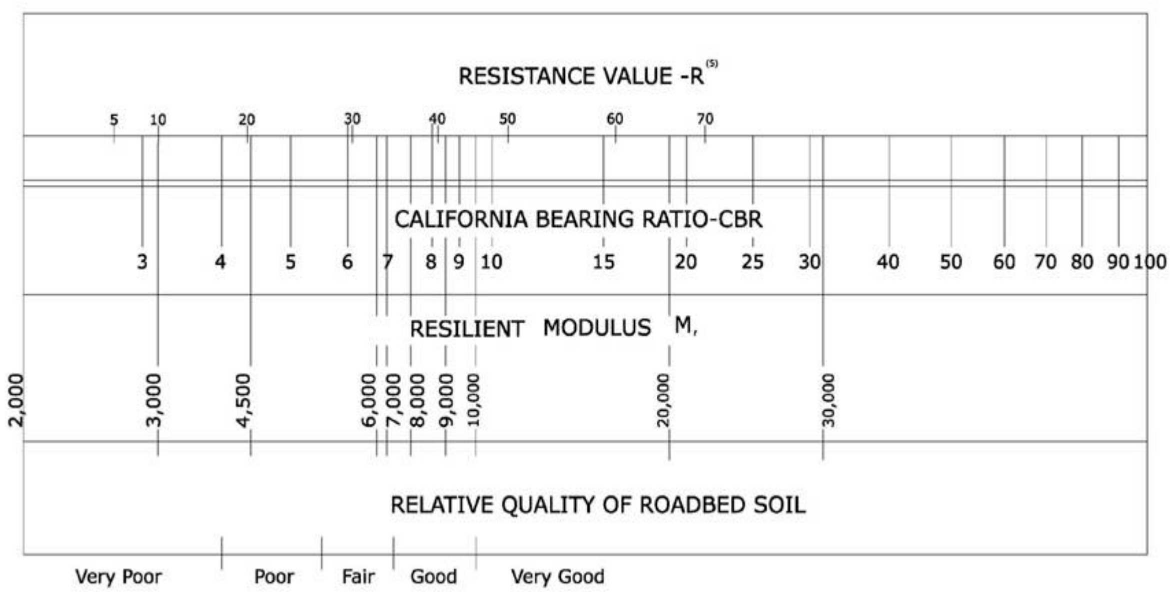
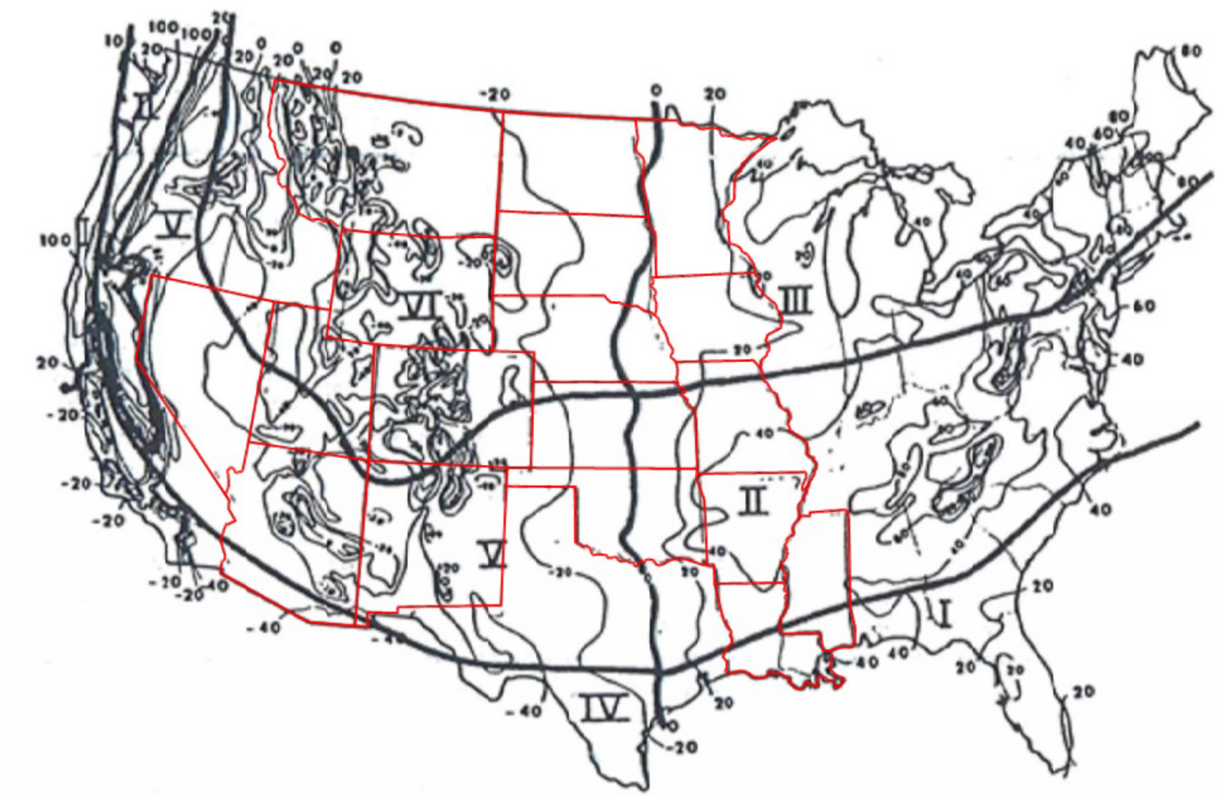


Exhibit 11.4.2-D – THE SIX CLIMATIC REGIONS IN THE UNITED STATES



REGION	CHARACTERISTICS
I	Wet, no freeze
II	Wet, freeze – thaw cycling
III	Wet, hard-freeze, spring thaw
IV	Dry, no freeze
V	Dry, freeze – thaw cycling
VI	Dry, hard freeze, spring thaw

4.4. Stormwater Drainage

1) Permanent Stormwater Drainage Design

a. Engineer will adhere to local regulations and published criteria for drainage design and site development. These criteria may require detention/water quality ponds, infiltration basins, level spreaders, etc.

b. The minimum recurrence event for the design for storm water conveyances shall be a 100-year storm. Unless superseded by local regulation or criteria, the minimum recurrence design event for pad drainage/conveyances shall be a 100-year storm.

c. Off-site runoff shall not be allowed to flow through or onto the substation pad. This practice will prevent pad flooding and subgrade damage, as well as avoid possible transfer of oil spill material to an offsite area, watershed or wetland. Storm water drainage onto adjacent property must be designed in accordance with local regulations.

d. Should a pond or other treatment system be used on the substation site, the entire pad and access drive shall be a minimum of 1.0' above the calculated 100 year, 24 hour duration High Water Level (HWL) or 0.5' above the designed overflow spillway, or emergency overflow elevation, whichever is higher. This will ensure the pad and drive do not flood during the design rain event or should the outlet system fail.

e. Rainfall data can be referenced in the links below:

i. NOAA Atlas 14 Point Precipitation Data available here: http://dipper.nws.noaa.gov/hdsc/pfds/

ii. *Technical Paper No. 40-Rainfall Frequency Atlas of the United States* Texas only. Available here: http://www.nws.noaa.gov/oh/hdsc/PF_documents/TechnicalPaper_No40.pdf

f. The finished slopes for substation grades shall provide for positive drainage of storm water to drainage ditches or inlets/pipes on or around the perimeter of the graded area. All concentrated flows shall be routed down the embankment in pipes, or armored rundowns. Erosion of pad edges requires careful consideration, such as:

i. Sheet flow length

ii. Embankment slope and height

iii. Erosive potential of in-situ soils

iv. Surface protection (grass, rock, geoweb, etc.)

g. Sheet flow for greater than 300’ is difficult to maintain. When designing larger pads, limit sheet flow to 300’ through the use of concentrated flow facilities.

h. Concentrated discharges through/under security fencing requires barriers to unauthorized entry.

i. Cable trenches, pull pits, and duct banks will intercept surface/subsurface drainage. Where possible, these facilities shall be located on drainage ridges or parallel to the direction of flow. Use of cable trenches is discouraged from a drainage standpoint however, if required, the civil engineer shall work with the electrical engineer to determine optimal placement.

j. Perched water tables, seasonal groundwater fluctuations, artesian weeps, and other complex subsurface drainage can cause frost heave and water infiltration issues in basements, pull pits, and trenches. Unfortunately, these conditions are difficult to predict and are often discovered during construction excavations. Subsurface dewatering/French drains should be used to minimize this condition. Additionally, where possible, pad placement should avoid the lowest areas of the substation properties.

2) Construction Storm Water Drainage Design

a. The Clean Water Act and resulting EPA regulation 40CFR Part 122 "National Pollutant Discharge Elimination System" (NPDES) governs storm water discharge during construction where the disturbed area is equal to or greater than one acre. These regulations require state permits for storm water runoff. Local regulations may be more restrictive.

b. Local and state construction storm water processes must be completed/approved prior to construction mobilization.

4.5. Floodplain Analysis

Sites located within, or adjacent to, mapped flood plains of rivers and tributaries shall be designed with top of grade for substation and its access a minimum of 1 foot above the FEMA defined 100-year Base Flood Elevation, or maximum flood of record (whichever is highest).

Flood information used for the design of substations shall be based on the more restrictive (highest) flood elevations as defined by FEMA or local jurisdictions. Coordination with local floodplain managers is often also required and may include floodplain development analysis/modeling and permitting. Please note: Elevation comparisons must account for any applicable datum differences. (There are two vertical datum typically used in the U.S. NGVD was established in 1929. NAVD was established in 1988. There is approximately a 3.0 foot difference between NAVD and NGVD, which varies slightly depending on the location horizontally on the earth.)

FEMA information: https://msc.fema.gov/portal/advanceSearch

4.6. Wetland and Waters of US Analysis

If a defined waterway or wetland is suspected to be located on, or potentially impacted by the substation project, an official evaluation must be conducted by a qualified individual. The evaluation will identify and delineate the Waters of the US and/or wetland extents, and will provide the basis for substation grading and drainage design. Any impact to a Waters of the US or wetland will required United States Army Corps of Engineers 404 permitting, such as a Nationwide or Individual Permit. PLEASE NOTE: 404 reviewing and permitting can be very time consuming and must be identified early in the siting and design process.

4.7. Oil Spill Containment

EPA 40CFR 112 Oil Spill Prevention Regulation establishes the requirement that Spill Containment and Countermeasure Plans (SPCC) be prepared for all applicable facilities. The size of the oil spill containment shall be determined by the oil volume plus 25-year, 24-hour rainfall. Engineers shall check with the OpCo they are working with for specific requirements.

4.8. Fencing

Fence design shall comply with XEL-STD-Guideline for Substation Physical and Cyber Security, Section 2.3. XEL-STD-Guideline for Substation Physical and Cyber Security.pdf

Fences shall be based on structural calculations for fence frame and foundation. Calculations shall be in accordance with “Chain Link Fence Wind Load Guide for the Selection of Line Post and Line Post Spacing (WLG 2445)” and “ASTM F567, Standard Practice for Installation of Chain-Link Fence”.

5 Geotechnical Design Criteria

5.1. Soil Parameters and Design Values

Minimum soil parameters and design values shall be determined on the basis of site-specific testing or representative testing selected on the basis of the geotechnical engineer's experience in the area. These minimum values must identify with correlated values indicative of the typical values judged to be inherent at the specific site.

A geotechnical investigation shall be required for new or existing sites where no previous investigations have been performed. Both site grading and foundation designs shall be established on the basis of known site conditions and engineering data, obtained from the investigation.

The classification of observed soils shall be made in accordance with ASTM D2487 and D2488 the "Unified Soil Classification System".

5.2. Sampling and Testing

5.2.1. Overview

Rock and Soil Sampling shall adhere to the requirements of ASTM D420. Soil sampling shall be performed in accordance with ASTM D-1586 for split spoon sampling, and D-1587 for thin wall Shelby tube sampling. Rock sampling shall be done in accordance with ASTM D2113.

5.2.2. Swell ASTM D4546

Specific design recommendations to minimize swell effects on foundations must be made to assure performance within the guidelines specified in the foundation and civil performance sections of these criteria.

5.2.3. Water Soluble Sulfates

Specific design recommendations as to type of cement to minimize sulfate effects on concrete must be made. The test for water soluble sulfate in soil shall be performed in accordance with ASTM C1580.

5.3. Design Recommendations

5.3.1. Frost Heave/swell

Specific design recommendations to minimize frost heave/swell effects on foundations must be made to assure performance within the guidelines specified in the foundation and civil performance sections of these criteria.

5.3.2. Settlement / Consolidation

The geotechnical engineer shall make recommendations for foundation sizing based on anticipated service loads provided by the engineer. Limits for settlement established in the foundation and civil sections of these criteria shall not be exceeded.

5.3.3. Water Conditions

When groundwater is present in the frost zone within the graded area of the substation or access, the geotechnical engineer shall make recommendations, which will minimize the heave potential caused by ice lensing in the soil.

Drain systems, engineered fills or other functional solutions shall be recommended with economic considerations of each alternative. Recommended choices should be made based on best performance and cost.

5.3.4. Backfill Material Qualification

Backfill for substation sub-grades shall be qualified to assure that material is sound and of sufficient strength to sustain specified equipment, traffic and maintenance loads without excessive deformation.

The geotechnical engineer shall qualify native sub-grade or imported materials used as backfill.

5.3.5. Sub-grade Treatment

Sub-grade treatment for slab foundations will be required in situations where soils with inadequate bearing capability or stability concerns that are not meeting performance criteria for foundations and equipment are present.

Sub-grades with excessive depths of soils with inadequate stability or deformation properties may require a geotextile material under the graded area or road access to provide the required stability under wet or saturated conditions.

Sub-grade preparation or geotextile treatment needs to be clearly stated and referenced on site grading or foundation drawings.

5.3.6. Foundation Recommendations

The civil/structural engineer is responsible for the design of foundations and sub-grade stability for substations. Structural aspects and the general understanding of the geotechnical issues are considered as a part of this role. The geotechnical engineer must determine and recommend specific design values that are geotechnical in nature and are appropriate for the intended use and application on each project.

The civil engineer must recommend design solutions to the geotechnical engineer and review with the geotechnical engineer design values and application of specific solutions. The civil engineer must negotiate and seek agreement with the geotechnical engineer, while maintaining focus on the technical and economic issues involved.

Typical conditions and standard foundation applications must be communicated to the geotechnical engineer. Recommendations for these conditions are more general in nature however, more specific design values such as bearing capacity must be determined and reported based on actual or closely correlated soil parameters.

Variable conditions where standard or special foundation application are a concern requiring more intensive technical study will require more in-depth communication with the Civil/structural Engineer on design solutions and soil recommendations.

The geotechnical engineer must perform qualification testing and prepare recommendations concerning the use of native materials as backfill.

Preface

P.1. Scope and Purpose

This document describes the parameters for conductor and other wire for use on overhead transmission lines. This applies to property unit 2920187209 for overhead conductor and shield wire, to property unit 2920188809 for OPGW, and to down guy-wires and span guy-wires.

P.2. Responsibilities

Effective design and use of conductor and wires requires the cooperation of multiple responsible parties internal and external to Xcel Energy. The System Planning department shall recommend the conductor to meet electrical requirements. The Transmission Engineering department will use this conductor recommendation to design the transmission line. It is the responsibility of each of these parties to understand the requirements and limitations described in this document and to apply them appropriately to each individual design.

Geographic location and special site conditions will at times cause deviation from these standard conditions. Exceptions to this standard require approval by the Director of Engineering.

P.3. Work Flow

P.3.1 Approval

The Xcel Energy Standards Council has approved this document.

Date	Name
2015/02/20	Cozad, Brad D
2014/11/17	Dunham, Michael P
2014/11/25	Long, Brian D
2014/11/17	Urban, Paul J
2015/02/20	Winter, Kent G
2014/11/25	Woodard, James C

P.3.2 Creation

The following committee wrote this document.

Name	Title
Benjamin Gallay	Senior Engineer
Jeff Gutzmann	Principal Engineer
Parker Wrozek	Senior Engineer
Terry Randall	Principal Engineer
Tim Wachholz	Engineering Manager

P.3.3 Version History

The personnel listed above have approved the following changes:

Date	Version Number	Change
2/20/15	1.0	Initial Version supersedes the following documents in whole or in part SPS-STD-TB001_Mechanical Deadend Use NSP-STD-TB003 Automatic Splice Use XEL-STD-Guideline for Eng & Design of Spiral Vibration Dampers NSP-STD-CONDUCTOR DESIGN CRITERIA PSC-STD-CONDUCTOR DESIGN CRITERIA SPS-STD-TRANSMISSION LINE DESIGN CRITERIA

Table of Contents

1 Overview

1.1. Philosophy

Select conductors, shield wires, and optical ground wires based on required capacity with consideration to both lowest initial installation cost and lowest life cycle cost.

- **Required Line Rating:** Xcel Energy System Planning or System Operations will determine a minimum line capacity. Transmission Line Engineering will select an appropriate phase conductor to meet or exceed this requirement. (See XEL-POL-Facility-Rating-Methodology.doc)
- **Tension Criteria – Mechanical Strength:** Design tensions may not exceed 60% of the rated breaking strength of the selected conductor, for the loads of Rule 250B, per the NESC and Xcel Energy Standards. Line designs must also consider the effect of Aeolian vibration and address it through tension reductions, use of vibration mitigation attachments, or a combination of both. These criteria must be met under all load cases. (See XEL-STD-Transmission Line Structural Loading Criteria)
- **Wire Hardware Criteria:** Wire attachments and support hardware should be consistent throughout an individual line design. Whenever possible, use the current standard stock hardware supported by Supply Chain.
- **Clearance Criteria - Environment:** Vertical and Horizontal clearance requirements, per the NESC and Xcel Energy Standards, must be met in all designs during the worst-case sag conditions for the line design. (See XEL-STD-Transmission Line Clearance Criteria)

1.2. Glossary

AAMT

Average temperature of the coldest month at geographic location of the line.

ACSR

Aluminum Conductor Steel Reinforced; is conductor that consists of a solid or stranded galvanized steel core surrounded by one or more layers of aluminum. The steel core provides the majority of the tensile strength of the conductor. The overall conductor strength derives from contributions of both the steel and aluminum.

ACSS

Aluminum Conductor Steel Supported; is conductor made of aluminum stranded around a steel core. ACSS is a high temperature conductor that allows for higher operation capacity. ACSS has annealed aluminum that does not provide significant tensile and bearing strength. Therefore, it is advisable to use clamps that apply the least bearing stress on the conductor.

Aeolian Vibration

Aeolian vibration is a high frequency motion that can occur when a smooth, steady crosswind blows on aerial cables.

Armor Rod

A set of preformed protective metal rods wound helically around a conductor at the suspension point, preformed and placed prior to the installation of the suspension clamp.

Armor Grip Suspension (AGS)

This is a Heliformed suspension clamp manufactured by PLP.

Catenary Constant

The constant in the catenary and parabolic equations, geometrically represented by the radius of curvature at the lowest point of the span. The catenary constant H/w is the quotient of the horizontal tension in the conductor H at a given temperature by its unit weight w, which must take into account the ice and wind loads, if applicable.

Conductor

A wire or combination of wires not insulated from one another, for carrying an electric current.

Cushion Grip Suspension (CGS)

This is a conductor clamp that has rubber bushings inserted into a metal body housing. CGS is a trademark of Preformed Line products.

Damper

A device attached to a conductor or an earth wire in order to suppress or minimize Aeolian vibrations due to wind

Departure Angle

The angle between the wire at the suspension point and the horizontal plane.

Fittings

Hardware equipment used to attach a suspension clamp to an insulator. Fittings include material like yoke-plates, corona rings, clevis eye, Y-clevis eye, socket eye, hold-down weight shackle, and socket clevis, shackle, link, turnbuckle, etc.

Galloping

Periodic motion of a conductor of the order of a fraction of one Hz and high amplitude, whose maximum value can be of the same order as the original sag.

Heliformed Suspension Clamp

This conductor clamp configuration uses a combination of armor rods, a rubber bushing, and a metal housing to suspend a conductor on a transmission line. There are two manufacturers of Heliformed suspension clamps: AGS by PLP, and HAWS by AFL.

Hinged Armor Wire Suspension (HAWS)

This is a Heliformed suspension clamp manufactured by AFL.

Hinged Bushing Clamp (HIBUS)

This conductor clamp has rubber bushings inserted into a hinged metal housing. HIBUS is an AFL trademark.

OHGW

Overhead Ground Wire, typically consisting of steel and/or aluminum strands and used to provide lightning protection to phase conductors; also called static wire or shield wire.

OPGW

Optical Ground Wire, typically consisting of fiber optic core strands surrounded by steel and/or aluminum outer support strands, provides for lightning protection as well as a communications path.

RTS

Rated Tensile Strength is the maximum load that a material can withstand while being stretched or pulled before failing a manufacturer's minimum rating requirements.

Ruling Section

A number of spans between two dead-ends.

Ruling Span

The span length in which the tension in the conductor, under changes in temperature and loading, will most nearly agree with the average tension in a series of spans of varying lengths between dead ends.

Sag

The maximum vertical distance in a span of an overhead line between a conductor and the straight line joining its points of support.

Shoe

This is industry jargon meaning standard suspension clamp.

Slip Load

The maximum load that a clamp can handle before losing grip on the conductor.

Span

The length of a line between two consecutive points of support of a conductor

Splice

a joint inserted between two lengths of a conductor to provide electrical and mechanical continuity of the conductor

Suspension Clamp

A device used to hold the conductor cable on a transmission line. Using fittings, it attaches to an insulator that is supported on the transmission structure. A standard suspension clamp consists of a saddle shaped metallic device and has a keeper held down using U-bolts.

Wire

Flexible strand or strands of metal used to bear mechanical load.

1.3. References

The following publications are useful to the proper understanding and implementation of this document. These references include internal Xcel Energy documents as well as external documents.

- XEL-STD-Specification for Procurement of Overhead Conductors
- CIGRE 273 Conductor Safe Design Tension with Respect to Aeolian Vibrations
- CIGRE 324 Sag-Tension Calculation Methods for Overhead Lines.pdf
- CIGRE-ELT-181-3-Modeling of Aeolian Vibration of Single Conductors
- CIGRE-ELT-223-2-Modeling of Aeolian Vibrations of Single Conductor plus Damper
- EPRI Orange Book (2005) Transmission Line Wind Induced Conductor Motion
- EPRI Red Book AC Transmission Line Reference Book-200kV and Above
- IEC 60050 - International Electrotechnical Vocabulary
- IEEE 524 Guide to the Installation of Overhead Transmission Line Conductors
- National Electrical Safety Code: 2012 Edition
- RUS Design Manual for High Voltage Transmission Lines 1724e-200
- XEL-POL-Facility-Rating-Methodology.doc
- XEL-STD-Guideline for Optical Ground Wire - OPGW
- XEL-STD-SHIELD WIRE SPECIFICATION
- XEL-STD-Specification for Procurement of Overhead Conductors

2 Electrical Criteria

2.1. Phase Conductors

The line capacity requirements given by Xcel Energy System Planning determine conductor selection for new lines. The design engineer should work closely with the planning to determine the appropriate conductor. The Xcel Energy Rating Methodology defines how transmission lines are to be rated: XEL-POL-Facility-Rating-Methodology.doc. These planning considerations set a lower limit on the aluminum content of the conductor (the value expressed in kcmil for ACSR and ACSS conductors).

The Siting and Land Rights department dictates secondary considerations. These include corona and other electromagnetic field effects that may dictate a minimum conductor diameter, or a conductor bundle. Also dictated by Siting and Land Rights is the choice of specular and non-specular conductor finish options. Non-specular finish is a postproduction process applied to the conductor as such it has a cost and production time increase versus a standard specular finish. This is a common permitting requirement to limit "visual pollution" on Federal ands.

Once these project requirements are understood, Transmission Line Engineering shall select an appropriate phase conductor, or bundle of conductors, to meet or exceed this requirement. (Mechanical constraints – see §3 – affect choice of conductor diameter and steel content. The engineer is at liberty to choose between ACSR and ACSS to minimize costs.) In the case of line maintenance, emergency repair, or line rebuild projects the conductor selection shall meet or exceed the capacity of existing conductor.

Whenever possible, the design engineer shall use Xcel Energy preferred conductors to maximize interchangeability of parts across the system. Listings of the preferred conductors can be found in XEL-STD-Specification for Procurement of Overhead Conductors. When design conditions dictate a non-standard conductor size be used, such as a long span crossing a restricted access area, the design engineer must develop emergency repair/replacement options and coordinate them with the Supply Chain, and construction groups. Both round wire and trapezoidal wire version of the standard conductor sizes are available. Diameter equivalent trapezoidal wire has several advantages to round wire from both an engineering and a construction perspective, and only a marginal cost increase over round wire due to the increased aluminum content. Trapezoidal wire should be considered as the primary design option by engineering, wherever an ultimate lowest INITIAL cost design is not required. System Planning may also require trapezoidal wire on a specific project due to long-term system considerations.

2.2. Overhead Ground Wire

2.2.1. Fault Current

The currents from phase-to-ground faults return through the ground and the ground wires. The fault can occur anywhere in the transmission line with short circuit current being higher near substations. These short circuit currents cause a temperature rise in the wire. This temperature rise can cause the aluminum to anneal, birdcage, or melt.

Equation 1 shows the design constraints on selecting shield wire (based on energy conservation during a fault). The left hand side consists of material constraints provided by the manufacturer. The right hand side consists of design requirements of interest to a utility, and is why OPGW is often listed in catalogs with the parameter $kA^2\cdot s$. 3/8" EHS stranded steel cable has a fault withstand capability of $24\cdot kA^2\cdot s$. The maximum allowable temperature for steel is its softening point at about 600·°C, allowing for a compact shield wire. The maximum allowable temperature for OPGW is the softening point of the glass fiber coating at about 180·°C generally requiring a much larger diameter and higher aluminum content.

Xcel Energy's engineer shall obtain the exact values of the three-phase fault current from the System Protection engineering group. A clearing time of 6 cycles shall be assumed. The line design (i.e. use of multiple shield wires) may allow for the fault current to split, and therefore allow for use of correspondingly smaller shield wires. The design engineer should consult with System Protection Engineering to determine the fraction of the total fault current that will flow through each individual shield wire. The maximum energy value of I^2*t, shall determine the short circuit current capability. Preferred shield wire sizes are listed in XEL-STD-SHIELD WIRE SPECIFICATION and XEL-STD-Guideline for Optical Ground Wire - OPGW.

When lines parallel communication circuits, railroads, or pipelines, shield wire may also be constrained by induced current effects during line faults. Under these situations, the design engineer shall perform a study to determine whether a higher conductivity shield wire is necessary.

$$D^4\cdot\left(\frac{T_H - T_L}{\alpha\cdot\rho^2}\right)\cdot C = i^2\cdot t$$

Equation 1: Material constraints on shield wire

D: Shield wire diameter
T_H: Maximum allowable temperature
T_L: Ambient temperature
α: Thermal diffusivity of wire
ρ: Electrical conductivity of wire
C: proportionality constant
i: fault current
t: fault duration

2.2.2. Optical Ground Wire

The Transmission Line Engineer or Designer should consult with System Protection Engineering and Communications Engineering departments to determine if OPGW is required on a specific project. The Transmission Line Engineer or Designer should prepare estimates for OPGW for all lines operated at or above 115-kV. Even if it is not required at the time of the current project, the final design should consider the need for possible future addition of a fiber-optic communication path in some fashion. ("External" or "competitive bid" projects with specific estimate guidelines may waive this requirement with the approval of the Director of Engineering.)

OPGW weights and diameters are, in many configurations, larger than traditional shield wires and require greater tensions to maintain comparable sag characteristics. The larger OPGW wire diameters result in greater structure loading due to the increase in wind and ice loads. Where OPGW replaces shield wire(s) on existing transmission lines, Xcel Energy's engineer shall evaluate the resulting sags and tensions for proper application. XEL-STD-Guideline for Optical Ground Wire - OPGW outlines additional details and standard OPGW sizes and hardware.

The Xcel Energy standard overhead shield wire is a 3/8" Extra High Strength stranded steel cable. EHS steel and alumoweld cables have a higher strength to weight ratio and therefore sag less than phase conductors. This assures that the shielding angle determined by the structure geometry will not diminish anywhere in the span, and neither will clearances with respect to galloping.

2.2.3. Grounding Methods

Xcel Energy's design shall bond the mechanical support of the shield wire to the structure ground. The existence of a jumper across the mechanical support is not necessary for lightning or fault current dissipation unless the shield wire is in uplift. Any resistance in the mechanical support for the shield wire will be overcome when the first traveling wave intersects the connection. An arc will quickly form, and the arc will provide a relatively low resistance connection during a fault or lightning event.

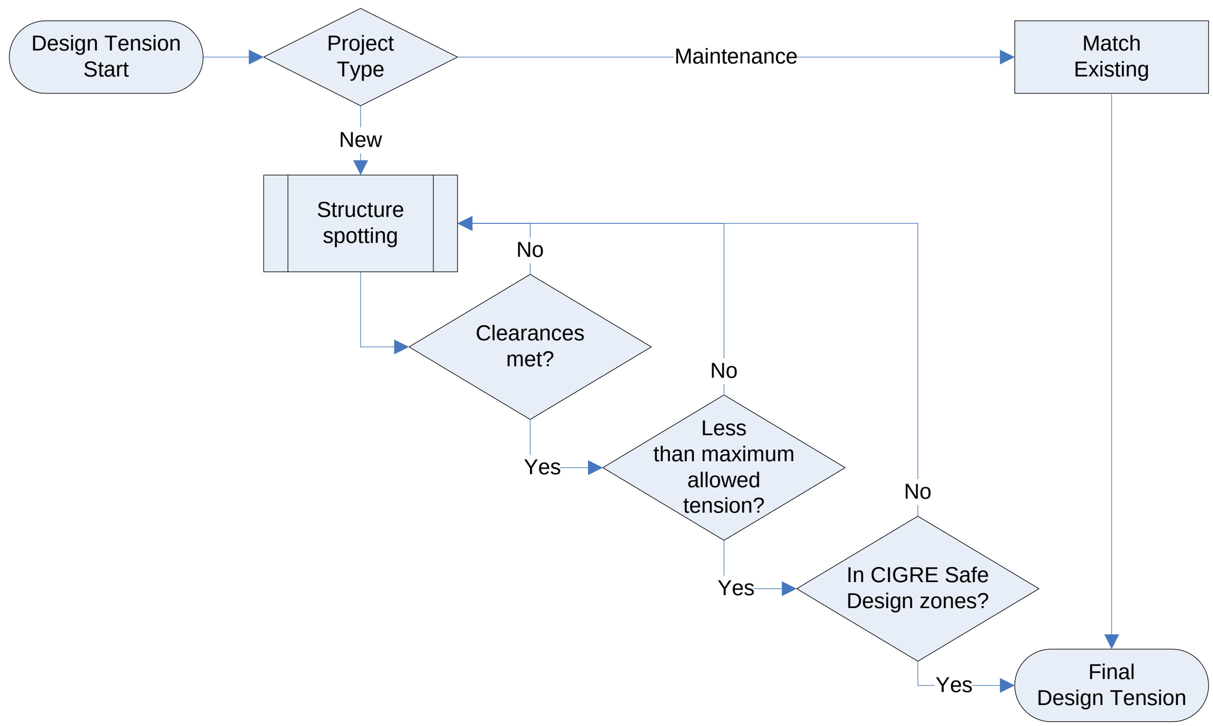


Figure 1: Flow chart showing iterative process for determining design tension for new line design, re-conductor, or maintenance projects.

3 Tension Criteria

3.1. Design Tension Process

Figure 1 shows the design tension process. Selecting design tension for a project is a tradeoff between several constraints: project constraints, clearance requirements, and the mechanical properties of the conductor. Limits on the mechanical properties of the conductor are the primary scope of this document, discussed below in § 3.2 and § 3.3. XEL-STD-Transmission Line Clearance Criteria discusses clearance requirements in detail. Project constraints include total budget, and available right-of-way. Appendix B provides guidelines for managing these constraints given clearance and mechanical limits.

3.2. Worst Case Mechanical Loading

Per the National Electrical Safety Code (NESC) phase conductor and overhead shield wire tensions shall not be more than: 60% of their rated breaking strength for the load of Rule 250B multiplied by a load factor of 1.0, or more than 80% of their rated breaking strength under loads of Rules 250C and 250D multiplied by a load factor of 1.0. They also shall not be more than (35% Initial) or (25% Final) of their rated breaking strength in an unloaded condition at the appropriate temperature for the loading zone used in the design.

Weather Parameters						Tension Limits (RBS)		
Case	Wire Temp (°F)	Wind (mph)	Wind (psf)	Ice (in)	Final / Initial	NESC Limit	XEL Limit ACSR	XEL Limit ACSS
NESC Rule 250B	See XEL-STD-Transmission Line Structural Loading Criteria				I	60%	40%	50%
NESC Rule 250C	60	90	20.7	0	I	80%	80%	80%
NESC Rule 250D	15	50	6.4	1	I	80%	80%	80%
NESC - Rule 261.H.1.b - Initial	NESC 250 B	0	0	0	I	35%	35%	35%
NESC - Rule 261.H.1.b - Final	NESC 250 B	0	0	0	F	25%	25%	25%

Table 1: Cable Tension Limits based on NESC Rule 261.H.1.

These tension limits will manage mechanical failure of the conductor or shield wire due to typical weather conditions across the United States. Table 1 lists these base conditions per the NESC as well as the Xcel Energy design standards chosen to exceed those requirements. Special loading areas exist throughout the United States and the Xcel Energy service area, examples such as the higher wind speed areas in south west Minnesota and along the Colorado foothills may require design limits in excess of those listed in the table.

Construction limitations must also be accounted for in determining the design tension such as; substation dead end loading limits, which typically require a “slack” span, limits due to available stringing equipment or available stringing locations in the field, mechanical damage to conductors due to the type of pulling grips available.

While the base cases shown in Table 1 account for the majority of these variables, it is the responsibility of the design engineer to intelligently apply and adjust these rules as required by the conditions specific to their project location.

These tension requirements apply equally to both phase conductors and shield wires, both OHGW and OPGW. (Shield wires will end up not having the same tension as phase conductors for two main reasons. First, OPGW and OHGW are made from different material so that weight per foot and RBS will be different; see XEL-STD-Guideline for Optical Ground Wire - OPGW for more details. Second, shield wire must always have less sag than phase conductors to provide adequate lightning protection; see XEL-STD-Transmission Line Clearance Criteria for more details.)

3.3. Conductor Fatigue

An important mechanical constraint on conductor tension is fatigue failure due to persistent Aeolian vibration. Since the 1960’s, an Every Day Stress (EDS) design evaluation has been used to evaluate Aeolian vibration and set upper limits to tension in terms of % RTS. (This is one of the reasons for the Xcel Energy standard design tension limits in Table 1 being more conservative than the limits imposed by the NESC: the NESC does not account for vibration fatigue.)

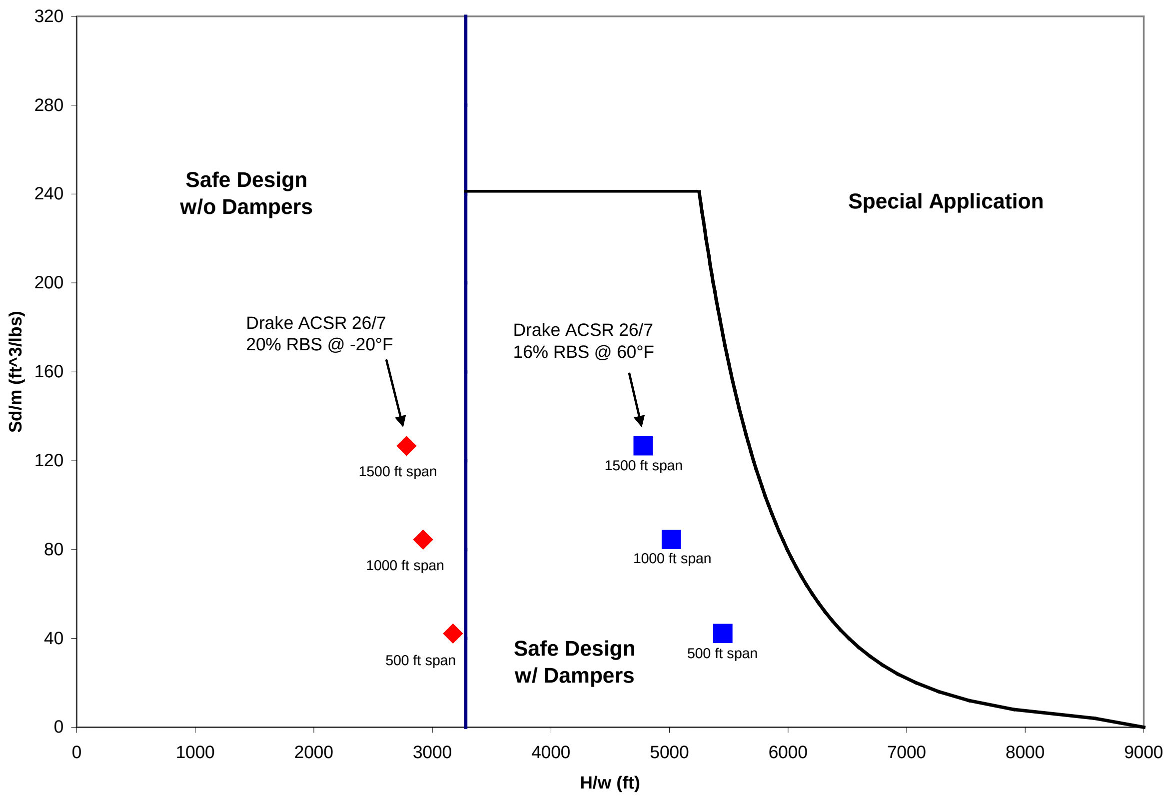


Figure 2: Recommended Safe Design Tensions for Single Conductor Lines. (Based on CIGRE TB 273, and Terrain Category 1.)

Modern studies have shown that while this method produces simple rule of thumb thresholds, it has proven to be inaccurate, as it does not account for all the variables that exist from span to span along a transmission line. For the purpose of fatigue endurance for ACSR conductor, it is the stresses in the outer aluminum strands that should be limited, rather than the average stress across all strands of the complete conductor as implied by EDS criteria. Because the final ratio of elastic moduli is approximately equal to the ratio of the densities of steel and aluminum, the tensile stress in the aluminum strands is a function of H/w, irrespective of the steel/aluminum ratio. The H/w ratio is the ratio between the initial horizontal tensile load (H), before any significant wind and ice loading and before creep at the average temperature of the coldest month at the location of the line, and conductor weight (w) per unit length. When using anti-vibration devices, such as Stockbridge dampers, an additional parameter is used to account for their effect on a given span, S·d/*m*: the span length S, times the conductor diameter d, divided by the conductor mass per unit length *m*.

CIGRE Technical Brochure 273 describes these parameters in detail, and design engineers should familiarize themselves with its contents, as it forms the basis for Aeolian vibration mitigation on all new construction at Xcel Energy. Figure 2 shows expected EDS and H/w values for Xcel Energy standard conductors applied to typical structure configurations and varying span lengths on the CIGRE design zone chart.

The intended design process is for the engineer to evaluate vibration effects as the last step in selecting design tension. Using the proposed design tension to this point, the engineer would plot H/w and S·d/*m* parameters for each differing design section of the overall line. Designs in the “No Damping” zone do not require dampers. Designs in the “End Damping” zone shall use dampers, with location and size determined per the manufacturer’s recommendations (see § A.4 for details). Designs that fall in the “Special Application” zone shall be redesigned, because custom and expensive damping solutions would be necessary to protect these designs.

Appendix A Accessories

A.1. General

Wire accessories and fittings should be consistent throughout an individual line design. Whenever possible, use the current standard stock hardware supported by Supply Chain.

A.2. Full Tension Accessories

A.2.1 Dead End Accessories

Compression dead end fittings shall be used for all conductor sizes and types. Compression dead end fittings, properly installed provide both a better conductive path for electrical connections as well as significantly higher holding strengths than are possible with bolted fittings.

An exception for the use of bolted dead end fittings can be requested for special cases where a specific need is identified, such as for temporary bypass or jumper configurations which would require frequent dis-assembly and re-assembly, or for installing taps energized. When specifying bolted fittings, the engineer must ensure that the conductor tensions do not exceed the rated holding strength.

A.2.2 Splices

Compression splices shall be used for all wire sizes and types. “Automatic splices” are not compressed with dies to provide holding strength but rely on internal automatic mechanism to hold the wires after they are inserted into the splice. Water runs down the wire, collects in the automatic splices (even those with drainage holes), and corrodes the wire or inner splice parts, which has resulted in mechanical failure and dropped lines.

A.3. Suspension Accessories

Armor grip suspension (AGS) units, or Cushion Grip suspension (CGS) units, shall be used on all sizes of ACSS conductor, as well as ACSR conductor larger than 636 kcmil. Clamps with armor rods may be used on ACSR conductor up to 636 kcmil. Clamps without armor rod shall not be used on any new construction.

All suspension hardware has an upper limit on departure angle to limit the bend radius and stress in the conductor at the suspension hardware. This limit may be 22.5° or 30°; the design engineer should consult the vendor data sheets. This is mostly a concern at angle structures where the angle of the line compounds the departure angle. At locations with a large departure angle, two clamps or grips are often necessary to spread the force applied to the conductor over a larger area.

A.4. Vibration Dampers

A.4.1 General

Dampers are devices attached to conductors and shield wires to reduce the fatigue on line components due to wind-induced vibration. While many types of dampening devices exist on the market Xcel Energy uses the two most common. Stockbridge type dampers are used on conductors that are 0.75·in in diameter and larger. Spiral Vibration Dampers should be used on shield wires and conductors that are 0.75·in in diameter and smaller. The same recommendation applies to OPGW.

A.4.2 Stockbridge Dampers

The Stockbridge-type damper reduces the vibration amplitude of the conductor by dissipating mechanical energy as heat. An example is shown in Figure 3. The friction between wires strands of the messenger cable is the location of this energy conversion. The Stockbridge type dampers perform in a wide vibration frequency bandwidth and protect the conductor even at high tensions and long spans. One (1) or more dampers may be required to provide the necessary protection. Stockbridge type dampers are placement sensitive and need to be installed at the optimum position recommended by the manufacturer. The different damper designs require each manufacturer's damper recommendation software be used exclusively for their corresponding dampers. Although there are many vibration-damping systems on the market today, the Stockbridge style dampers is the most time tested and economical solution to reduce conductor fatigue on the transmission system with conductors larger than 0.75” diameter. The line designer should keep in mind that Stockbridge type dampers are span and tension dependent

The main concern in regards to the use of Stockbridge type dampers on small diameter

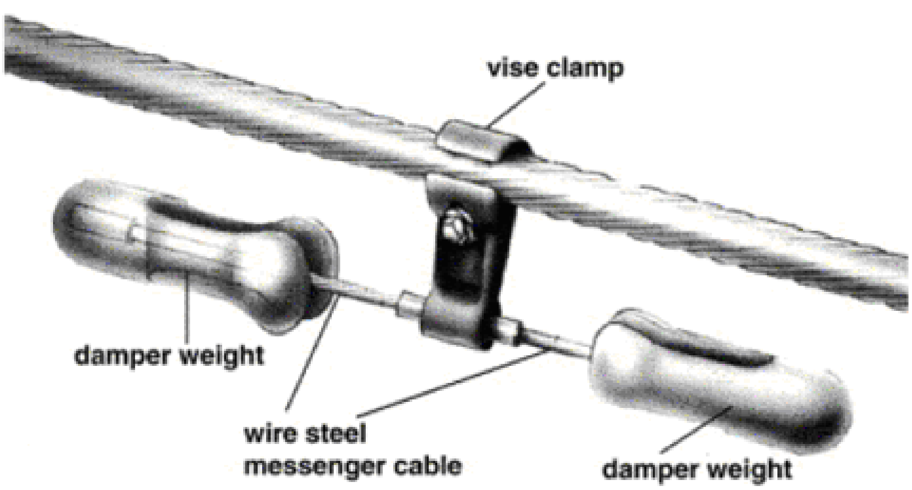


Figure 3: Example of Stockbridge vibration damper.

Conductor	AFL		Fargo 4-R	
	Cat ID	Part No.	Cat ID	Part No.
266..8	201548	1704-5BA	217818	607051011
336.4	197278	1704-6BA	217818	607051011
477	76375	1705-7	217818	607051011
636	51432	1706-9	217820	6071012
795	51433	1706-10	217820	6071012
954	51433	1706-10	217821	6071513
1033.5	51436	1707-11	217821	6071513
1272	51435	1707-13	217821	6071513

Table 2: Passport Cat ID's for Stockbridge Dampers.

conductors is the installation precision. Stockbridge type damper must move to dissipate energy. As the conductor diameter decreases, the loop lengths also decrease. The decrease in loop length causes the node and anti-node to converge, which places more emphasis on the installers precision. If a Stockbridge type damper is installed at a node, it becomes ineffective and may begin to create issues rather than suppress them.

Table 2 lists standard stockbridge dampers available through Passport. These must be sized using the applicable manufacturer's software. In addition to typical project data - such as span length – the software will also ask the user for the following three assumptions:

- Terrain Category: Use category should be Category 1 / open terrain.
- Direction of line: Use the direction between dead-ends for each ruling section.
- Average Annual Minimum Temperature: Use -20°F in the PSCo and NSP regions and 0°F in the SPS region.

A.4.3 Spiral Vibration Dampers

The Spiral Vibration Damper (SVD) is an impact style damper that interrupts and negates the Aeolian vibration motion so the conductor or wire does not lock into resonance and cause fatigue damage. Spiral dampers are most effective at high vibration frequencies (100 Hz to 300 Hz) associated with smaller wires. A decrease in diameter results in higher vortex frequencies and shorter loop lengths, so this makes spiral dampers an ideal candidate to

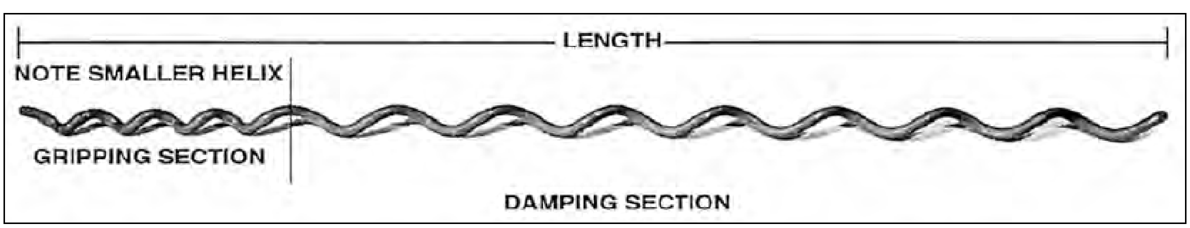


Figure 4: Example of spiral vibration damper.

Span Length	0-800’	801’-1600’	1601’-2400’
Standard	**2**	**4**	**6**
Hi-Mass	**1**	**2**	**3**

Table 3: Number of SVD’s per span.

Catalog ID	Manufacturer	Part Number	Type	Diameter Range
217928	PLP	5050200	Hi-mass	0.250" - 0.326"
212981	PLP	5050201	Hi-mass	0.327" - 0.461"
212982	PLP	5050202	Hi-mass	0.462" - 0.563"
217929	PLP	5050203	Hi-mass	0.564" - 0.760"

Table 4: Passport Cat ID’s for SVD’s.

suppress Aeolian vibration on conductor’s less than 0.75”, shield wire, and OPGW. SVDs are not available for wires larger than 0.75” diameter as they are not economically feasible to manufacture and use when compared to Stockbridge-type dampers.

All conductors, shield wire, and OPGW less than 0.75" in diameter shall use spiral vibration dampers. This decision was made based on the following.

- Spiral dampers are most effective at higher frequencies, which are associated with smaller diameter wires.
- As diameter decreases the nodes and anti-nodes converge, which places more emphasis on the precision of installation, when compared with Stockbridge dampers, spiral dampers are NOT placement sensitive.
- Spiral dampers are theoretically less susceptible to weather events
- PLP, a spiral damper manufacturer, has performed tests that show equivalent power dissipation between their Stockbridge-type dampers and their spiral dampers

The Hi-mass spiral design shall be specified whenever possible. The Hi-mass design allows for fewer components and installations when compared with standard designs.

The quantity of spiral dampers is dependent on the length of the span. If the manufacturer of the spiral damper is PLP, Table 3 provides the minimum quantity requirements.

The placement of spiral dampers does not require any software or calculations. The recommended installation point for spiral dampers is approximately one hand's length from the end of the armor rod or other hardware.

A.5. In-Span Accessories

A.5.1 Aerial Warning Markers

The FAA or Army Corp of Engineers may require spherical markers be attached to the top wire of a transmission line to increase visibility of the wire. Markers are installed in spans crossing navigable rivers and where aircraft operate close to the ground. One must take into account the added weight of the markers in the sag-tension calculations.

A.5.2 Bird-Diverters

The Department of Natural Resources (DNR) or the United States Fish and Wildlife Service, in areas of heavy bird traffic, sometimes request installations of bird-diverters to increase the visibility of the wires to the birds. Many varieties of bird-diverters exist; in the absence of a specific permitting requirement, Xcel Energy uses a spiral-type bird-diverter, similar to the spiral vibration dampers in design and installation. The additional weight of the bird-diverters shall be considered in the sag-tension calculations.

Appendix B Design Considerations

B.1. General

This Appendix provides guidelines for managing project constraints given clearance and mechanical limits. Picking a cost-effective, project specific design tension involves many tradeoffs. In addition, engineering judgment plays a determining factor. The material in this appendix is informative only and is not a mandatory part of the standard.

When the design engineer makes final decisions about tension – and correspondingly, sag – this must be documented carefully. See EDG-E.11-001 Sag Tables and Miscellaneous Attachments.DOC and EDG-E.11-002 Sag Tables and Miscellaneous Attachments - Check List.doc for details.

B.2. Worst Case Sag

Design tensions must provide for the NESC required code clearances during the worst-case sag conditions for the line design. These minimum clearance limits are specified in the NESC section 23. The Xcel Energy standard design clearances are selected to exceed these requirements and have been outlined in XEL-STD-Transmission Line Clearance Criteria. An optimum tension can be found where the change in sag becomes small compared to the tension change. This optimal tension point, when meeting the required maximum tension limits, should be used as the base case for cost comparisons between alternate line designs.

The maximum sag condition used for this evaluation is typically the maximum operating temperature condition for the conductor type. These temperature and weather conditions are established in the XEL-POL-Facility-Rating-Methodology.doc. However, there may be instances where a weather condition, such as extreme ice and wind loading, will exceed a maximum operating sag condition. It is the responsibility of the design staff to evaluate a range of possible sagging conditions and select the appropriate maximum sag condition for the line design.

B.3. Vertical Clearance - Sagging

B.3.1 Structure Height

Structure heights play an important role in determining the optimal conductor tension for a line design. The design engineer must pay attention to locations where structure height is determined by external factors, such as airport approach areas, highway and railway crossings, or sensitive areas with restricted access. Increasing or decreasing design tensions beyond what is typical on the Xcel Energy system may be required to optimize designs in these situations and is an acceptable practice.

B.3.2 Structure Type

Higher tensions will result in higher cost for dead end and angle structures due to increased loading; conversely, lower tensions will result in high tangent structure costs due to the increased height needed to maintain the minimum required ground clearances. The design engineer should consider the number of each type of structure in a ruling segment, and find an optimal tension that provides the most efficient overall design.

B.3.3 Under build

Under built services are common on transmission structures. Typical applications are distribution primary service lines, owned by Xcel Energy as well as other utilities, and third party communications circuits. The design engineer should consider the sag characteristics of these under built facilities and adjust the design tension to coordinate with them and maintain the required safe clearances.

B.4. Horizontal Clearance - Blowout

B.4.1 Span Length

The span or span length is the distance between two consecutive points of support. With longer spans, fewer structures are required but the structures required will be stronger i.e. taller, higher-class poles and heavier steel structures. The design engineer should perform a cost comparison using different span lengths and tensions to determine the most economical design.

Several factors may limit span length due to the amount of conductor blowout experienced at a give design tension. Limited available right of way width and NESC safe clearance requirements to buildings, bridges, trees or other objects may require increase design tensions where shorter spans are not an option.

While modern line modeling such as PLS-CAD has made it efficient to do span-by-span calculations, the Ruling Span method is still widely practiced and often referenced when describing the design tension for a line segment. Tests have shown that wood poles and cross arms supporting conductors attached by means of pin, or suspension, type insulators are quite flexible. Therefore, when temperature changes or changes in loading tend to cause different tensions to exist in spans of different lengths, the poles, and cross arms, are flexible enough to

$$S_R = \sqrt{\frac{\sum_n S_n^{\ 3}}{\sum_n S_n}}$$

Equation 2: Definition of Ruling Span

S_n: Length of span *n*
S_R: Ruling span

equalize these differences and the conductor tension will be substantially the same in all spans. Thus, it is possible to calculate the length of dead end span that will have the same changes in insulator swing or cross-arm deflection as will be found in a series of spans of varying lengths between dead ends. The ruling span is the length of an equivalent span with the average slack per span between dead-ends, using a parabolic approximation (see Equation 2).

B.4.2 Parallel Lines

Just as with under built facilities, the design engineer must coordinate clearances with parallel lines – both those owned by Xcel Energy as well as those owned by other utilities. Safe clearances to these adjacent facilities must be maintained during conductor blow out conditions, as well as the spacing needed for construction activities within the right of way, and may well set a lower limit on the design tension.

Appendix C Down and Span Guys

C.1. Material

C.1.1 Strength

Three different strengths of guy-wire are available for most guying applications. 7-No. 8 alumoweld wire with a strength rating of 15,000 pounds is most commonly used. For structures with heavier loads 25,000 pound, 25m alumoweld, or 35,000 pound, 5/8" steel is used. When loads exceed 35,000 pounds, doubling of the wires or a larger wire should be considered.

The factored load in the guy-wire must not exceed 90% of the rated breaking strength of the guy-wire.

C.1.2 Hardware

Two types of end fittings are used on the guy-wire. A preformed grip is less expensive and is used at the pole; a strand-vice is used at the anchor because the tension in the guy-wire is more easily adjusted with this type of fitting.

Splices are not allowed in overhead or down guy-wires. Broken or damaged guy-wires shall be completely replaced between attachment points.

When automatic splices are installed during line restoration, the field engineer should schedule a return trip to replace the automatic splices with compression splices as soon as practical. Order correct length (longer than normal) compression splice to allow for cutting out of automatic splice or splice in wire with two compression splices to replace the automatic splice.

For existing automatic splices in lines, note their location in the TAMS maintenance database as a critical replacement item. The automatic splices should be replaced in the next capital project on that line section or regularly scheduled maintenance project whichever occurs first.

C.1.3 Guy Markers

Per NESC Rule 264E, the ground end of an anchor-guy exposed to pedestrian traffic shall be provided with a substantial and conspicuous marker. Xcel Energy requires guy-markers installed on all guy-wires.

C.1.4 Grounding

To protect a person on the ground from contacting an energized guy-wire, all guy-assemblies shall be bonded to the ground wire of the pole.

C.2. Design

The purpose of structure guying is to keep a structure in a vertical position when loads due to line angle and wind are applied. The strength of the guy-assembly must be sufficient to support these loads. Typically, a guy-assembly consists of a length of cable with one end attached to the pole near the attachment point of the shield wire or conductor and the other end attached to an anchor embedded in the ground.

Guy wires that cycle through zero stress will fail – keep them under tension always. If positive tension cannot be maintained due to structure or anchor settlement then there will be trouble some day; vendors recommend a minimum tension of 10% RTS. On angle structures, the design engineer must perform a review of all conditions at which transverse wind blows into the guy-wire causing it to unload and subjecting the pole to material bending.

The analysis of single pole guyed structures is based either on bending stress just above the highest guy-attachment and/or Euler long column buckling theory. If the structure has more conductor attachments than guy-wires and the highest guy-attachment is below the lowest conductor attachment (see figure A), then bending is induced in the pole and it will need to be checked for both bending and buckling. If the structure has the same number of conductor attachments as guy-wires and the conductor attachments are at the same approximate elevations as the guy-wires (see figure B) then the pole just needs to be checked for buckling since no bending is induced. Guy-assemblies (per NESC Rule 261C) when used to meet the strength requirements, shall be considered as taking the entire load in the direction in which they act, when the structure is acting as a strut only. The bending moment capacity of the pole is disregarded in calculating the load in the guy-assembly.

Preface. Specification for Transmission and Distribution Wood Poles

P.1. Purpose

This Specification covers the manufacturing, preservative treatment, inspection and handling of Distribution and Transmission wood poles.

P.2. Applicability

This document is a standard and shall be followed by all employees with XEL Company. Any deviations must be approved by Standards Council.

P.3. Work Flow

P.3.1 Approval

The Xcel Energy Standards Council Sponsors {have / have not} approved this document. This document was set to release on {field}.

Approval	Date	Name	Title

P.3.2 Creation

The following committee wrote this document. The committee forwarded this document to the standards council on {field}.

Approval	Date	Name	Title
		Michael Garrels	Transmission & Substation Standards
		Dave Flaten	Senior Specialty Engineer, Distribution
		Rob Nelson	Project Director, EDM International

P.3.3 Version History

The personnel listed above have approved the following changes.

Date	Version Number	Supercedes	Change
8/31/09			Latest Version

1 Scope

This Specification covers the manufacturing, preservative treatment, inspection and handling of Distribution and Transmission wood poles.

2 General Requirements:

Poles supplied to Xcel Energy shall be in accordance with the American National Standards Institute (ANSI) O5.1, "Specifications and Dimensions of Wood Poles" and American Wood Protection Association (AWPA) standards as referenced herein. The latest version of the standards shall apply unless otherwise specified.

Xcel Energy only accepts full-length pressure treated wood poles.

Manufacturer shall maintain facilities, quality control processes and trained staff to assure compliance with all elements of this specification.

Final inspection will be performed by Xcel Energy or its designated agent either at the manufacturing facility and/or upon receipt to assure compliance of material to this specification.

3 Species Requirements:

Southern yellow pine, lodgepole pine, red pine, western redcedar and Coastal Douglas fir are acceptable species for poles 50 feet in length or shorter. For poles in excess of 50 feet in length, only western redcedar and Douglas fir are acceptable species.

4 Material Requirements:

Materials and methods of manufacturing shall comply with the ANSI O5.1, with the following exceptions:

Knots

Spike knots (sucker knots) are prohibited unless and except it is no wider than 2" and no longer than 4".

Spiral Grain

Spiral grain shall not exceed 1 twist in 20 ft for poles 45 ft and shorter.

Spiral grain shall not exceed 1 twist in 30 ft for poles 50 ft and longer.

SPLITS AND CHECKS

Splits and through checks (two or more checks intersecting at the pith) extending more that 6 ins. from the pole top are prohibited.

5 Manufacturing Requirements:

5.1. Framing:

5.1.1. Unless specified on the purchase order, all poles shall be undrilled.

5.1.2. All drilling specified on purchase order shall be done prior to preservative treatment.

5.1.3. The tops of all poles shall have a flat roof only.

5.1.4. To mitigate top splits, Pole Anti-splitting devices (ASDs), such as the Star Lock or equivalent, shall be placed in pole tops in all Douglas fir and western redcedar species poles in excess of 50 feet in length prior to treatment. ASDs may also be installed in pole tops in shorter poles prior to treatment at the discretion of the pole supplier. The device is not to be used to repair split tops.

5.2. Incising and Through-Boring:

5.2.1. Western redcedar poles shall be incised to a depth no less than 0.75 in. and the area shall be 3 ft above to 3 ft below the specified groundline.

5.2.2. Douglas fir poles 40 feet in length and longer shall be through-bored prior to treatment in accordance with Drawing 1. Through-bored poles shall use holes one-half (1/2) in. in diameter and spaced per Drawing 1 Through-Boring Specification. All poles shall be drilled two (2) ft above to four (4) ft below the ground line unless otherwise specified on the purchase order.

5.2.3. If sapwood thickness is less than 7/8 in. in thickness measured near the brand location, the pole shall be full-length incised above the through-bored zone.

5.3. Marking:

All poles shall have two, *non-corrosive* tags stamped with the following information: pole length, class, species code, treatment code, treatment date and supplier's name and plant location. All code lettering of the tag shall comply with the latest revision of AWPA Standard M6. One pole tag shall be placed on the butt of the pole and the other placed on the *face* (concave surface if present) of the pole at a point six (6) ft $\pm$ two (2) in. above the standard groundline, as defined by ANSI O5.1 or otherwise specified in the purchase order.

Tags shall be two (2) in. diameter and recessed ¼ in. below the surface of the pole and attached with two, 2-in. aluminum twist nails.

5.4. Seasoning:

5.4.1. The seasoning of all poles shall be as per ANSI O5.1.2008, except as noted below.

5.4.2. Air drying of poles is permitted provided:

a. To prevent the formation of blue stain and decay, the supplier shall, as appropriate, completely saturate the outer surface of poles with a chemical solution as soon as possible after debarking.

b. Poles are stacked so as to allow the free circulation of air around individual poles.

5.4.3. Southern yellow pine poles shall not be air seasoned for more than three (3) months and other pine species shall not be air seasoned for more than ten (10) months.

5.4.4. Southern yellow pine and red pine poles shall be tested randomly prior to treatment to ensure that the moisture content at the mid-point and at the three-inch depth does not exceed 35%.

5.4.5. A combination of Boulton drying, air seasoning, and kiln drying of Douglas fir is acceptable provided that the sterilization requirement of section 6.2 is met.

6 Preservative Treatment:

6.1. Process:

An empty-cell process shall be used to treat the material. Treatment shall be in accordance with the requirements of AWPA Standards U1 for Use Category 4B, and T1-07, except as modified or changed by this Specification.

6.2. Sterilization

Air seasoned poles must be subjected to a heating period sufficient to continuously raise the temperature at the pith center of the largest pole in the charge to a minimum 160°F for a minimum of 75 minutes.

7 Acceptable Preservatives:

7.1. Pentachlorophenol:

Pentachlorophenol (penta) shall meet the requirements of AWPA Standard P-8. It shall be dissolved in hydrocarbon solvent Type A complying with the requirements of AWPA P-9.

7.2. Creosote:

Creosote shall meet the requirements of AWPA Standards P1/P13.

8 Treatment Results:

8.1. Penetration:

8.1.1. Penetration and retention shall be determined from increment borer cores, taken approximately one (1) foot below the brand. Where penetration is difficult to detect, such as in material treated with a light-colored solvent, AWPA Standard A-3 Section 6 shall be used. Where dark-colored solvents are used, a visual examination should be sufficient. Poles that do not comply with the above requirements for penetration shall be rejected but may be retreated provided that the total treatment time does not exceed any heating limitations.

8.1.2. Douglas fir poles shall also have penetration and retention in the through-bored zone determined from increment borer cores taken approximately one (1) foot below the assumed groundline. Borings shall be taken on through-bored poles near the midline of the pole at the location shown in Drawing 2. The increment bore shall be directed parallel to the through borings toward the center of the pole. Penetration of preservative on through-bored poles shall be as specified in Table 1.

8.2. Net Retention:

The net retention of Pentachlorophenol shall be determined in the appropriate assay zone by the lime-ignition method of chemical analysis as indicated in AWPA Standard A5 Section 5, or by x-ray spectroscopy according to AWPA Standard A9. All treatment shall be in accordance with Use Category 4B in sections U1-07 and T1-07. See Table 1 for minimum requirements. Poles that do not conform to the above requirements for retention shall be rejected.

Table 1 - Penetration and Retention Requirements for Treatment of Poles

Category	Southern yellow pine	Lodgepole pine	Red pine	Western redcedar	A.1. Douglas fir
Penetration	3.0" or 90% of sapwood	0.75" or 85% of sapwood	2.5" or 85% of sapwood	0.5" or 100% of sapwood	.75" or 85% of sapwood. 100% in the Through-Bore zone* (see note)
Retention Assay Zone	0.5–2.0"	0.1–0.75"	0.1–1.6"	0.0–0.50"	Outer 0.25–1.0" Inner 3.0--3.5"
Retention (lbs/cubic ft of wood)					
Creosote	7.5	12.0	10.0	20.0	Outer zone - 9.0 Inner zone - 4.5
Pentachloro-phenol	0.38	0.60	0.50	1.0	Outer zone - 0.60 Inner zone - 0.30

*Douglas Fir Through Boring Note: In the through boring zone, there will 100 % penetration to pith center. Core may reveal only one annual ring skip in the 4" to pith center zone. Cores must be to the pith center or at least a minimum of 10 inches long for poles larger than 20 inches in diameter.

8.3. After Treatment Moisture Content:

The average moisture content after treatment for Douglas fir poles, using a moisture meter fitted with insulated probes inserted to a depth of 2 inches at the mid-point of the pole, shall not exceed 22%. Poles shall be tested randomly, after treatment, to ensure compliance.

8.4. Retreatment:

Rejected poles may be retreated one time provided the temperature and pressure limits applying to the original treatment apply to retreatment and do not exceed maximums allowed in AWPA. Retreated material shall be inspected the same as when material was originally treated.

8.5. Pole Appearance:

When creosote, creosote solutions, or oil borne preservatives are used, material should be supplied reasonably free of exudates and surface deposits. The surface appearance can be inspected using the BMP (Best Management Program) Quality Assurance Inspection Program. The exudates may evaporate, remain liquid and greasy, or harden into a semisolid or solid state.

The preservative solution and the process for Pentachlorophenol treatment shall be such that the surface of all poles shall be reasonably clean, dry, and free from blooming (crystallized penta on the pole surface). Poles exhibiting evidence of bleeding or otherwise out of compliance with the *appearance* requirements shall be rejected.

9 Cleaning:

At the supplier's option, the poles rejected for cleanliness may be offered for inspection after they have been cleaned. To be accepted, poles must comply with the *appearance* requirements, Section 8.5.

10 Inspection:

Plant inspection, by the supplier, of 100% of the poles in the white wood stage and after treatment to ensure compliance with the above requirements is mandatory. Evidence of these inspections should be maintained by the Supplier for review.

At Xcel Energy's discretion poles may be inspected at the supplier's yard by Xcel Energy or its designated representative. Inspection shall be performed in accordance with AWPA Standard M-2 except where modified or amended in this Specification. Inspectors shall stamp their mark on the top of the pole for material approval and on the butt for approval of treatment. Test borings in all respects shall be made in accordance with this Specification. Borings shall be furnished to Xcel Energy or its representative when requested.

11 Reports:

11.1. Supplier

Upon request, the supplier shall furnish (for mailing to Xcel Energy or its representative) one copy of the treating report. When a kiln drying is used, a copy of the kiln chart or schedule shall be supplied.

11.2. Inspector/Designated Representative:

Upon request, the following information shall be made available:

- One (1) complete inspection report for every accepted charge of poles treated for the purchaser.
- One (1) shipping report for every carload of poles shipped to the purchaser.
- One (1) complete inspection report for every charge of poles not accepted.
- One (1) copy of the chemical analysis work sheet or if an X-Ray analyzer is used for retention analysis, a printout (or legible copy) shall be supplied as a part of each inspection report.

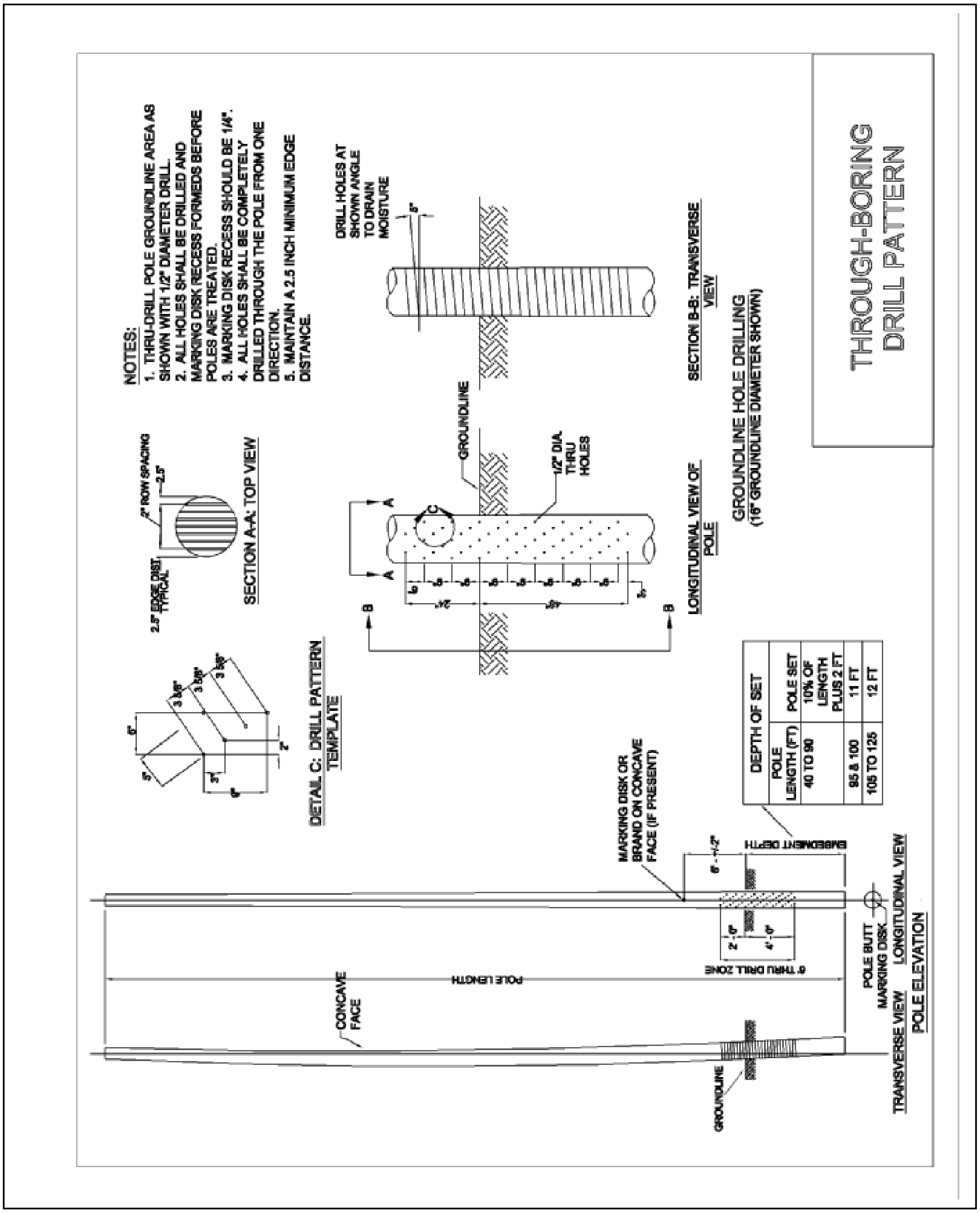
Included in the reports shall be sapwood and preservative penetration measurements, treatment retention by charge, and the number and cause for all rejected poles. Each shipping report and invoice shall show the material Purchase Order number and release number. The shipping report shall show the street address of the delivery point for the poles. All reports shall be mailed upon request to the appropriate party.

12 Shipping:

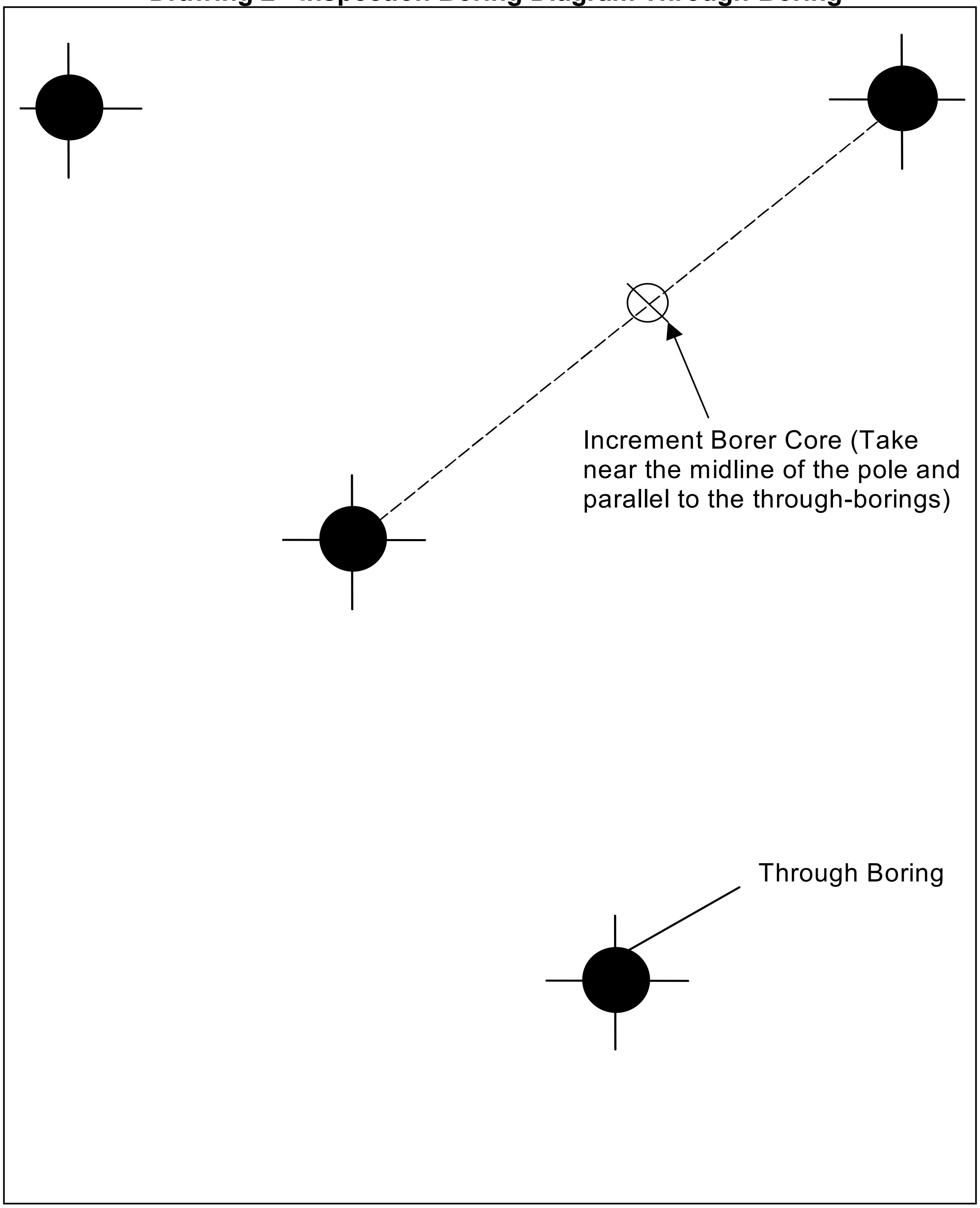
All poles shall be shipped by either rail or trucks. When poles are shipped via rail and Xcel Energy is responsible for the unloading, the poles shall be loaded on flat cars in accordance with the latest edition of the "Rules of the Mechanical Division of the Association of American Railroads Governing the Loading of Commodities on Open Top Cars". All rail cars shall have a card showing the street address of the delivery point attached to the poles at a point near the center of the load on the side of the rail car.

Attachments:

Drawing 1 Through-Boring Drill Pattern



Drawing 2 - Inspection Boring Diagram Through-Boring



Preface

P.1. Scope and Purpose

This specification covers the minimum requirements for furnishing all material, labor, and equipment necessary to design and fabricate tubular steel transmission pole structures for use by Xcel Energy. This includes poles for use under property unit 6460816409, arms under property unit 6460817409, and anchor bolt cages for use under property unit 3580274409.

This specification covers the technical aspects of design, materials, fabrication, welding, inspection, protective coatings, Vendor's drawings, and delivery of welded tubular steel pole structures for overhead electrical transmission and distribution lines. This specification does not include contract pricing (front-end) documents or specifications for construction.

P.2. Responsibilities

All Xcel Energy personnel and contractors shall use this document and the procedures herein when purchasing and designing tubular steel transmission pole structures. Xcel Energy is responsible for supplying configuration drawings and load requirements adequate for the design of steel transmission pole structures. Xcel Energy is responsible for reviewing Vendor design calculations, drawings, and test reports in a timely manner.

The Vendor shall use this document and the procedures herein to design and fabricate all tubular steel transmission pole structures for Xcel Energy. Xcel Energy will not allow exceptions to this document unless submitted in writing.

P.3. Work Flow

P.3.1 Approval

The Xcel Energy Standards Council has approved this document.

Approval	Name	Title
2014/11/03	Cozad, Brad D	Manager Transmission Engineering, PSC
2014/10/30	Dunham, Michael P	Manager Trans Line Const. & Maint, NSP
2014/11/04	Kunze, Robert H	Manager Strategic Sourcing
2014/10/30	Urban, Paul J	Manager Trans Line Const. & Maint, PSC
2014/11/06	Winter, Kent G	Manager Transmission Engineering, SPS
2014/10/31	Woodard, James C	Manager Trans Line Const. & Maint, SPS
2014/10/30	West, Julia A	Manager Safety & Training

P.3.2 Creation

The following committee wrote this document:

Name	Title
Brad Hill	Engineer, NSP
Mark Flashinski	Engineer, NSP
Eliot Fisher	Engineer, SPS
Tim Wachholz	Engineer, Xcel Energy
Cary Yuan	Engineer, PSCo
Mike Garrels	Engineer, Transmission Standards
Stacey Barajas	Strategic Sourcing

P.3.3 Version History

The personnel listed above have approved the following changes.

Date	Version Number	Change
25 July 2012	1.0	Initial Version
10 November 2014	2.0	Contract revision Supersedes the following: NSP-STD-STEEL POLE STRUCTURES PROCUREMENT PSC-STD-Specification of Tubular Steel Pole Structures SPS-STD-STEEL POLE STRUCTURES

Table of Contents

1 Overview

1.1. Philosophy

The design, fabrication, allowable stresses, processes, tolerances, and inspection shall conform to the American Society of Civil Engineers (ASCE) Standard 48, "Design of Steel Transmission Pole Structures," with the additions and/or exceptions as described herein. This document lists minimum design parameters to be used unless project specific submittals indicate otherwise.

The steps for design, fabrication, and shipping of the steel structure shall be as described in Figure 1. Proceeding to subsequent steps without review by Xcel Energy will be at the Vendor's risk.

	Xcel Energy Responsibilities	Vendor Responsibilities
Structure Design	Prepare and Submit Design Loads and Structure Configuration Drawings Review and File Design Calculations, provide extended Anchor Bolt length (if applicable)	Prepare and Submit Design Calculations
Detailing	Review and File Anchor Bolt & Structure Assembly Drawings	Prepare and Submit Anchor Bolt & Structure Assembly Drawings
Fabrication	Review and File Material Test Reports, Plant audit (if desired)	Fabricate Anchor Bolts & Structures, Prepare and Submit Material Test Reports
Shipping & Installation	Receive and Install Structure	Load and Ship Structure

Figure 1: Process for steel pole design and purchasing. Anchor bolt drawings, fabrication, and delivery may precede the structures for construction and sequencing.

1.2. Glossary

Anchor Bolt

High strength threaded deformed reinforcing steel bar used to transfer loads from the pole base-plate to the concrete foundation.

Arm

Tubular structural element in predominantly horizontal orientation that supports shield wires or phase wires. Arms attach to the face of pole shafts. Arms may be uniform and attached at each end to multiple pole shafts or tapered and attached at one end.

Base-Plate

Plate attached to the bottom of the pole shaft with a full penetration weld and attached to a concrete foundation with anchor bolts.

Camber

Pole curvature, induced in fabrication, used to counteract predetermined pole deflection, such that the pole will appear straight under a specified load condition.

D/t

Ratio of the diameter of a tubular pole, or flat to flat outside diameter for polygonal pole of more than 16 sides to wall thickness

Flange Plate

Connection plate element welded to the end of pole sections and used to connect adjacent pole sections. Connection includes an equally spaced series of bolts installed through both plate elements with a recommended bolt pre-tension load.

Ground-Line

A designated location on the pole where the surface of the ground will be after installation of a direct embedded pole.

Pole Shaft

Tubular structural element in a predominantly vertical orientation, which supports wire loads with davit arms, cross arms, swinging angle brackets, or vangs, and may be freestanding or guyed.

Slip Joint

Connection of two tapered, tubular pole shaft sections where sections telescope together.

Structure

A structure consists of one or multiple tubular steel pole and all attachments, including vangs, arms, braces, brackets, anchor bolt cages, etc., supporting one or more circuits of conductors and static wires.

Swinging Angle Bracket

Support for a conductor insulator to provide adequate air gap to arm above, found on pole shafts or at the end of a davit arm.

Twist

The as-constructed angle from centerline of the arm or vang appurtenance to the theoretical location of the design reference line of the arm/vang appurtenance on the base-plate before the arm or vang is loaded.

Vang

Attachment plate used to attach shield wire or conductor insulator located either on pole shaft or on arm.

Vendor

Party named on the Purchase Order who shall be responsible for designing, fabricating, and delivering the structures covered by this specification. Work done by a subcontractor of the Vendor is the responsibility of the Vendor.

WPS

Welding Procedure Specification: the detailed essential variables, methods and practices including all joint welding procedures involved in the production of a weldment.

w/t

Ratio of the flat width to the plate thickness of a flat side of a polygonal pole.

Xcel Energy

Party on purchase order that shall be responsible for requesting and receiving structures covered by this specification. This may refer to Xcel Energy, its wholly owned subsidiaries Northern States Power Company (NSP), Public Service Company of Colorado (PSCo), and Southwestern Public Service Company (SPS) or any agents on its behalf. Its agents include staff employees, outside consultants and their duly authorized assistants and representatives.

1.3. References

Codes, standards, or other documents referred to in this specification are part of this specification, as are documents referred to in those references, etc. Unless otherwise indicated in this specification, the current edition of these references as of the date of the contract documents shall govern.

In the event of conflict between this specification and referenced documents, the requirements of this specification shall take precedence. In the case of conflict between several referenced documents, the more stringent requirement shall control. If a conflict exists between this specification, the referenced documents, or the supplied drawings, the supplied drawings shall control.

The following codes and standards are part of this specification:

- ASCE 48 Design of Steel Transmission Pole Structures
- ASTM A6/A6M Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
- ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A325 Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105·ksi Minimum Tensile Strength
- ASTM A350 Standard specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
- ASTM A354 Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners
- ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products
- ASTM A385/A385M Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
- ASTM A388 Standard Practice for Ultrasonic Examination of Steel Forgings
- ASTM A500/A500M Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- ASTM A563 REV A Standard Specification for Carbon and Alloy Steel Nuts
- ASTM A572/A572M Standard Specification for High-Strength Low-Alloy Columbium Vanadium Structural Steel
- ASTM A588/A588M Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50·ksi [345·MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
- ASTM A615/A615M Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
- ASTM A633/A633M Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates
- ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless

Steel Sheet, Strip, Plate, and Flat Bar

- ASTM A673/A673M Standard Specification for Sampling Procedure for Impact Testing of Structural Steel
- ASTM A780/A780M Standard Practices for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- ASTM A847/A847M Standard Specification for Cold-Formed Welded and Seamless High-Strength, Low-Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance
- ASTM A871/A871M Standard Specification for High-Strength Low-Alloy Structural Steel Plate with Atmospheric Corrosion Resistance
- ASTM A1066/A1066M Standard Specification for High-Strength Low-Alloy Structural Steel Plate Produced by Thermo-Mechanical Controlled Process (TMCP)
- ASTM E165/E165M Standard Practice for Liquid Penetrant Examination for General Industry
- ASTM E709 Standard Guide for Magnetic Particle Testing
- ASTM F436 Standard Specification for Hardened Steel Washers
- ASTM F1554 Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
- AWS C2.16 Guide for Thermal Spray Operator Qualification
- AWS C2.18 Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites
- AWS D1.1/D1.1M Structural Welding Code - Steel
- AWS QC1 Standard for AWS Certification of Welding inspectors
- NEMA CC 1 Electric Power Connections for Substations
- SSPC SP 1 Solvent Cleaning
- SSPC SP 7 Brush-off Blast Cleaning - NACE No. 4
- SSPC SP 8 Pickling
- SSPC SP 10 Near-White Blast Cleaning

2 Design

2.1. Process

2.1.1. Xcel Energy Submittals

Xcel Energy will provide the Vendor with design loads and geometric configuration drawings per ASCE 48 Chapter 4. Any design parameters not listed in this specification, ASCE 48, or the Xcel Energy submittals shall be at the discretion of the Vendor.

Xcel Energy provides configuration drawings as conceptual and dimensional guides. Vendor shall maintain outline dimensions as shown on Xcel Energy's detail drawings. Material dimensions presented on drawings are for guide purposes and the Vendor may deviate from them as necessary.

Xcel Energy will review the Vendor submittals. Review by Xcel Energy does not relieve the Vendor of the responsibility for the adequacy of the design calculations.

2.1.2. Vendor Calculations

The structure shall be capable of withstanding all specified loading cases, including secondary stresses from foundation movements, deflections, or apparatus loads, but not considering the possible restraining effect of conductors or shield wires. The structure shall withstand the loads without failure, permanent distortion, or exceeding any specified deflection limitations.

The Vendor shall design poles to resist, in addition to all other loads and their appropriate overload factors, the effect of deflection on all vertical loads including the dead load of the pole. The flexibility of the structure shall not reduce the specified longitudinal loads.

The Vendor shall furnish to Xcel Energy a complete set of loading calculations used in the design of each individual structure or structure family. Calculations shall include applied loads and dimensions used in final design of pole shaft, base-plate, anchor bolts, and arms. The Vendor shall supply the following information:

- Geometry, material thickness, section properties, deflections, stresses, and forces in the X and Y directions, w/t for polygonal and D/t for round cross-sections at all splices, ends of members, and at arm attachment points (top and bottom), and at least every 10-ft along the pole.
- List of materials with weights of all sections, base-plate, and anchor bolts - with appropriate ASTM specifications for the materials used.
- Ground-line reactions due to all loads for all load combinations.
- Base-plate configurations and bolt spacing.
- Anchor bolt lengths, sizes, quantities, type of materials and safety factors.

The design calculations shall be the responsibility of the Vendor. Vendor shall indicate the source of the analysis and the design of the structure if the Vendor does not perform it in-house.

The Vendor shall submit one electronic portable document format (PDF) copy of design calculations for review by Xcel Energy for each structure design or family. Vendor shall provide a table of contents for submittals that contain calculations for more than one structure.

If the Vendor believes that it would be advantageous to deviate from the requirements specified, then the Vendor may submit such alternatives. The Vendor shall indicate such alternate calculation packages with an estimate of cost or lead-time savings.

2.2. Design Restrictions

2.2.1. Material

Computed unit stress under the full design load shall be less than the minimum specified material properties as stated in the applicable ASTM specifications. Allowed grades of steel for galvanized structures are limited to ASTM A350, ASTM A572, ASTM A633, and ASTM A871. Allowed grades of steel for weathering structures are limited to ASTM A871, ASTM A588, and ASTM A1066. The Vendor shall design pole shaft and arm components with a minimum wall thickness of 3/16-in.

2.2.2. Pole Shaft Joints

The Vendor shall design the pole shaft with as few pieces as practicable for shipping and field assembly. Pole shaft joints for Xcel Energy to assemble in the field shall be slip joints or bolted flange joints. All switch poles shall have flanged joints. All other pole shaft joints shall be slip joints unless otherwise indicated on Xcel Energy submittals.

2.2.3. Deflection

Deflection at the top of the structure shall not exceed 2% of the structure height under the deflection load case unless otherwise indicated on Xcel Energy submittal.

2.2.4. Camber

The Vendor shall camber the pole if deflection of the top of the pole shaft under the camber load case is greater than one-half of the pole top diameter. The camber shall be the calculated deflection plus the tolerances specified in section 3.2.1.

2.2.5. Tolerances

The phase-to-phase and phase-to-ground dimensions on the Xcel Energy submittals are minimums. The Vendor shall account for cumulative fabrication and installation tolerances from foundation, pole shaft, joint slip, connections, and arms to maintain these design dimensions. Tolerances on loads shall be as indicated in Xcel Energy submittals.

2.3. Foundation Restrictions

2.3.1. General

For all load cases, the Vendor shall include a foundation rotation from vertical of 1.5° unless otherwise stated on the Xcel Energy submittal.

2.3.2. Direct Embedment

Direct embedded structures shall have a solid bearing plate not more than 2·in greater than the pole base diameter. (Any holes for drainage shall be in shaft walls.)

2.3.3. Foundation Supported

For structures indicated as such the Vendor shall design a base-plate and anchor bolt arrangement to resist the ground-line loads induced by the pole. The Vendor shall design base plates such that the design moment load may be applied in any direction, regardless of the base plate orientation.

The Vendor shall design the anchor bolt cluster such that the required strength is satisfactory to withstand all design conditions and tolerances without requiring the use of grout or other similar material between the base-plate and top of concrete. The design shall assume a clear space between the top of the foundation and the bottom of the base-plate equal to 2·in plus the height of the leveling nut. The minimum anchor bolt projection out of the top of concrete shall be 12·in unless otherwise indicated in the Xcel Energy submittal. Concrete strength to be used for anchor bolt design shall be as noted on the Xcel Energy drawings.

The Vendor shall supply anchor bolt patterns as specified on the Xcel Energy drawings. The Vendor shall provide an optimum bolt pattern based on minimum structure cost, and when requested, the Vendor shall provide an optimum bolt pattern minus 6·in, or an optimum bolt pattern minus 12·in. Xcel Energy will select the structure design based upon the economics of the total combined installed cost of the structure and foundation.

For design requirements pertaining to poles installed on drilled piers, detailing, fabrication, and acceptance criteria for anchor bolt cages, see Appendix A.

3 Detailing

3.1. Process

3.1.1. Xcel Energy Review

Xcel Energy will provide the Vendor with detail requirements concurrently or separately from the geometric configuration drawings. Any detailing not listed in this specification, ASCE 48, or the Xcel Energy submittals shall be at the discretion of the Vendor.

Xcel Energy will review the Vendor assembly drawings. Review of the drawings by Xcel Energy does not relieve the Vendor of responsibility for the adequacy of the design, correctness of the dimensions, details on the drawings, and the proper fit of parts. Material ordering and fabrication prior to Xcel Energy review will be at Vendor's risk.

3.1.2. Vendor Assembly Drawings

The Vendor shall furnish to Xcel Energy a complete set of assembly drawings used in the design of individual structures or structure families. Assembly drawings shall include final drawings and calculations for pole shaft, base-plate, anchor bolts, arms, and other appurtenances – including their connections – for all structures. The Vendor shall submit one electronic portable document format (PDF) copy of assembly drawings for review by Xcel Energy for each structure design or family. Drawings shall utilize Xcel Energy title blocks and drawing numbering as noted in the Xcel Energy submittal. Vendor title blocks may be used in addition to the Xcel Energy title blocks and shall be suitable for including a table of revisions. Drawing numbers shall be suitable for indexing and cross-referencing.

Assembly drawings shall show, as a minimum, the following information:

- Structure type
- Structure geometry, including pole height, phase spacing, arm length, design line angle
- Maximum design reactions at base
- Tube section data (tube length, plate thickness, large and small end OD, taper)
- Materials of construction
- Pole camber
- Bill of materials required for erection
- Individual weights of all components and the total weight of the structure
- Size and number of bolts, nuts and washers required for each connection
- Entire assembled structure, including pole shafts, arms, vangs, etc., shall be shown on a

single sheet indicating their position

- All erection procedures including bolt tensioning and slip joint jacking procedures

The Vendor shall furnish PLS-Pole back-up models of each structure prior to commencing fabrication of individual structures.

3.2. Structures

3.2.1. General

When fully assembled, structures shall meet the following tolerances:

- Straightness or camber in 10·ft: +1/8·in, -1/8·in
- Total straightness or camber: +3·in, -0·in

3.2.2. Identification

Each structure shall be permanently marked with a structure identification plate on the pole shaft at 60·in above ground-line. The marking shall include the following information:

- Structure Identifying Number
- Structure Height
- Structure Type
- Date of Fabrication
- Vendor Name
- Vendor serial number
- Ground-line Moment in ft-kips

Xcel Energy uses the following as Structure Identifying Numbers:

- NSP OpCo = Xcel Energy's item number - from the Owner supplied drawings.
- PSCO OpCo = Structure number.
- SPS OpCo = Vendor's pole number - from the assembly drawings.

When indicated on Xcel Energy submittals, structures shall also have brackets for aerial markers or welded nuts for number signs.

Positioning of identification plates shall be to the following tolerances:

- Location of Identification plate or bracket: +24·in, -24·in

Characters shall be at least 3/8·in tall, and shall be clearly legible after finishing.

3.3. Members

3.3.1. General

All longitudinal welds on tubular members shall be at least 80% penetration welds. For at least 6·in from the end of each pole shaft section – and within 6·in of circumferential butt welds – longitudinal welds shall be 100% penetration welds. In the female slip joint area (up to maximum overlap), longitudinal welds shall be 100% penetration welds up to maximum overlap length. 100% penetration welds shall be provided at all butt joints of backup strips and at circumferential welds joining structural members.

The Vendor shall fabricate members to the following tolerances:

- Arm length per 10 ft of arm length: +1·in, -1·in
- Arm rise per 10·ft of arm length: +1·in, -1·in
- Length of individual section: +3·in, -3·in
- Dimension of major axis, minor axis or diameter: +1/2·in, -1/4·in
- Total twist of members (per 10·ft of length): +1°, -1°

3.3.2. Identification and Marking

Each separate part of the steel pole structure (arms, pole shafts, etc.) shall be permanently marked to identify the type, structure, and position of the piece on the structure. The vendor shall weld one (1) nameplate on the lower end of each member. Characters shall be at least 3/8·in tall, and shall be clearly legible after finishing. For multi-section poles, the vendor shall install all nameplates on the same flat from pole top to bottom. This nameplate shall include:

- Vendor unique identifier to match with inspection reports
- Type identifier to match with assembly drawing

Identifiers shall be temporarily marked on the bottom of each pole shaft's bearing, flange, or base-plates to aid in delivery and storage. Identifiers shall be temporarily marked on each end of all davit arms to aid in delivery and storage.

Center of gravity shall be temporarily marked on at least two sides of each member to aid in handling and assembly.

3.3.3. Arm Connections

Arm connections to the pole shaft may be pinned or bolted, at the discretion of the Vendor. Pin fasteners shall utilize through bolts at ends to prevent pin removal with ANCO® lock nuts (or equivalent ratcheting style). Cotter pins, cotter keys, and common keeper pins are not acceptable. Structural pins shall have tapered ends to aid in connection fit-up.

Arms connected to two or more pole shafts shall be detailed with slotted holes or multiple holes to allow for construction tolerances to aid in field erection

Detail design of arms and pole shafts by the Vendor shall minimize the effects of biological and environmental damage. At arm end openings and at channel or box arm connections to thru vangs, provisions are required for openings greater than 1·in in any dimension to eliminate access by birds and nesting insects, and to minimize moisture retention. The vendor shall submit these details in the fabrication drawings to Xcel Energy.

The Vendor shall fabricate arm connections to the following tolerances:

- Outer dimension of inside piece of fitting pieces: +0·in, -1/8·in
- Inner dimension of outside piece of fitting pieces: +3/16·in, -0·in
- Deviation from flat of mating flat pieces in 12·in: +1/8·in, -0·in
- Spacing between holes of same connection: +1/16·in, -1/16·in
- Hole size for connection bolts or pins: +1/16·in, -0·in
- Position of arm connection relative to pole shaft: +3/4·in, -3/4·in
- Twist of arm connection relative to pole shaft center line: +2°, -2°

3.3.4. Slip Joints

Slip joints shall be marked for ease of assembly in the field. The male end shall be marked with design, maximum, and minimum insertion depths.

- Minimum slip joint – 1.5 times the maximum diameter
- Design slip joint – Minimum * 1.1
- Maximum slip joint – Design slip +5·in

The Vendor shall weld nuts (lugs) as shown on Xcel Energy submittals to provide capability to jack structure sections together. The Vendor shall provide locking devices as necessary to counteract uplift and other motion.

3.3.5. Flange Plates and Base-Plates

Circumferential welds connecting flange plates or base-plates to pole shaft shall be complete penetration welds. The Vendor shall match mark base-plates to anchor bolt template, and flange-plates to flange plate connections.

Positioning of flange and base-plates shall be to the following tolerances:

- Plate diameter: +1·in, -1/4·in
- Base-plate perpendicular to pole 1/8·in for 5·ft as measured on a perpendicular axis.

- Deviation from flat of plates in 12 in : +1/8 in, -0 in
- Spacing between holes on plates (non-accumulative): +1/16 in, -1/16 in
- Hole sizes in flange plates: +1/8 in, -0 in
- Hole sizes in base-plates: +3/8 in, -0 in
- Height of assembled structure (with flanges): +12 in, -6 in
- Total twist of base plate from center line: +2°, -2°

3.3.6. Detailing for Maintainability

The Vendor shall design tubular members of galvanized poles to minimize environmental degradation. Galvanized poles shall have a drain hole at the bottom. Galvanized arms shall have drain holes where appropriate. Galvanized poles shall have a metal cap plate covering the entire pole shaft opening to minimize wind noise and rain entry. For members of galvanized structures with openings greater than 1 in wide, the Vendor shall cover the openings to eliminate bird or pest entry.

The Vendor shall design tubular members of weathering steel to minimize environmental degradation. The Vendor shall design weathering steel pole shafts so that they are sealed against moisture penetration once erected. The Vendor shall provide airtight seal on both ends of the bottom pole section and all arms. The Vendor shall seal the upper end of the top pole section. The intermediate pole ends do not need to be sealed. The Vendor shall seal all weathering steel arms. The Vendor shall sleeve all drilled holes in weathering steel members. The Vendor shall detail weathering steel structures to avoid uncoated pockets, crevices, and faying surface that can collect and retain water, damp debris, and moisture.

Poles for direct embedment shall have a corrosion collar (ground sleeve) welded at the ground-line. Corrosion collars shall have a minimum thickness of 3/16 in. Corrosion collars shall have a length of at least 4 ft, and have 2 ft above ground-line and 2 ft below ground-line, unless otherwise indicated on Xcel Energy submittals. The Vendor shall seal weld the corrosion collar to the pole shaft to prevent moisture intrusion.

3.4. Appurtenances

3.4.1. General

Hardware attachments such as vangs, equipment brackets, end plates, swinging angle brackets, insulator attachments, and other appurtenances shall be provided when listed on Xcel Energy submittals. Holes and cuts shall be true to size, smooth, and clean without excessive tear-out or depressions. Burrs that remain after machining shall be removed by grinding, reaming, etc. The Vendor shall not perform field fabrication without approval from Xcel Energy.

Fabrication of appurtenances shall be to the following tolerances:

- Size of Chamfer: +1/32·in, -1/32·in
- Drilled Hole Sizes for Bolts and Attachments: +1/16·in, -0·in
- Hardware attachment locations relative to pole top: +2·in, -2·in
- Length and Width of Plates: +1/2·in, -1/2·in
- Location of a Drilled Hole in a Piece: +1/16·in, -1/16·in

3.4.2. Fasteners

Minimum bolt diameter for use in attaching arms, flanges, and other appurtenances shall be 5/8·in. The Vendor shall furnish bolts of sufficient length to assure full thread engagement of the nut during field assembly.

All bolts shall conform to ASTM A354 or ASTM A325. All washers shall conform to ASTM F436. All nuts shall conform to ASTM A563. The supplier shall furnish ANCO® lock nuts (or equivalent ratcheting style) for all structural and keeper bolts. Surface finish of nuts, bolts, and washers shall conform to the finish of the structure.

3.4.3. Climbing Devices

Pole shafts shall have ladder attachment clips or step lugs where indicated on Xcel Energy submittals. Ladders shall be “McGregor” type ladders or equivalent. The Vendor shall space the ladder attachment clips to avoid interference with the jacking device at pole splices. The Vendor shall place clips for ladders on one face of the pole from the top of the pole to approximately the ground-line or base-plate. The Vendor shall place clips on three additional faces from the top of the pole to approximately 10·ft below the bottom conductor attachment unless otherwise indicated on Xcel Energy submittals. Clips shall be evenly spaced around the diameter of the pole.

Each ladder clip shall support a minimum 1000·lb. vertical load and a minimum 200·lb. horizontal working load. The Vendor shall weld ladder clips to the pole surface. Ladder clips shall be located to avoid interference between ladders and other attachments. Ladder clips shall provide maximum safety, minimal projection beyond the pole shaft surface, minimum opportunity for corrosion, and shall not permit air to enter the pole shaft.

Arms or other non-vertical members shall have climbing devices if detailed on Xcel Energy submittals.

Positioning of ladder clips shall be to the following tolerances:

- Spacing between independent ladders: +3·in, -0·in
- Spacing of ladder lugs or climbing loops: +1/8·in, -1/8·in

3.4.4. Grounding Devices

The Vendor shall provide NEMA terminal pads per the dimensions described in NEMA CC-1 Annex A for grounding of the structure at all structure ground-lines, shield wire attachment points, and bolted or pinned armed connections. The Vendor shall also provide NEMA pads at flanges and slip joints on weathering steel structures.

The pads shall be stainless steel plate welded to the structure with holes tapped to a depth of at least 1/2·in. The default size shall be two-hole pads unless Xcel Energy submittals indicate otherwise. The Vendor shall not paint or cover grounding devices with any coating, and shall remove galvanizing, to shiny surface, from terminal pads on galvanized structures. For poles with base-plates, the pad shall be located 18·in vertically above the base-plate. For poles with corrosion collars, the pad shall be located 6·in vertically above the corrosion collar.

The Vendor shall provide personnel grounding loops below each conductor attachment. Personnel ground loops shall be 3/4·in diameter, stainless-steel rod. Ground loop shall be 1·ft long and project from the pole 4·in. The Vendor shall remove galvanizing, to shiny surface, from personal grounds of galvanized structures.

3.4.5. Lifting Devices

The Vendor shall provide instructions for the handling and assembly of structures. The Vendor shall provide lifting lugs or rigging holes in appropriate locations on all pole shaft sections. On single piece pole shafts and the top section of multi-piece pole shafts, the Vendor shall provide two (2) vangs at the top end of the top pole section for lifting purposes. These vangs are to be located on opposite faces that are parallel to one side of the base-plate, if possible. The Vendor may design static wire vangs to support the total weight of the structure for use as lifting vangs. The Vendor shall provide two (2) holes 2-1/2·in diameter at the top end of the base and middle pole sections for lifting purposes. These holes are to be located on opposite faces parallel to one side of the base-plate.

4 Fabrication and Quality Control

4.1. Process

4.1.1. Xcel Energy Review

Quality assurance by Xcel Energy of steel structures will occur by any or all of the following:

- Qualification of individual Vendor plants by periodic or random audits, inspections, and witnessing by Xcel Energy or third party to ensure compliance with the requirements of the specification, codes, and procedures. Xcel Energy shall have access to all parts of the Vendor's plant, which concerns the fabrication of structures under purchase. Plant inspections may be planned or unplanned.
- Review of material test reports and quality control records or other information for all major components and anchor bolts cages. Vendor shall make available material test reports and quality control records upon request for 10 years from installation.
- Random or systematic field inspections of staged or installed structures by Xcel Energy or third party.

Failure of Xcel Energy to exercise the right to inspect, witness, or audit prior to shipment shall not relieve the Vendor of the obligation to comply with the terms and conditions of the purchase order.

4.1.2. Vendor Reports and Quality control records

The Vendor shall be responsible for all quality control. Upon request, the Vendor shall clearly define their quality control functions, and provide quality control manuals for review by Xcel Energy or third party. The Vendor shall maintain permanent records of all pertinent information on materials, welding procedures, welder identification, type of inspections, inspector's test result, all visual and nondestructive testing, and other items.

The Vendor shall give written notice to Xcel Energy upon significant process changes including change of primary manufacturing plant for Xcel Energy projects, change of material, and change of welding procedures. A change of manufacturing plant shall include any manufacturing plant not used for Xcel Energy projects in the past two years. For commonly used plants, the Vendor shall provide scheduling information upon request to allow for manufacturing plant audits. The Vendor shall provide notice sufficiently in advance of the start of fabrication to permit Xcel Energy to make arrangements for inspection of facilities, materials, and fabrication methods.

The Vendor shall furnish upon request to Xcel Energy a quality control record for each major component shipped indicating materials, welding procedures, welder's identification, type of inspection, inspectors test results, records of all visual inspection and nondestructive testing, inspectors' identification and other items agreed upon between Xcel Energy and the Vendor.

Test reports include mill test reports, and Charpy test reports as described in Section 4.2. Inspection reports include but are not limited to quality control records, weld inspection reports, and coating thickness reports as described in Section 4.4.3 and Section 4.4.4.

4.2. Material Testing

4.2.1. Chemistry

The Vendor shall provide test reports indicating compliance with the chemistry requirements of ASTM A572, ASTM A588, ASTM A633, ASTM A847, ASTM A871, or ASTM A1066 for all plate used in arms, pole shafts, flanges, vangs, and base-plates. Any deviations from these compositions – such as for "roll forged plate" – shall be approved for use in writing by Xcel energy.

The Vendor shall use these test reports to reject material under the following circumstances:

- The Vendor shall reject material with high carbon equivalent for weldability. The Vendor shall reject ASTM A572 and ASTM A633 material with a carbon equivalent greater than 0.50%. The Vendor shall reject ASTM A588, ASTM A871, and ASTM A1066 material with a carbon equivalent greater than 0.60%.
- The Vendor shall manage ASTM A572 and ASTM A633 material based on silicon content to ensure high quality zinc coatings. Recommended values for silicon content are discussed in ASTM A385.

4.2.2. Mechanical Strength

The Vendor shall provide test reports indicating compliance with mechanical requirements of ASTM A6 and their respective standards for all plate used in arms, pole shafts, flanges, vangs, and base-plates. Xcel Energy requires that the mechanical test coupons shall not be heat treated separately from the plate material used.

Xcel Energy requires the Vendor to reject material that does not comply with the following supplementary requirements of ASTM A6:

- S5. Charpy V-Notch Impact Test
  All plate shall have Charpy V-Notch Testing. The frequency of the testing shall be on a heat lot basis. Minimum average absorbed energy shall be 15·ft-lb on full size samples at -20·°F.
- S18. Maximum Tensile Strength
  All plate shall comply with the maximum tensile strength limits stated in ASTM A6 S18. Maximum tensile strength of steel having a specified minimum tensile strength of less than 70·ksi, shall not exceed the minimum specified tensile strength by more than 30·ksi. Maximum tensile strength of steel having a minimum specified tensile strength of 70·ksi or

higher shall not exceed the minimum tensile strength by more than 25 ksi.

The Vendor shall use only material specified in the Vendor calculations agreed upon in Section 2 of this document.

4.2.3. Geometry

The Vendor shall provide test reports as described in Section 4.1.2 indicating compliance with geometric requirements of ASTM A6 for all plate used in arms, pole shafts, flanges, vangs, and base-plates. Xcel Energy will allow machining to achieve surface roughness requirements.

The Vendor shall ensure that all structural material is straight and clean before being laid out or worked in any manner. If straightening is necessary, the Vendor shall do it by methods that will not compromise the metal. The Vendor shall do all forming or bending during fabrication by methods that will prevent embrittlement or loss of strength in the material being worked.

The Vendor shall document all dimensional errors and steps taken to correct them on the quality control record. The Vendor shall inspect all structural components for dimensional compliance with shop detail drawings, assembly drawings, procedures, established tolerances, as defined in Section 3 of this document. All parts of the structure shall be neatly finished and free from kinks or twists. Blocks, clips, and copes shall be clean and of good quality without torn, ragged, or sharp edges

The Vendor shall reject material that does not comply with all of the above requirements.

4.3. Welding

4.3.1. Welding Program

All welding shall be in accordance with AWS D1.1. The Vendor shall demonstrate the quality of their welding program by providing the following documents for all welds (structural, non-structural, repair, etc.):

- Welding Procedure Specification (WPS)
  The Vendor shall prepare a WPS for each weld type performed. The WPS shall include the essential variables used in production welding including material parameters, type of weld joint, welding process, welding position, preheat and interpass temperatures – including provision for interruption of welding – and electrical characteristics of the weld. Any deviation from the essential variables as outlined here and in AWS D1.1/D1.1M shall require re-qualification.

- Procedure Qualification Record (PQR)
  The Vendor shall prepare a PQR to qualify each weld type performed at each factory. Certain weld types may be pre-qualified under AWS D1.1; the Vendor shall indicate as such on the WPS. Complete Joint Penetration (CJP) welds for use on base plates or flange plates, and not pre-qualified under AWS D1.1, shall be qualified as described in Appendix B.

- Welder Performance Qualification Record (WPQR)
  Welders shall be qualified in accordance with AWS D1.1 Clause 4, Part C: Performance Qualification. WPQR shall be kept for six (6) years by the Vendor.

Welding consumables used to fabricate weathering steel structures shall conform to the requirements of AWS D1.1 Clause 3, subsection 3.7.3. Welding consumables used to fabricate structures that are to be galvanized shall conform to the same requirements as prescribed in this specification for the plate materials.

4.3.2. Weld Inspection Program

The Vendor shall demonstrate weld inspection capabilities as part of their quality control program. The Vendor shall provide a concise inspection procedure, referencing the use of mock-up blocks for inspector training, equipment calibration, and sensitivity standards. Personnel qualification for nondestructive weld testing shall be in accordance with AWS D1.1 Section 6.14.6.1. The Vendor's inspection department shall demonstrate they can locate discontinuities in the base-plate, in the weld joining the base to the pole shaft, and toe cracks that may result from hot dip galvanizing. This demonstration shall be done using mock ups, as defined in AWS D1.1, Annex S, UT Examination of Welds by Alternative Techniques. The toe crack mockup shall replicate the typical formed corner of the multi-sided pole shaft. Vendor shall have bare steel and galvanized steel ultrasonic calibration blocks made of the same pole shaft material(s) utilized in the pole shafts to be used for calibrating the ultrasonic equipment prior to testing the pole shafts. Transfer correction method is an acceptable calibration method in lieu of the calibration blocks.

The Vendor shall provide certified welding reports for each structure. Report shall include all welds of the structure. The Vendor shall clearly identify each weld and the report shall consist of the method of acceptance testing, if the weld is acceptable, structure identification, date and name and signature of inspector. The Vendor shall have inspectors qualified according to AWS QC1.

4.3.3. Weld Inspection Procedures

The Vendor shall inspect all welds – including backer welds and backer strips – for cracks and other defects. The Vendor shall visually examine work to determine if it meets the requirements of this Specification. The Vendor shall measure the size and contour of welds with calibrated gauges. Welds shall be free of any cracking, either surface or subsurface, rollover, and incomplete fusion. Weld quality shall comply with AWS D1.1 Clause 6, Part C, subsection 6.9, and Table 6.1. Magnifiers may be required for clear visibility. The Vendor shall supplement visual inspection with dye penetrant inspection per ASTM E165, magnetic particle testing per ASTM E709, and ultrasonic testing, as necessary.

Quality and acceptability of complete penetration welds shall be determined by ultrasonic testing per AWS D1.1. Backing bar splice joints shall be complete penetration welds and included in the final weld joint ultrasound testing to assure complete fusion and soundness. Areas of the backing splice that fall outside of the weld zone shall be visually inspected as required by the preceding paragraph. The vendor shall not perform testing until the weldment has cooled to ambient temperature allowing potential defects time to form. The Vendor shall use a 70° 5/8·in minimum size transducer per AWS D1.1 on the entire circumference of the shaft-to-base-plate and flange plate welds, with specific emphasis on the bend lines for evidence of toe-cracking. The Vendor shall perform 100% volumetric ultrasonic testing in the weld zone to assure against shadows, dead zones, or any defects which could lead to lamellar tearing. Galvanized surfaces shall be prepared to provide a smooth surface for ultrasonic inspection on the full circumference of the shaft. Acceptance-rejection criteria shall be as defined in AWS D1.1 table 6.2 for Statically Loaded Connections.. All rejectable indications greater than 50% screen height at scanning level and within 1/16·in of the weld surface shall be investigated further with MT examination."

Additionally – for complete penetration base plate and flange plate welds subject to the thermal shock of the hot dip galvanizing process – the Vendor shall perform post-galvanizing ultrasonic inspection as outlined in AWS D1.1 Annex S, or shall perform post-galvanizing magnetic particle testing per ASTM E709.

4.3.4. Weld Repair

Any positive indications found during these examinations, and considered unacceptable, shall be repaired and re-examined using the same methods.

- All rejectable indications shall be properly excavated and magnetic particle tested to verify their removal.
- A WPS shall be used for the repair weld.
- At completion of repairs, the vendor shall inspect the repair zone plus 12·in on either side.

4.4. Surface Finish

4.4.1. Inspection

The Vendor shall document all finishing discontinuities and steps taken to correct them on the quality control record. Fabrication shall be complete prior to finishing. The Vendor shall remove all flux from welds and all sharp edges and burrs prior to finishing. The inside surface of female slip joints shall be free of any material detrimental to the assembly of the slip joint.

4.4.2. Weathering Steel

After fabrication, the Vendor shall clean the outside surface of all weathering steel structures of oil, scale, etc., removing all visible deposits of oil, grease or other contaminants in accordance with SSPC SP 1. Surface preparation Standards SSPC SP 7 shall be followed to ensure uniformed cleaning of the steel to provide the promotion of its protective oxide layer.

4.4.3. Galvanizing

For poles to be galvanized, the Vendor shall remove all flux, surface (silicone) glaze or any other inert materials or contaminants from welds, and sharp edges and burrs prior to finishing. The Vendor shall do no punching, drilling, reaming, bending, or cutting after galvanizing. After fabrication is complete, the surface of all steel for galvanized structures shall be prepared in accordance with SSPC-SP8 before zinc is applied.

The Vendor shall hot dip galvanize in accordance with ASTM A123 subject to the quality constraints described in ASTM A385. The Vendor may repair defects sized less than 0.75·in by any method described in ASTM A780. The Vendor shall repair defects sized greater than 0.75·in by thermal spray coating, or zinc based solder (“hot patching”). The Vendor shall apply protective zinc coating as follows:

- Members requiring galvanizing and with base-plate diameter less than 84·in shall be welded then hot dip galvanized.
- Members requiring galvanizing and with base-plate diameter greater than 84·in shall be hot dip galvanized, then ground to bare metal in the weld area, then welded. After completion and inspection of the welds, they shall be thermal spray coated, or zinc based soldered (“hot patched”).

For thermal spray repair work, the Vendor shall have an Operator Qualification for thermal spray zinc coating in accordance with AWS C 2.16. The Vendor shall thermal spray coat in accordance with AWS C2.18. Thermal spray coating shall have a minimum thickness of 0.005·in. Thermal spray coating of welds or repairs shall overlap galvanizing by a minimum length of 2·in.

The Vendor shall inspect thermal spray zinc and hot dip galvanized coatings for thickness by a magnetic thickness gauge. The poles shall be free of dirt, oil blisters, flux, black spots, dross, teardrop edges, or flaking zinc. In general, the structure shall be smooth, attractive, and unscarred.

Members requiring “dull galvanizing” shall be galvanized then chemically treated to provide a coloration of aged, naturally weathered, and dulled galvanized steel, except that it may be a gray or blackish gray. The treatment shall eliminate the gloss and reduce the reflectance of all surfaces, and shall provide a uniform appearance. The Vendor shall provide dulling upon request, and shall provide samples for confirmation of quality.

4.4.4. Direct Embed Coating

Poles for direct embedment shall have a coating applied that is resistant to abrasion and ultraviolet light. The coating shall extend from the butt of structure to the top of the corrosion collar. After fabrication and prior to coating, the Vendor shall clean the portion of the structure to of oil, scale, etc., in accordance with SSPC-SP10.

The Vendor shall use Chemline Chemthane 2260 or equivalent. The Vendor may change coating type, application method, and inspection procedure with prior approval by Xcel Energy. Coating shall have reliability proven by accelerated laboratory tests and outdoor exposure tests. Coatings shall have adhesion to substrate of at least 2000·psi per ASTM D4541. Further the Vendor shall ensure that the controlling state is inter-coating failure.

Direct embedment coatings showing sags, checks, teardrops, or fat edges are not acceptable. The Vendor shall check product preparation and coating thickness to ensure minimum dry film thickness requirements. The dry film thickness shall be a minimum of 15·mils. The Vendor shall perform visual inspection to detect pinholes, cracking, and other undesirable characteristics. The Vendor shall remove and recoat poles with defects of size larger than 0.75·in. Defects of size smaller than 0.75·in may be touched up.

5 Acceptance

5.1. Process

5.1.1. Xcel Energy

Acceptance is subject to Xcel Energy inspection and receipt of final calculations, drawings, and reports.

Xcel Energy will make payment of invoices for structures upon receipt and acceptance of the complete structure.

5.1.2. Vendor

The Vendor shall furnish to Xcel Energy a final set of documents used in the design and fabrication of the structures. Documents include Vendor calculations per Section 2.1.2, final assembly drawings per Section 3.1.2 and inspection reports per Section 4.1.2, The Vendor shall have a Professional Engineer seal all final drawings and calculations.

The Vendor shall notify Xcel Energy at least 48-hours (2-business days) prior to shipment that such shipment is to take place. During the 48-hour grace period following the Vendor's notification and prior to poles leaving the Vendor's plant, Xcel Energy reserves the right to delay shipment when crews, equipment, and lay-down yards are not available. Xcel Energy reserves the right to inspect the components prior to shipment. The notification shall include an electronic version of the Bill of Materials, as described in Section 5.2.2, as well as names of common carriers used, and expected time of arrival.

Any structure that is of unique and/or complex design should be shop assembled before shipment.

5.2. Shipping

5.2.1. Handling

Unless otherwise specified, the Vendor shall deliver the shipment to the address shown on the purchase order. The Vendor shall notify Xcel Energy when making each shipment. The notification shall give quantities, weight, and name of common carrier used, bill of lading number, expected time of arrival, and other pertinent information. The truck driver or railroad shall notify Xcel Energy three (3) business days prior to delivery or car spotting. Xcel Energy will furnish the name and telephone number of the representative for material receipts prior to shipping. Tubular steel structures shall be shipped in optimized truckloads, and in order of installation as stated on the Xcel Energy submittal.

All parts required for any one structure should be in one shipment, if possible. The Vendor should ship structure components or parts no more than five (5) days after the first of its component delivers. The Vendor shall box, crate, or bundle – and identify by structure – bolts, nuts, and other small hardware to prevent loss or damage, and identified by structure. The vendor shall furnish nuts and locking devices (excluding anchor bolts/nuts) in a quantity five percent over actual requirements, with a minimum of one extra per structure, unless otherwise indicated on the Xcel Energy submittals. The Vendor shall provide a field repair kit for the embedded pole coating with each shipment.

All sections shall be prepared for shipment to prevent damage during transit. The Vendor shall not use salt-treated wood blocking and urethane foams when shipping or storing weathering steel poles. The Vendor shall allow coatings to fully cure before structures are loaded for shipment. To prevent damage to the finish of the items, the Vendor shall not use chains to secure loads. The Vendor shall install plastic plugs or screws in nuts welded to the structure and to tapped holes. The Vendor shall properly block material on trucks to prevent damage to the finish or distortion of components during transit and to facilitate unloading. The Vendor shall ship all structures completely "knocked down" unless otherwise specified. The Vendor shall support pole shafts and arms with dunnage, and secure with straps as necessary. The Vendor shall properly secure the shipment to allow for safe unloading.

5.2.2. Bill of Materials

Each shipment shall be accompanied by a detailed Bill of Materials. The minimum information required on the Bill of Materials shall be: Xcel Energy project number, title, purchase order, work order number, and the Bill of Materials for each item shipped. The Bill of Material shall include description, dimension, and weight of each attachment item, section, and total assembled structure. Xcel Energy shall use this information for coding, receiving of materials, and payment for materials received.

The Vendor shall identify arms, bolts, and miscellaneous hardware by the list for match-up with the respective pole shaft. Each container or bundle of parts shall bear a waterproof tag containing the following information: Xcel Energy's name, purchase order number and purchase order item number; Vendor's name and shop order number.

5.3. Field Inspection

5.3.1. Receipt

Upon receipt, the structure will be subject to random field inspections for compliance with all of Section 3 and Section 4 of this document. The supplier is responsible for any cost associated with repair caused by fabrication error or shipment. The cost for rejected material and associated costs shall be at the expense of the Vendor.

5.3.2. Field Repairs

The quality and re-inspection requirements for field repairs shall be the same as for repairs done at the Vendor's facility. This limits the feasibility of field repairs in certain scenarios. Specifically:

- If the shipment fails to meet the requirements of Appendix A, the Vendor shall replace the material.
- If the shipment fails to meet the requirements of Section 3 or of Section 4.4 the Vendor may perform field repairs.
- If the shipment fails to meet the requirements of Section 4.2 or of Section 4.3 the Vendor shall perform shop repairs or replace the material.

Appendix A Anchor Bolt Cages

A.1. Detailing

A.1.1 Drawings

Anchor bolt drawings shall indicate:

- Bolt size
- Bolt length
- Thread length
- Bolt embedment
- Bolt projection
- Bolt arrangements
- Bolt circle
- Embedded bolt template dimensions

A.1.2 Anchor Bolts

The Vendor shall fabricate anchor bolts from steel bar conforming to ASTM A615 Grade 75. Fabrication of the threaded portion – including tolerances, galvanizing, and recommended nuts and washers – shall conform to ASTM F1554. The Vendor shall thread extended length anchor bolts at the top end to the projection length listed on Xcel Energy submittals. The Vendor shall thread partial length anchor bolts at the top end a minimum of 12·in, or as listed on the Xcel Energy submittal. Anchor bolts shall be galvanized at the top end a minimum of 24·in. Each anchor bolt shall include two hex nuts. After galvanizing, the Vendor shall thread a nut fully onto the anchor bolt and leave on for shipping.

The Vendor shall cut all anchor bolts to the length listed on the assembly drawings. The Vendor shall provide extended length anchor bolts when indicated on Xcel Energy supplied Drawings.

The Vendor shall fabricate anchor bolts to the following tolerances:

- Length of anchor bolts: +3·in, -0·in
- Length of galvanized portion on anchor bolts: +12·in, -0·in

A.1.3 Templates

The Vendor shall furnish one (1) bottom anchor bolt template (minimum thickness: 3/8·in) required that can be embedded with each foundation. The Vendor shall also furnish one (1) top anchor bolt template (minimum thickness: 3/8·in) for each foundation. Xcel Energy may request additional templates. The Vendor shall furnish intermediate anchor bolt template (minimum thickness: 3/8·in) as required that can be embedded with each foundation. The Vendor shall reinforce all templates or otherwise design them to maintain flatness and warping tolerance as specified below for optimum cage alignment after assembly.

The removable template at the top of the anchor bolt assembly shall be marked with two (2) v-notches to show the transverse direction for tangent structures and the angle bisector for angle structures. The Vendor shall drill two (2) 1/2·in diameter holes in the template at locations 90° to bisector.

The Vendor shall fabricate anchor bolt templates to the following tolerances:

- Deviation in bolt hole size in top template: +1/16·in, -0·in
- Deviation in spacing between Holes in base-plate and templates: +1/16·in, -1/16·in
- Deviation of flatness of top templates: +5/8·in, -0·in

A.1.4 Assembled Cages

The Vendor shall design anchor bolts for shipment as a rigid cage with top and bottom plates holding the anchor bolts in place. However, anchor bolt assemblies may be shipped assembled or un-assembled at the discretion of Xcel Energy.

The Vendor shall design anchor bolt assemblies to be rigid enough to withstand the normal jolts of shipping, handling, and installation with no displacement of bolts from the proper positions within the cluster, or twisting or racking of the assembly. The Vendor shall weld anchor bolts to the holding plate no more than 3·in from the bottom of the cage. The Vendor shall cut and weld cage-forming members in accordance with AWS D1.1 Section 8. The Vendor shall design the top template to be removable and to support the assembled cage during lifting and setting operations without detrimental deformations. The Vendor shall consider all miscellaneous steel used in the cage assembly for the anchor bolts as non-structural. For anchor bolts to be shipped loose, template bracing and spacers shall be provided and kitted together with the anchor bolts, templates, nuts, and miscellaneous parts for each foundation.

The Vendor shall fabricate anchor bolt cages to the following tolerances:

- Distance between anchor bolt in cluster (accumulative): +1/8·in, -1/8·in
- Distance between anchor bolts in cluster (non-accumulative): +1/16·in, -1/16·in

A.2. Fabrication

The Vendor shall provide upon request test reports with each anchor bolt assembly indicating compliance with the chemical, tensile, and bend requirements of ASTM A615 for all bar used in anchor bolts. The Vendor shall provide certification that the anchor bolts comply with the dimensional requirements of ASTM F1554. Galvanizing requirements shall be per ASTM A153. All anchor bolts shall be free of loose rust, scale, or coatings that reduce bond.

All rebar shall have Charpy V-Notch Testing. The frequency of the testing shall be on a heat lot basis (Frequency H) according to ASTM A673. Charpy impact requirements shall be 15 ft-lb minimum at -20·°F, and measured in accordance with ASTM A370.

A.3. Shipping and Handling

Anchor bolt cages shall be marked in accordance with the Vendor's drawings and shipped prior to the rest of the pole shipment, unless otherwise specified. The Vendor shall ship anchor bolts and templates together and identify each bundle by job number, customer PO, structure number. All anchor bolts after threading or galvanizing, shall be handled and stored in a manner not to damage threads. The Vendor shall handle anchor bolt assemblies and transport them to the delivery site in a manner that does not result in racking, bending or twisting of any part of the assembly. Xcel Energy considers damaged threads, or deformed, bent, or distorted anchor bolt assemblies at the delivery site reasonable cause for rejection of the material.

Xcel Energy will make payment of invoices for anchor bolts – assembled or loose – upon receipt and acceptance of the complete cage.

Appendix B CJP Weld Qualification

The Vendor shall prepare a PQR to qualify Complete Joint Penetration (CJP) welds for use on base plates or flange plates welded to shaft walls. A weld test assembly shall be prepared for through-thickness testing of the weld. A welding procedure qualification test shall be performed on the weld test assembly according to the requirements of AWS D1.1/D1.1M and additional requirements listed in this Appendix.

The weld test assembly is sketched in Figure 2. The weld test assembly shall consist of two (2) shaft plates welded perpendicular and on opposite sides of the base material. The shaft plates shall be aligned with each other and of sufficient height to obtain adequate length for through-thickness tensile specimens (suggested overall length of 20·in.). The base material shall be the maximum thickness intended for production welding, or 4·in, whichever is greater. The required test specimens shall have weld joint lengths of at least 20·in. Additional plates shall be welded to the two sides of the assembly to prevent warping. The welding of the test assembly shall be witnessed by an Xcel Energy approved independent third party.

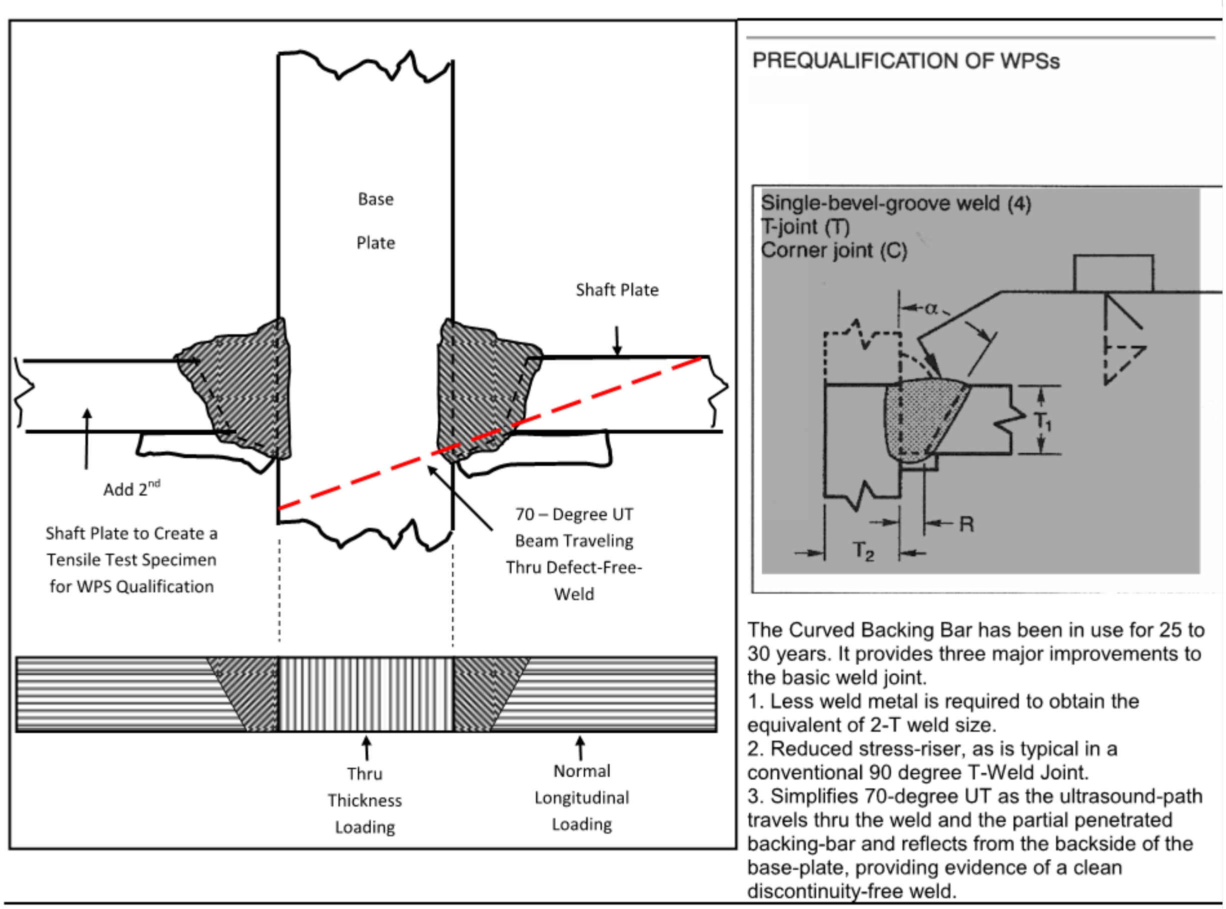


Figure 2: Weld test assembly for CJP weld qualification.

The tests conducted on the weld test assembly shall be according to the requirements of AWS D1.1/D1.1M plus additional requirements of Charpy V-notch impact specimens for both base metals (pole shaft and base-plates), both heat-affected zones, the weld deposit, and two macro-etch specimens that include the entire weld cross section (3/8·in. thick). The through-thickness tensile specimens shall include the weld joints on both sides of the base material. The Charpy specimens shall consist of one (1) set of three (3) specimens at each location. Charpy impact requirements shall be 15 ft-lb minimum at -20·°F, and measured in accordance with ASTM A370. Metallographic specimens cut from one of the macro-etch specimens shall be tested for micro-hardness across the heat-affected zone for the face of both the pole shaft and base material and at the root of the weld. Micro-hardness test results shall be 37 HRC max with an average no higher than 33 HRC in the heat-affected zone, starting at the weld interface extending for 0.060·in into the base-plate, and in accordance with ASTM A370.

The tests shall be conducted by an Xcel Energy-approved independent testing laboratory and shall be witnessed by an Xcel Energy-approved independent third party. The test results shall meet the requirements specified in AWS D1.1/D1.1M and shall be submitted to Xcel Energy for review. The Vendor shall provide and pay for program tests.

Power Transformer/Reactor Material Standard	Version: 2
File Name : XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD	Page 1 of 86

P.1. Scope and Purpose

This standard details the technical and quality assurance requirements for furnishing, testing, and delivering single- and three-phase power transformers and oil filled reactors. It supplements project specific Transformer or Reactor Detail Sheets. Provisions in this standard may be overruled by exceptions stated within the project specific Transformer or Reactor Detail Sheet. Use of this standard by the recipient is restricted to Xcel Energy, (hereafter referred to as "Purchaser,") business only. Distribution of this standard, in part or whole, to utilities or consultants outside of the Purchaser without written permission from the Purchaser is strictly prohibited.

P. 2. Responsibilities

The individuals listed below were on the Transformer Committee at the time the document was revised. The standard is a Material Standard for use with the applicable Transformer or Reactor Spec Detail Sheet.

Name	Title
Mike Ibold	Mgr –PSC Substation Engineering & Design
Susan McNelly	Lead – NSP Substation Engineering
Nate Steward	NSP Substation Engineering - Alternate
Josh Trimble	PSC Substation Engineering
Chad Schell	PSC Substation Engineering Alternate
Juan Nieto	SPS Substation Engineering
Mike Rebstock	SPS Substation Engineering - Alternate
Tom Matson	PSC Substation Maintenance Engineering

P.3. Work Flow

P.3.1 Approval

The Xcel Energy Standards Council Sponsors have not approved this document. This document was set to released on **/**/****.

Approval	Date	Name	Title

P.3.2 Version History

Extremely important to have a well documented history of major changes even when the document is being drafted. These changes may be documented when versioning through Projectwise.

The personnel listed under Section P2 above have approved the following changes.

Date	Version Number	Change
//****	2	Initial Version

Table of Contents

1. General

1.01. Scope

This standard details the technical and quality assurance requirements for furnishing, testing, and delivering single- and three-phase power transformers and oil filled reactors. It supplements project specific Transformer or Reactor Detail Sheets. Provisions in this standard may be overruled by exceptions stated within the project specific Transformer or Reactor Detail Sheet. Use of this standard by the recipient is restricted to Xcel Energy, (hereafter referred to as "Purchaser,") business only. Distribution of this standard, in part or whole, to utilities or consultants outside of the Purchaser without written permission from the Purchaser is strictly prohibited.

1.02. References

Power transformers and reactors shall meet the requirements of the following Standards listed and all other Standards as appropriate. Unless otherwise stated, the latest revisions of ANSI, ASME, ASTM, AWS, IEEE, NEMA, and OSHA Standards shall be met in the design, testing, and manufacture of the transformer~~(s)~~ or reactor, related equipment, and accessories. The ~~transformers(s)~~transformer or reactor shall be designed, manufactured, and tested in strict compliance with the latest revision of ANSI C57 series of transformer standards. Where the Transformer or Reactor Detail Sheet or this Material Standard differ from the ANSI C57 series of transformer/reactor standards, the transformer~~(s)~~ or reactor shall be supplied in compliance with the Transformer or Reactor Detail Sheet and/or Material Standard.

1.02.01. ANSI

C57.12.00	IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
C57.12.10	Transformers 230 kV and Below, 833/958 through 8333/10 417 kVA Single Phase, and 750/862 through 60 000/80 000/100 000 kVA Three Phase, Requirements for
C57.12.90	Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
C57.13	IEEE Standard Requirements for Instrument Transformers
C57.19.00	IEEE Standard General Requirements and Test Procedure for Outdoor Power Apparatus Bushings
C57.21	IEEE Standard Requirements, Terminology, and Test Code for Shunt Reactors Rated Over 500 kVA
C57.91	IEEE Guide for Loading Mineral-Oil-Immersed Transformers
C57.98	IEEE Guide for Transformer Impulse Tests
C57.100	IEEE Standard Test Procedure for Thermal Evaluation of Liquid-Immersed Distribution and Power Transformers
C57.104	Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers
C57.106	Guide for Acceptance and Maintenance of Insulating Oil in Equipment
C62.11	Metal-Oxide Surge Arresters for Alternating Current Power Circuits

1.02.02. ASTM

D877	Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
D924	Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
D971	Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method
D974	Standard Test Method for Acid and Base Number by Color-Indicator Titration
D1298	Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
D1500	Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
D1524	Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field
D1533	Standard Test Methods for Water in Insulating Liquids by Coulometric Karl Fischer Titration
D1816	Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes
D3283	Standard Specification for Air as an Electrical Insulating Material
D3612	Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography
D5837	Standard Test Method for Furanic Compounds in Electrical Insulating Liquids by High- Performance Liquid Chromatography (HPLC)

1.02.03. IEEE

C57.13	IEEE Standard Requirements for Instrument Transformers
C57.93	IEEE Guide for Installation of Liquid-Immersed Power Transformers

1.02.04. NEMA

ICS1	Industrial Control and Systems: General Requirements
ICS2	Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC
TR 1	Transformers, Regulators, and Reactors

1.02.05. OSHA

29CFR 1926	Safety And Health Regulations For Construction

2. Performance and Operation

2.01. Overload Capability and Ratings

2.01.01. The transformer shall be capable of performance at the ANSI Standard loading conditions and at the overload and normal load conditions provided in Table 1 below. All per unit overload multipliers in Table 1 shall be applied to the transformer's 65°C top nameplate rating. Bushings, tap changers, bushing current transformers (including any LDC or WTI current transformers), leads, and all other auxiliary equipment shall be provided so as not to limit the capabilities of the transformer. Lead hot spot rises shall not exceed the winding hot spot rises.

2.01.02. The transformer~~'s~~ overload capability shall be designed to perform at the per unit overloads identified in Table 1 for a 24-hour duration load cycle without exceeding the specified maximum temperatures (top oil temperature and hot spot temperature).

2.01.03. For Distribution Transformers, the overload rating shall be designed for sequential loading starting with a pre-load condition (90% of the transformer's top 65°C MVA rating for a minimum of 8 hours in duration), followed by the two-hour emergency rating, and finally the single cycle rating . The overload conditions above will be followed by a return to the 90% load condition for the remaining time of the 24-hour load cycle. The average ambient temperature is assumed to be 30°C with a peak ambient temperature of 40°C.

2.01.04. For Transmission Transformers the overload rating shall be designed for sequential loading starting with a pre-load condition (90% of the transformer's top 65°C MVA rating for a minimum of 8 hours in duration), followed by the one-half hour emergency rating, the two-hour emergency rating, and finally the multi-cycle rating. The overload conditions above will be followed by a return to the 90% load condition for the remaining time of the 24-hour load cycle. The average ambient temperature is assumed to be 30°C with a peak ambient temperature of 40°C. The overload rating applies to simultaneous loading with a full reactive, unity power factor and with the tertiary at full nameplate rating.

Table 1

Emergency Loading Criteria for Power Transformers

	Per unit overload at 30°C ambient [a,b]	Per unit overload at 0°C ambient [a,b]	Maximum Hot Spot (°C)	Maximum Top Oil (°C)
Distribution Transformers				
Emergency (2 hour) Loading	1.50 [c]	1.60	180	110
Single-Cycle (8 hour.) Loading	1.25 [d]	1.45	140	110
Multi-Cycle (8 hour) Loading	1.15 [d]	1.35	130	110
Normal (24 hour) Loading	1.05 [d]	1.20	~~120~~110	105
Transmission Transformers				
Emergency (1/2 hour) Loading	1.35 [c]	1.55	140	110
Emergency (2 hour) Loading	1.25 [c]	1.40	140	110
Multi-Cycle (8 hour) Loading	1.15 [d]	1.30	130	110
Normal (24 hour) Loading	1.00 [d]	1.00	~~120~~110	105

a **Distribution Transformers:** The temperatures and loading levels for Emergency and Single-Cycle loading are approximately equal to the "0.25% Loss of Life" per cycle rating in IEEE C57.92-1981 for the two step model for 90% pre-load, 30°C ambient, and an 8 hour peak.

b **Transmission Transformers:** The temperatures and loading levels for the 8 hour, 2 hour, and ½ hour loadings are approximately equal to the Normal Life rating in IEEE C57.92-1981 for the two step model for 90% pre-load, 30 °C ambient, and an 8 hour, 2 hour, or ½ hour peak

c The per unit overload assumes a peak ambient temperature of 40°C

d The per unit overload assumes a average ambient temperature of 30°C

2.02. Temperature and Altitude Conditions

2.02.01. The transformer or reactor shall be capable of operation for an ambient temperature range of -40°C to +40°C. All external auxiliary equipment and components shall be designed for an ambient temperature range of -50°C to +40°C, whether the ~~transformer~~equipment is in operation or in storage.

2.02.02. The transformer or reactor shall be designed for the elevation option identified in Table 2 below that correlates to the elevation identified on the Transformer or Reactor Detail Sheet. The specified impedance will be on the base ONAN MVA rating for the elevation designated as the full MVA elevation.

Table 2

Transformer Detail Sheet Elevation Requirement	Nameplate Rating Information	Minimum Elevation for Auxiliary Components and Bushings
Full MVA at 1000 m	MVA Ratings at 1000 m	1000 m
Full MVA at 1000 m, Derated at 2000 m	MVA Ratings at 1000 and 2000 m	2000 m
Full MVA at 2000 m, Derated at 3000 m	MVA Ratings at 1000, 2000, and 3000 m	3000 m
Full MVA at 3000 m	MVA Ratings at 1000, 2000, and 3000 m	3000 m

2.02.03. The ~~transformer~~ auxiliary equipment and other components (such as bushing external BIL levels and clearances) shall not limit operation of the transformer or reactor at the altitude indicated in the column labeled “Auxiliary Components and Bushings” in Table 2 above based on the elevation requirement specified on the Transformer or Reactor Detail Sheet.

2.03. Sound Levels

The transformer or reactor average load sound level shall be designed not to exceed the ~~following~~ maximum levels indicated in the Spec Detail Sheet, regardless of DETC or LTC tap position, at the transformer top 65°C MVA rating or at 115% voltage (maximum operating voltage) for reactors. Maximum levels specified are with transformer loaded to full nameplate and all fans, pumps, and equipment, such as oil filters, in operation:

~~Transformer Top Rating~~	~~Maximum Sound Level~~
~~≤ 70 MVA~~	~~10 dB below NEMA TR 1~~
~~> 70 MVA~~	~~NEMA TR 1~~

3. Design and Construction

3.01. Parallel Operation

When paralleling with LTC transformers for which a nameplate drawing and test report have been provided, the impedances must be matched at the neutral tap, as well as, within ±10% at the 16R and 16L LTC taps.

3.02. Windings and Leads

3.02.01. Windings and leads shall be made of copper material. Aluminum windings and leads are not acceptable. Rectangular windings are not acceptable for the main, tap, or regulating windings.

3.02.02. Transformer or reactor windings shall be designed to be free-buckling and shall not rely on winding tubes for their short circuit strength.

3.02.03. Winding transitions or crossovers spanning across a key spacer column **are not allowed**.

3.02.04. Insulation sleeves or flex tubes are not allowed on winding leads.

3.02.05. The Seller shall provide certification that all insulation materials used in the transformer or reactor meet the requirements of IEEE Standard C57.100 for thermally upgraded insulation.

3.02.06. For windings utilizing continuously transposed cable (CTC) type conductor, Dennison ~~calendared~~ calendered-crepe type, thermally upgraded tape shall be used~~. An alternative~~, at a minimum, for the outside two layers of tape. Alternative paper may be provided ONLY if certified thermal upgrading test results based on IEEE Standard C57.100 aging tests are provided.

3.02.07. Angular displacement of high voltage and low voltage windings shall follow C57.12.00 unless otherwise specified. Tertiary windings, when required, shall lag the high voltage windings by 30 electrical degrees unless otherwise specified.

3.02.08. Plastic self-locking tie wraps are not an acceptable material for lead support.

3.02.09. All windings, components, and parts of the transformer or reactor shall be mechanically braced to withstand through faults. The source of the fault should be assumed to be from an infinite source at one per unit voltage.

3.02.10. The transformer or reactor windings shall be oil immersed.

3.02.11. Transformer or reactor designs **shall not** include internal or LTC surge arresters.

3.02.12. Cleats and leads structure members in contact with winding leads shall be pressboard material for BIL levels 450kV and above.

3.02.13. Tertiary/Stabilizer Winding

3.02.13.01. The tertiary bushings will be located on Segment 4 unless otherwise specified.

3.02.13.02. A tertiary winding, when required, will have three leads brought out for each three-phase transformer and two leads brought out for each single-phase transformer. When a buried tertiary is specified, no leads are required to be brought out. Labeling of the tertiary shall be Y1, Y2, Y3, from left to right when facing the transformer tank.

3.02.13.03. The tertiary impedance shall be sized such that the maximum symmetrical fault at the terminals is less than 32,000 amperes for 13.8kV or 16,000 amperes for 34.5kV tertiaries. The impedances to tertiary ($Z_{(H-T)}$ and $Z_{(L-T)}$) are desired to be as low as practical while still meeting these fault requirements. All values of negative sequence impedances ($Z_{2(H-L)}$, $Z_{2(H-T)}$, and $Z_{2(L-T)}$) shall be equal to the positive sequence values, on the same base MVA. All values of zero sequence impedances ($Z_{0(H-L)}$, $Z_{0(H-T)}$, and $Z_{0(L-T)}$) shall be equal to or less than the positive sequence impedance values. When calculating fault values, assume HV and LV both as infinite bus sources.

3.02.13.04. The transformer shall be designed such that the tertiary, when present, can be simultaneously loaded by either vectoral or arithmetic, whichever is the worst-case, with the HV fully loaded for Step-Down operation, the LV fully loaded for Step-

Up operation, or either the HV or LV fully loaded for respective Step-Down or Step-Up operation as identified on the Transformer Detail Sheet.

3.02.13.05. The Seller shall indicate on the transformer main nameplate the maximum MVA load that the tertiary can carry using either arithmetic or vector loading, whichever is the worst-case condition, for the operation specified on the Transformer Detail Sheet.

3.02.14. The neutral rating from the neutral point to the bushing shall be rated for line current.

3.02.15. An X_0/X_1 ratio of 2 shall be used for the short circuit fault current calculations.

3.03. Core

3.03.01. The transformer design shall limit the internal core temperature for overload ratings as identified in Section 2.01 including simultaneous loading of the tertiary when present, to **less than** ~~130~~90°C~~.~~ rise over ambient air temperature. The reactor design shall limit the internal core temperature for specified maximum ratings to **less than** 90°C rise over ambient air temperature

3.03.02. Materials in contact with the core surface must be rated for operation at the maximum calculated core surface temperature for the overload operation requirements in Section 2, including simultaneous loading of the tertiary when present.

3.04. Drying and Processing

3.04.01. The core and coil assembly and all other internal components shall be dried by vapor-phase process to assure proper dryness of the insulation material. Transformers or reactors 450 kV BIL or below, may be dried by another method if pre-approved by the Purchaser.

3.04.02. Oil impregnated core and coil assemblies of any voltage class, which have been exposed to the atmosphere for longer than one week, shall be dried by vapor-phase process, or by another method approved by the Purchaser to assure proper dryness of all insulation material.

3.05. Transportation Strength

3.05.01. The transformer or reactor shall be designed to withstand transportation related mechanical loadings generated by impacts, swaying, yawing, fatigue, and vibration. The minimum design limits for impact loading for units shipped by rail or truck only with respect to the transformer shall be: 5 g longitudinal, 1 g vertical, and 3 g transverse directions. The minimum design limits for impact loading for units shipped by sea vessel with respect to the transformer or reactor shall be: 5 g longitudinal, 3 g vertical, and 3 g transverse directions. The transformer or reactor shall be designed to allow transportation by both rail and truck, as well as, by sea vessel when the unit will be shipped from outside North America.

3.05.02. The core legs shall have a solid support from the bottom to the top clamp to prevent sideways deformation and bulging of the outermost laminations. The core shall be adequately braced to the core clamping structure, so that it cannot move in any direction. The windings shall be tight to prevent sideways movements. The core and coil assembly and other internal components shall be supported by permanent bracing to the interior of the tank. No temporary shipping braces shall be allowed without special approval.

3.06. Load Tap Changer (LTC)

3.06.01. LTC Operation

3.06.01.01. The LTC shall provide for adjustment of the low voltage in 32 approximately equal steps in accordance with the percentage required in the Transformer Detail Sheet.

3.06.01.02. The tertiary voltage shall be constant for a constant high voltage level independent of the low voltage LTC position.

3.06.01.03. The transformer shall be suitable for full capacity operation at nominal X-terminal rated voltage and above, and reduced capacity (constant current) operation below nominal X-terminal rated voltage. The function of the LTC shall be to maintain constant voltage at the X terminals for fluctuating voltage applied at the H terminals, and to regulate the voltage at the X terminals for fluctuating load levels.

3.06.01.04. On all two winding transformers, the LTC shall be located in the low voltage winding.

3.06.02. LTC Mechanism

3.06.02.01. The LTC shall be reactance-compensated vacuum or spring-charged, resistance-bridging type.

3.06.02.02. On vacuum type LTCs, there shall be a monitoring system that supervises the integrity of the vacuum bottle. See Alarm Requirements Section 4.07.04.

3.06.02.03. The LTC shall have a 400,000 operation contact life at top nameplate rating of the transformer. The LTC shall be capable of withstanding a minimum of 200 operations over the life of the transformer at an overload of 150% of the transformers 65°C top nameplate rating.

3.06.02.04. The LTC switching compartment shall be separate from the main transformer tank. If the LTC is vented it shall pass through a desiccant to prevent the introduction of moisture to the compartment. The LTC switching compartment shall have a pressure relief device. See Section 3.15.02.01 for details.

3.06.02.05. The LTC is to be designed so that for a complete loss of control power it shall remain on position.

3.06.02.06. The LTC equipment shall be constructed so that a tap-change, once started, will be completed even if the supply or control voltage is interrupted. In the case of vacuum LTCs where this is not possible, the LTC shall be constructed so that no damage will result if the tap-changer remains in the intermediate position under full load.

3.06.02.07. A hand wheel or crank shall be provided for use during maintenance, interlocked with motor control.

3.06.02.08. An oil level indicator with high and low alarm contacts shall be installed on the side of the LTC compartment and any other isolated, oil filled compartment that may be required for the LTC. The indicator shall be readable from ground level.

3.06.02.09. The LTC switching compartment door shall have jack bolts with captive hinge pins, or similar devices, to assist in opening the door.

3.06.02.10. Any LTC equipment which requires de-energizing the transformer and draining the oil from the LTC compartment during maintenance of the drive motor and related mechanism will not be accepted.

3.06.02.11. The LTC motor drive must be designed to run off of an AC, preferably 120VAC, single-phase, source. If necessary, a three-phase 240 Volt Delta connected or 208 Volt Wye connected requirement will be allowed, but the Supplier shall verify with the Purchaser which voltage will be available. A DC voltage requirement will not be acceptable.

3.07. De-energized Tap Changer (DETC)

3.07.01. Welded, gasketed access ports on the side of the transformer must be provided if the DETC is not accessible from the top of the transformer.

3.07.02. The DETC mechanism shall be externally operated by a single operating handle extended through the wall of the tank. DETC linkage should be kept to a minimum and be such that the tap position is in a clearly defined position. The DETC handle shall have provisions for padlocking with a minimum 3/8” diameter hole for the padlock hasp, and shall provide visible indication of the tap position from the ground without unlocking. The DETC nameplate shall indicate "for de-energized operation only" or similar wording. No keyed locking device other than the provision for the padlock is allowed.

3.07.03. The DETC shall be capable of continuous operation on one tap position without rotation through the tap positions on a routine basis. Devices requiring periodic rotation through tap positions are not acceptable.

3.08. Insulating Oil

3.08.01. Insulating Oil shall conform to the requirements of ANSI C57.106. It shall be completely tested, in accordance with ASTM standards, including ASTM 1275 Method B for corrosive sulfur, and certified test reports shall be provided at the time of oil shipment.

3.08.02. Insulating oil will be Type II (inhibited) mineral oil with a target inhibitor level of 0.25% by weight and a minimum inhibitor level of 0.2% and a maximum inhibitor level of 0.3% by weight.

3.08.03. The insulating oil shall be identified on the transformer or reactor main nameplate as Type II inhibited mineral oil.

3.08.04. The Seller shall furnish a sufficient quantity of oil for the complete ~~transformer~~ installation.

3.08.05. All oil-filled compartments, including bushings, shall be certified to be less than one (1) part per million PCB. The certification shall be permanently attached to the individual compartments.

3.08.06. Transformers or reactors shipped without oil shall have oil delivered by tanker truck for Purchaser performed installations:

3.08.07. Installation of the transformer or reactor by the Seller:

3.08.07.01. The Seller shall furnish oil test reports which include all tests indicated in C57.106 and fall within guidelines indicated in C57.106.

3.08.07.02. If the transformer or reactor is shipped without oil, transfer of the oil from the truck or rail shipping container into the transformer **is not allowed** until receipt oil testing for each shipping container has been completed and reviewed by the Purchaser for acceptability.

3.09. Oil Preservation System

3.09.01. On transformers rated greater than 70 MVA top 65ºC rating, a conservator type oil preservation system is required for the main tank oil preservation system. For transformers less than or equal to 70 MVA top 65ºC rating, a gas blanketed or conservator type oil preservation system may be provided for the main tank oil preservation system. Proposals shall indicate which type of oil preservation system will be provided.

3.09.02. Spaces in which oil is in contact with air shall have a dehydrating breather provided.

3.09.03. Gas Blanketed System

3.09.03.01. Sealed tank with inert gas pressure system (nitrogen bottle make-up) with a pressure/vacuum gauge with a scale range of positive 10 psi to negative 10 psi shall be provided.

3.09.03.02. A bleed tube for gas blanket dew point measurement shall be provided from the gas space to an elevation of five feet above the base of the transformer or reactor.

3.09.03.03. The system shall include a gas control cabinet with the top mounted six feet above the base of the transformer or reactor. As per Exhibit E, typical nitrogen system.

3.09.03.04. The system shall include one standard gas storage ~~bottle~~cylinder (220 cu ft @ 21ºC, 2200 lb/sq inch).

3.09.03.05. ~~Storage bottle~~Gas cylinders shall be manufactured to US DOT type 3AA high-pressure cylinder specifications and the Supplier shall comply with the transportation requirements of the Federal Regulations, 49 CFR.

3.09.03.06. Cyliners shall be stamped or stenciled "Property of Xcel Energy" "Fill and Return". The nitrogen ~~bottle~~cylinder shall be installed at a location on the transformer or reactor, near the base of the ~~transformer~~ main tank.

3.09.03.07. Provide a one and one-half (1½) inch upper filter valve located below the 25°C liquid level, and located diagonally opposite from the drain valve (See Section 3.09.06.01). The valve shall have a flanged and gasketed connection to the tank.

3.09.04. Conservator System

3.09.04.01. Air-sealed, bladder-type conservators shall include an oil level gauge on the conservator set to alarm before exposing active part (live parts inside the ~~vacuum/pressure bleeder operates~~equipment). The gauge shall be legible from the ground.

3.09.04.02. Complete dimensions, drawings, manufacturer, and part numbers for conservator bladders must be provided in the final record drawing package.

3.09.04.03. A dehydrating breather shall be provided for the air space between the conservator tank and the bladder.

3.09.04.04. The conservator tank shall have a one and one-half (1½) inch oil fill and a two (2) inch oil drain valve.

3.09.04.05. Provide one and one-half (1½) inch upper filter valve within six (6) inches of the top (above the core and coils) of the main tank. The upper filter valve shall be located diagonally opposite from the main tank drain valve (See Section 3.09.06.01). The valve shall have a flanged and gasketed connection to the tank.

3.09.04.06. A shut-off valve shall be provided on each end of the connection piping to the main tank.

3.09.04.07. The conservator tank shall be located on Segment 4, except in the case where a tertiary winding is brought out. In the case where a tertiary is brought out, the Seller will discuss conservator tank location options with the Purchaser before the design is finalized.

3.09.05. LTC Oil Preservation System

The LTC oil preservation system shall include the following devices:

3.09.05.01. Filtered dehydrating breather, responsive to pressure or vacuum changes.

3.09.05.02. Relief of sudden, excessive pressure changes shall be provided as required in Section 3.15.02.01 of this Material Standard.

3.09.05.03. Oil level indicator, as required in Section 3.09.06.02.

3.09.05.04. A one and one-half (1½) inch or two (2) inch drain valve shall be provided to drain the oil as completely as possible but to at least within one (1) inch of the bottom of the LTC compartment.

3.09.05.05. An oil filtering system shall be provided on transformers with non-vacuum type LTCs. The filtering system shall include pumps, filters, pressure controlled shut-off switches with alarms, and an adjustable timer (settable from daily, or every other day in 2, 3, 8, and 24 hour operation intervals).

3.09.06. Accessories

3.09.06.01. A combination drain and lower filter valve shall be provided to drain the oil as completely as possible but to at least within one (1) inch of the bottom of the main tank and for outlet to the filtering means. The drain valve shall be two (2) inches with a built-in 3/8-inch sampling device. The valve shall have a flanged and gasketed connection to the tank.

3.09.06.02. Liquid Level Indicators

a) Liquid level indicators (Main Tank and **all** other oil filled compartments) shall be provided with all alarm contacts wired to terminal blocks located in control cabinets.
b) The main tank shall either have a single, magnetic-type, level indicator with two low level and one high level alarm contacts or two separate, magnetic-type, level indicators. All contacts shall be Form “C” contacts.
   i) The first low level contact and the high level contact shall activate at a level considered safe for continued operation of the transformer.
   ii) The second low level oil level indication contact is for emergency tripping on rapid loss of oil due to physical damage to the transformer.~~.~~
c) All other oil filled compartments shall have single indicators at the lowest level considered safe for continued operation of the transformer and wired to terminal blocks in the main control cabinet.

3.10. Cooling System

3.10.01. The cooling system shall be complete with power and control wiring, conduit, and automatic control of fans and pumps. Fans and pumps shall be individually connected and grounded to the power supply through a flexible, rubber-covered cord with weatherproof plugs and receptacles. Each stage of cooling shall be connected through separate circuit breakers or fuses to the power supply for protection. See Exhibit B~~1~~ for wiring details.

3.10.02. A switch shall be installed to select which bank of cooling will be designated as Stage 1 for those transformers specified with more than one stage of forced cooling. The transformer cooling must be designed (fan locations for Stage 1 and Stage 2 should be interspersed) such that the Stage 1 MVA rating is not reduced due to a rotation of the cooling stages.

3.10.03. Seller shall furnish for each cooling stage total watt and kVA requirements for the cooling power supply on the bid data sheet and on the certified test report.

3.10.04. Motors shall be totally enclosed and shall have sealed bearings. Non-metallic bearings for fan and pump motors are not acceptable.

3.10.05. When pumps are provided, a liquid flow gauge with alarm contacts shall be provided responsive to pump flow and flow direction. The flow gauge shall be located on the lower cooler piping.

3.10.06. All radiators shall be mounted separately and provided with valves so that any radiator can be removed while the rest remain in service. The radiators shall be provided with vent plugs. It is preferred that the radiators have two lifting eyes on the top of each radiator and one on the bottom. When a radiator header is provided, a shut off valve to the main tank and a drain valve shall be provided.

3.10.07. One set of additional ports, complete with valves, shall be provided to accommodate the addition of one future radiator or portable cooler for enhanced cooling.

3.10.08. Pumps, when provided, shall have valves on both sides and have bypass piping to allow removal or maintenance without having to remove or drain oil from the radiators or coolers. TecSonic bearing wear monitors shall be provided which are manufactured by Harley.

3.10.09. On two winding transformers, radiators shall not be mounted on Segment 1.

3.10.10. Fans should be mounted on the sides of the radiators, rather than on the bottom.

3.10.11. Components manufactured outside of the United States must be fully interchangeable with domestically available devices. For example, foreign manufactured fans must be interchangeable in all aspects with domestically supplied fans. This means that if the device such as a fan were replaced, that there would be no affect on the operation (in this case cooling capability) of the transformer or reactor.

3.11. Bushings

3.11.01. All bushings provided shall be sized per Exhibit A, A1.

3.11.02. All bushings shall be PD free and either porcelain, oil-filled, condenser-type, with a visible oil level gauge or sight glass at the top; or silicon weather shed type bushings.

3.11.03. Bushing external clearances shall at a minimum meet the minimum external clearances per IEEE C57.12.00. These clearances shall not be reduced due to the application of surge arresters on the transformer or reactor.

3.11.04. All bushings, including the core ground bushing, shall be cover mounted.

3.11.05. The bushing color shall be ANSI 70 light gray.

3.11.06. Draw lead bushing leads must be insulated.

3.11.07. On Distribution transformers, the neutral and LV bushings shall be identical in kV BIL and ampere ratings. On Small System and Large System transformers with graded insulation, the neutral and TV bushings (unless the TV is buried) shall be identical in kV BIL and ampere ratings.

3.11.08. The Transformer or Reactor Detail Sheet provides a minimum external bushing kV BIL rating based on a 1000m elevation. For elevation requirements above 1000m, it shall be the Seller's responsibility to ensure that external BIL and clearance requirements can be met for the increased elevation requirements. The Seller shall provide higher BIL bushings than the specified minimum rating when necessary to meet the elevation requirements as identified in the Transformer or Reactor Detail Sheet and Section 2.02.02 of this document.

3.11.09. A NEMA four–hole or larger pad for bushing terminal connectors, depending on overload ampacity requirements, shall be furnished by the Seller and shall be tinned for compatibility with either aluminum or copper connections. For 230 kV (900kV BIL) and above, corona free terminal connectors shall be provided. The bushing terminals shall be threaded type studs.

3.11.10. Draw lead or draw rod connections with silver plated threaded studs are preferred. The lead shall be tied inside the bushing cover for shipment.

3.11.11. All bottom connected bushings must be accessible through a cover mounted removable access plate.

3.11.12. Bushings rated 350 kV BIL and above shall have a bushing test tap.

3.11.13. The tertiary bushings shall be located on top of the transformer cover, common to Segment 4.

3.11.14. To facilitate neutral grounding of the high and/or low voltage neutral (H_o/X_o), the Seller shall furnish a permanently installed 1/4" x 3" rigid copper grounding bus. This bus shall be installed from a stainless steel, NEMA standard four (4) hole ground pad on the transformer or Reactor cover adjacent to the neutral bushing, down the side to the stainless steel, NEMA standard four (4) hole ground pad (referenced in section 3.15.02.05) located six (6) inches from bottom of transformer base. The copper ground bus shall be painted ANSI 70 gray except at the termination points to blend with the transformer tank.

3.11.15. The transformer or reactor design shall not utilize reduced clearance capabilities specific only to one bushing manufacturer. The transformer or reactor design shall allow for interchangeability of all approved manufacturer's bushings in accordance with ANSI C57.19.00. The Purchaser understands that adaptation of the bushing flange may be necessary for interchangeability.

3.11.16. Core Ground Bushing(s)

3.11.16.01. ~~The transformer core~~Core grounds (main, preventative autotransformer, and series transformer) shall be grounded on top of the main ~~transformer~~ tank.

3.11.16.02. The core ground bushing(s) shall be rated 5 kV minimum.

3.11.16.03. The core grounds shall be connected to the tank with a detachable connector so the cores can be meggered without opening the tank or lowering the transformer or reactor oil.

3.11.16.04. The core ground assembly shall be enclosed with a weatherproof, removable cover to prevent physical damage to the core ground bushing~~.~~ and to the ground circuit. The ground point should be inside the protective cover.

3.11.16.05. The lead, connector, and bushing shall be accessible from a handhole or manhole in the transformer or reactor tank cover for core ground testing purposes.

3.11.16.06. A core ground nameplate shall be supplied adjacent to the bushing protective cover. When multiple ground bushings are brought out, they shall be clearly labeled as to their purpose.

3.12. Bushing Current Transformers (BCT)

3.12.01. Bushing and in winding current transformers shall meet IEEE C57.13 and be furnished as required in the Transformer Detail Sheet.

3.12.02. The continuous current Thermal Rating Factor (TRF) shall be as specified on the Transformer Detail Sheet and shall be identified on BCT performance curves, on the main nameplate with BCT information, and stamped on the CT nameplate (See Exhibit B~~2 and B3~~ for terminal block wiring details).

3.12.03. The bushing and in winding current transformers for Purchaser’s use shall be ANSI standard multi-ratio type unless otherwise specified.

3.12.04. The set of relay class BCTs (not including WTI BCTs or in-winding CTs unless otherwise noted) closest to the windings on the HV and LV bushings should have the polarity towards the windings, all other BCT polarities should be on the side towards the bushings.

3.12.05. Metering BCTs, when required, shall be ANSI standard with an accuracy class as specified on the Transformer or Reactor Detail Sheet.

3.12.06. For autotransformers, the WTI CT shall be installed ~~on~~for the series, common (neutral end, not line end), and tertiary windings.

3.12.07. There shall be no internal splices or joints in BCT or CT wiring between the BCT or CT and the junction box.

3.13. Arresters

3.13.01. Approved Arrester suppliers are listed Exhibit A, Section A2.

3.13.02. Arresters shall be in accordance with the latest IEEE C62.11.

3.13.03. Surge arresters shall be gapless, metal-oxide, station-class arresters and shall have polymer housings.

3.13.04. Arrester ratings shall be supplied as specified on the Transformer or Reactor Detail, Sheet. The ~~transformer~~manufacturer shall provide arresters and self-supporting, tank-mounted, arrester brackets adjacent to their respective bushings on all winding phases brought out.

3.13.05. The arrester color shall be ANSI 70 light gray.

3.13.06. All required terminal connectors and hardware (including voltage grading rings as recommended by the arrester manufacturer) shall be included with the arresters. Arresters shall have a two-hole or four-hole NEMA terminal connector. Spacing of arresters and bushings must take into account grading rings and hardware.

3.13.07. Arrester line terminals shall be tin plated.

3.13.08. A copper ground bus loop, consisting of rigid copper bus bar or 4/0 AWG cable shall be provided by the Seller to provide an electrical ground connection between the arrester grounds and the ground pads (referenced in section 3.15.02.05) at the base of the transformer tank. The copper down lead shall be supported on the tank at intervals not to exceed 4.5 feet. The copper ground lead shall be painted ANSI 70 gray except at the termination points to blend with the ~~transformer~~ tank.

3.13.09. Arrester mounting brackets shall not be mounted directly on radiators or radiator headers.

3.14. Neutral Grounding Reactors (NGR)

3.14.01. When specified, the Seller shall furnish a tank-mounted, air-cooled, outdoor, neutral grounding reactor, complete with all mounting material and a nameplate, but without a surge arrester.

3.14.02. The tolerances for the neutral grounding reactor impedance shall be +7 to -3%.

3.14.03. The neutral grounding reactor color shall be ANSI 70 light gray.

3.14.04. The neutral grounding reactor nameplate shall be mounted near the transformer nameplate and shall show reactor impedance (in ohms), continuous current rating, voltage rating, and the 10 second current rating.

3.14.05. The neutral grounding reactor impedance in ohms shall also be clearly shown on the main transformer nameplate.

3.14.06. The neutral grounding reactor shall be mounted on the transformer tank near the X_o neutral bushing. The neutral grounding reactor shall be mounted to the left of the X_o bushing on segment 1 side of the cover, such that a minimum clearance of 24" shall be maintained from the reactor and a plane perpendicular to the tank wall. When "*mounting provisions only*" are specified in the Transformer Detail Sheet, the mounting bracket shall allow the above requirements for the specified neutral grounding reactor information.

3.14.07. A ¼" by 3" rigid copper bus shall be provided to connect the neutral grounding reactor to the X_o bushing and from the neutral grounding reactor to the ground pad (referenced in section 3.15.02.05) at the base of the transformer as required in Section 3.11.14.

3.15. Tank

3.15.01. General

3.15.01.01. The transformer or reactor shall be designed with the following facilities for moving and handling:

a) Welded cover with lifting eyes
b) Lifting facilities for the core and coil
c) The jacking point shall be not less than sixteen inches above the floor line and shall provide a minimum unobstructed jack clearance of six inches from the tank wall or other obstruction. The jack pad shall have a minimum area of 4" x 4".
d) The tank base shall be designed to be capable of moving the completely assembled transformer, with or without oil, on pipe rollers along either axis, and to prevent corrosive failure in the presence of water on a flat concrete slab. Flat base transformers are preferred and must be at least ¾ inch thick. This capability shall be indicated on the base and outline drawing.

3.15.01.02. Center lines of gravity (shipping and complete) of the transformer or reactor shall be identified and designated by punch marks or nameplates on each side and each end of the ~~transformer~~tank.

3.15.01.03. Oil filled compartments (main tank, LTC, piping, and auxiliary) shall be designed for full vacuum filling. If a compartment cannot be independently vacuum filled, an exception shall noted on the proposal. If a compartment cannot be independently vacuum filled this shall be clearly stated on the outline drawings and on the transformer or reactor nameplate. Valves capable of withstanding full vacuum shall be provided to isolate all of these compartments.

3.15.01.04. All interiors and exteriors of tanks (including the base), enclosures, cabinets and other metal parts which are not galvanized, stainless steel or of corrosion resistant material and are exposed to oil or weather shall be thoroughly cleaned and painted as required in Section 3.15.01.05 and 3.15.01.06. Galvanized materials shall not be used for any interior parts exposed to or in contact with oil, including all valves.

3.15.01.05. The interior color of the transformer or reactor tank and control cabinet(s) shall be white and shall be fully capable of withstanding ~~transformer~~ operating conditions as identified in Section 2.01 without degradation such as chipping, cracking, or peeling.

3.15.01.06. Exterior color of the transformer or reactor and ~~transformer~~ accessories shall match in color, and shall be ANSI 70 light gray. The Seller shall supply a minimum of two (2) 12oz. spray cans of touch up paint.

3.15.01.07. The top of the transformer or reactor tank shall be covered with a skid resistant paint, the same color as the exterior tank walls. A note indicating that this has been provided shall be included on the ~~transformer~~equipment outline drawing.

3.15.01.08. Tank side seams and the connection point of the tank sides to the tank bottom shall be fully welded both inside and outside.

3.15.01.09. Tank corner seams shall be set back a minimum of 2 inches from the actual tank corner.

3.15.01.10. Leaks discovered during tank and component testing in the factory shall be repaired by welding only. Leaks shall not be repaired by use of epoxy or other similar substances.

3.15.01.11. Manholes

a) A minimum of two 24” diameter manholes shall be provided on top of the transformer or reactor tank.
b) One of the required manhole covers shall include a one (1) inch threaded nipple and a flanged vacuum fitting for connection of a four (4) inch diameter vacuum hose. The four (4) inch (nominal) vacuum fitting shall have eight (8) ¾-inch diameter bolt holes, equally spaced on a 7½-inch diameter bolt circle. The vacuum fitting flange shall be mounted sufficiently high off of the manhole cover to allow for easy access for removing and replacing bolts and nuts.

3.15.02. Accessories

3.15.02.01. Pressure Relief

An automatic, directed-flow, pressure relief device shall be provided on the cover of both the ~~transformer~~ main tank and the LTC compartment to relieve excessive internal pressure. The location of the pressure relief device shall be such that operation of the device will not result in physical damage to bushings.

PVC piping for directed flow is not allowed. Piping be shall be screened at the bottom to prevent access to birds and animals.

a) Pressure Relief Device (Main Tank): An automatic pressure relief device (63P-1(MT)) with form C alarm contacts wired out for Purchaser's use (see Exhibit B~~1~~) shall be provided on the cover of the ~~transformer~~ main tank to relieve excessive internal pressure. This device shall be of the mechanical, automatic resealing type, and shall include a manually resettable target.

b) Pressure Relief Device (LTC Compartment): A pressure relief device (63P-2(LTC)), with form C alarm contacts shall be provided wired out for Purchaser's use (see Exhibit B~~1~~). The device shall be of the automatic resealing type, and shall include a manually resettable target.

3.15.02.02. Fall Protection Devices

a) Brackets for mounting of 2 inch diameter pipes for use as safety rails shall be provided at the top of the transformer or reactor. Design and fabricate brackets to resist OSHA required lateral loads at the top of the safety rail. Brackets shall be spaced a maximum of 4 feet apart, with one on or near each corner of the transformer or reactor. See Exhibit C, Figure 1 for details.

b) A weld-on base as shown in Exhibit C, Figure 2 shall be provided near the center of the transformer or reactor top. It will be used for attaching a 4' Purchaser supplied tether pole to meet OSHA's 29CFR 1926.502(d). The base should be designed to support a horizontal force of 10,800 lbs at the top of a 4' tether pole. The area above the base should be clear of obstructions as to facilitate attachment of the Purchaser supplied tether pole.

c) ~~Unique Concepts Ltd.~~Capital Safety (DBI SALA) weld-on base(s), item #~~108168~~517412 with a tie off anchor, shall be installed by the Seller for attachment of a portable fall arrest system provided by the Purchaser. The weld-on base shall be installed on the transformer or reactor cover within three (3) inches of each manhole. See Exhibit C, Figure 3 for placement details. A Seller fabricated version of this part is NOT acceptable.

3.15.02.03. All gauges or indicators shall be legible from the ground. Devices mounted at a height of greater than ~~6'~~10' from the base of the transformer or reactor shall be mounted at an angle of 30° from the vertical plane.

3.15.02.04. All accessories, including the LTC indicator, having drag pointers that need resetting, shall have the reset device located no higher than six (6) feet above the base of the transformer or reactor.

3.15.02.05. Four stainless steel, NEMA standard four (4) hole ground plates one on each corner of Segment 1 and 3, one stainless steel, NEMA standard four (4) hole ground plate located on the top of the transformer or reactor near the ~~H_0/X_0~~neutral bushing(s), and stainless steel, NEMA standard two (2) hole ground plates adjacent to each core ground bushing.

3.15.02.06. Two (2) grounding brackets, for portable grounds, shall be provided per high- and low-voltage side of the transformer or reactor, for a total of four grounding brackets. The brackets shall be made of copper or stainless steel and shall be brazed if copper, or welded if stainless steel to the tank near each corner on both the high- and low-voltage sides. A minimum of 6 inches of clear space to all sides of the bracket shall be provided. If brackets cannot be mounted due to obstructions such as radiator fins, the brackets should be mounted just around the corner. Appropriate procedures for brazing copper or welding stainless steel to the tank shall be used to ensure both good electrical conductivity and mechanical strength. The brackets shall not be painted. See Exhibit D for dimension details.

3.15.02.07. Gaskets and gasketed joints shall be designed so that the gasket shall not be exposed to the weather or standing water, and shall be provided with mechanical stops to prevent crushing. Dimension and material information shall be supplied for all gaskets with Approval and Final drawings.

3.15.02.08. The Seller shall furnish one (1) complete extra set of gaskets for all bolted gasketed manholes, handholes, and bushings to replace shipping gaskets for the initial installation.

3.15.02.09. The transformer or reactor shall be fitted with a suitable connection for the future addition of a gas-in-oil monitor. This connection shall include ~~a~~two 1½ inch ~~valve and~~valves, with a protective cover over ~~the~~each valve opening. The ~~valve~~valves shall have ~~a~~ flanged and gasketed ~~connection~~connections to the tank. See Exhibit A, Section A3 for information regarding the location and specification of mounting provisions.

3.16. Nameplates

3.16.01. All nameplates shall be inked and engraved stainless steel. Nameplates shall be attached by at least four bolts or rivets. Mounting holes shall be provided with rubber grommets or equivalent to decrease vibration noise.

3.16.02. The main ~~transformer~~ nameplate shall be in accordance with ANSI C57.12, and shall include the following additional information:

3.16.02.01. The ~~transformer~~ main nameplate shall include the Purchaser's transformer Uniquely Tracked Commodity (UTC) number, which is a unique number for tracking transformers. The UTC number will be provided to the Seller at the time Approval Drawings are reviewed.

3.16.02.02. The ~~transformer~~ main nameplate shall include the transformer MVA or reactor MVAR ratings at the altitudes identified in Section 2.02.02.

3.16.02.03. For transformers with a tertiary winding that is brought out, the nameplate shall indicate the maximum MVA load that the tertiary can carry per Section 3.02.13.05 and whether the loading is vectoral or arithmetic.

3.16.02.04. The nameplate shall indicate that the transformer or reactor was originally provided with Type II inhibited oil per Section 3.08.03.

3.16.02.05. The CT Thermal Rating Factors shall be identified on the main nameplate per Section 3.12.02.

3.16.02.06. The neutral grounding reactor impedance, when required, shall be provided on the main nameplate per Section 3.14.05.

3.16.02.07. Any oil filled compartment (including conservator bladders) that cannot be independently vacuum filled shall be identified on the main ~~transformer~~ nameplate per Section 3.15.01.03.

3.16.02.08. Ratios and ampacity of series or preventive auto transformers and/or the LTC, when present, shall be provided on the main nameplate.

3.16.03. A temperature relay nameplate shall be supplied and shall give the recommended temperatures at which the first set of cooling equipment shall be started, the second set of cooling equipment shall be started, and the temperature at which an alarm shall be actuated. All of these shall be calculated on the basis of operation at 65°C winding temperature rise. This information shall also be provided on the wiring diagram. The nameplate shall be mounted on or near to the temperature indicator(s) and shall be identified on the transformer outline drawing.

3.16.04. LTC and DETC nameplates shall be provided and shall include make and model information, the turns ratio of the LTC coupling transformer, if applicable, year of manufacture, model number, continuous current rating and the maximum overload rating.. These nameplates shall be mounted next to the main nameplate or the information may be incorporated into the main nameplate.

3.16.05. All gauges shall have a nameplate to identify their specific function, i.e. “Main Tank Oil Level.” This includes, but is not limited to, oil levels, oil temperatures, and winding temperature gauges. The nameplates and their locations shall be identified on the transformer outline drawing.

4. Controls and Protection

Standardized control drawings (See Exhibit B) have been provided as a guide/example for the Supplier to follow in preparation of control drawings. These drawings are meant to depict a general uniform look and feel that Xcel Energy would like to see used for the control drawings. The drawings in Exhibit B are only examples. Some of the information shown is to provide an example of what type of information for devices should be provided. They are not an indication as to specific vendors, materials, or catalog numbers, **unless** those vendors, materials, or catalog numbers are specifically required to be used per this Power Transformer/Reactor Material Standard or any of the remaining Exhibits.

4.01. Main and LTC Control Cabinets

4.01.01. All equipment, alarms, controls, protection, and current transformer leads shall be brought to individually identified terminals on terminal blocks centralized in a NEMA type 3 control cabinet mounted on the equipment tank. The cabinet(s) shall be fabricated of steel plate of sufficient thickness to prevent warping or buckling and shall have drip-proof hoods.

4.01.02. The cabinet(s) shall include vertically hinged doors arranged to permit ready access to the cabinet from the ground level. A locking device shall be provided to hold the doors in the fully open position. If design of cabinets be such that door width is in excess of 30 inches, double doors shall be provided such that the door width does not exceed 30" and the doors shall be hinged for center opening. Hinge material shall be stainless steel. If it is not possible to limit the door size to 30", suitable cross bracing must be used strengthen the door and prevent twisting or flexing of the door.

4.01.03. Doors shall have three-point latches for the closed position and shall include provisions for attaching padlocks. Additional locking provisions using keys, screwdrivers, special tools, bolts, or screws to secure the door shall not be used. The control cabinet outline layout drawing shall indicate with a note that the three-point latch is provided.

4.01.04. The control cabinet preferred location is on Segment 1 of the transformer or reactor. The top of control cabinet(s) shall not be more than seven (7) feet above the bottom of the tank. The bottom of the control cabinet(s) shall be located a minimum of 2.5 feet above the bottom of the tank. If location of the control cabinet on Segment 1 will require it to be removed for shipment, alternate locations should be discussed with the Purchaser.

4.01.05. A removable, gasketed plate, minimum size 12" x 16", shall be provided in the bottom of control cabinet(s) to permit field drilling and installation of control system conduits. The Seller shall not place the plate directly under any device within the control cabinet that would encumber the pulling of control conductors into the cabinet.

4.01.06. A metal drawing pocket shall be installed inside the main control cabinet. The size of the pocket shall be a minimum of 12 inches wide by 8 inches high by 3 inches deep or larger if required. The transformer or reactor shall be shipped from the factory with a complete instruction manual, all drawing attachments, and a copy of the test report included within the drawing pocket.

4.01.07. All control devices, controllers, and control systems and assemblies shall be in accordance with NEMA ICS 1 and 2 and shall meet the requirements of this Standard.

4.01.08. The transformer or reactor control cabinets shall be equipped with both thermostatically and continuously energized heaters. The continuously energized heater shall be adequate for prevention of condensation buildup, without overheating any apparatus, for the ambient temperature range indicated in Section 2.02.01.

4.01.09. The control cabinet shall be equipped with a 120V duplex receptacle (3-wire) with ground fault interruption (GFI) served from the same air circuit breakers as the cabinet lighting. The air circuit breakers shall be sized to provide overcurrent protection. A work light shall be mounted in the control cabinet with a door activated switch.

4.01.10. Cable conduits entrances into the control cabinet shall have a protective grommet to protect cable from rubbing on the edge of the conduit.

4.02. Auxiliary Power

4.02.01. All auxiliary components requiring AC power shall be capable of operation at 120/240 Volt, three-wire, single-phase and 120/208 Volt, three-wire, single-phase.

4.02.02. The DC source voltage shall be as indicated in the Transformer or Reactor Detail Sheet.

4.02.03. All auxiliary power circuits shall be protected by air circuit breakers at the control cabinet. The supply voltages will be regulated to within plus and minus 10% of nominal.

4.02.04. All air circuit breakers required by this document shall be industrial class, molded case, UL listed for use on 125 volt DC, minimum 10,000 amp DC I.C. and 240 Volt AC, 22,000 amp I.C.

4.02.05. Provide separate circuits for cooling and LTC control AC power sources.

4.02.06. The total auxiliary load shall be noted in kVA on the control schematic diagram.

4.03. Rigid Conduit

4.03.01. ~~Rigid~~ Appropriate UV-rated, rigid (galvanized steel) conduit shall be used for all power, control, and alarm external wiring. When the wiring terminates at an externally tank-mounted power, control, or alarm device, rigid conduit shall be provided to a suitable location near the device. Wiring may be routed through tank support channels as an alternate to rigid conduit.

4.03.02. Liquid-tight, flexible, metal conduit may be provided from a point near the device to the device itself.

4.03.03. All conduit, cable, and fittings shall be weatherproof, and securely fastened to the transformer at regular intervals. Rubber covered cable is acceptable for fans and gauges, and external wiring runs of less than 4 feet, however, its use shall be limited. Cable lengths shall be appropriate to the location of the device. Excess cable that has to be coiled is not acceptable. Fan cables shall not be tied to radiator fins.

4.04. Wiring

4.04.01. All wire shall be stranded, tinned, copper conductor with 600V flame-retardant, cross-linked synthetic polymer insulation, type XHHW or equal.

4.04.01.01. The minimum size for control and alarm functions shall be stranded No. 14 AWG.

4.04.01.02. The minimum wire size for motor circuits, power circuits, and CT circuits shall be No. 12 AWG.

4.04.02. Wiring shall not be spliced or tapped. All interconnections shall be made and identified with wire markers at equipment terminals or terminal blocks.

4.04.03. Enclosed terminal boards with screw-type terminal blocks and marking strips shall be used to terminate all wiring. Screws shall be cinch-head type or shall include star or lock type washers. Screws provided shall have slotted-head, not universal-type head. Approved terminal blocks are listed in Exhibit A, A4. A minimum font size of 8pt shall be used on terminal block marking strips.

4.04.04. Associated terminal points shall be grouped together to facilitate the use of multi-conductor control cables for interconnecting equipment. A minimum of 10 percent spare terminals shall be provided and shall be grouped and reserved for Purchaser's use only (See Exhibit B~~1~~). All equipment shall be wired to the terminal blocks in the control cabinet.

4.04.05. All terminal blocks shall be mounted on side or back walls only, and shall be easily accessible with normal tools.

4.04.06. All CT secondary leads shall be brought to terminal blocks identified in Exhibit A, A4 mounted in a junction box outside the transformer tank.

4.04.07. All connectors used for terminating current transformer, control, and secondary wiring shall be full circle lugs with non-insulating, seamless barrels for visible crimping. Burndy type YAV Hylugs are preferred.

4.05. Fault Pressure Relay

4.05.01. On conservator type ~~transformers~~units, a gas-detector relay (71GD), Buchholz fault sensing relay, shall be provided, see Exhibit A, A5.01 for approved types. The relay shall be located in the piping between the main tank and the conservator. Form C contacts rated for a minimum of 10A (wired out to terminal blocks for Purchaser's use) shall be provided – see Exhibit B~~1)~~. The Seller is responsible for providing the Purchaser information on the Buchholz relay to be used. This relay shall be complete with piping, fittings and detailed instructions that describe the mounting of the relay to the piping in the assembly instructions of the transformer. Methods for directing evolved gases from the transformer or reactor other than external piping are preferred. If external piping is provided, it shall be of rigid steel with minimal joints. Piping, when necessary, shall not impede access to manholes, hand holes, fall protection mounting provisions, junction boxes, or other necessary access points. See Section 3.09.04.06 for valve requirements.

4.05.02. For gas-blanketed type transformers or reactor, an oil type, flange mount rapid pressure rise relay (RPRR, dev. 63-1 (MT)) shall be provided, see Exhibit A, A5.02 for approved devices.

4.05.02.01. A continuous wire assembly without splice shall be provided between the RPRR connector and the transformer or reactor control cabinet. The cable assembly shall terminate at the RPRR with a female Mil Spec pin and sleeve connector. See Exhibit A, A5.02 for approved devicesA straight connector is preferred. The cable from the RPRR to the control cabinet shall be protected from the elements by weatherproof conduit, a weatherproof armored flexible cable, or Sealtite conduit. The conductor shall not be exposed rubber insulated or jacketed.

4.05.02.02. A two (2) inch shut-off valve shall be provided between the tank and the relay on the transformer or reactor for purposes of isolation and testing. The valve and RPRR assembly should be mounted on the side of the main tank, accessible for testing from ground level. The mounting height of the RPRR shall be no more than 5 feet above the bottom of the ~~transformer~~main tank. The RPRR shall be mounted or protected in such a manner that it is protected from falling objects.

4.05.03. An oil type, flange mount rapid pressure rise relay (RPRR, dev. 63-1 (MT)) shall be provided on the LTC, see Exhibit A, A5.03 for approved devices.

4.05.03.01. A continuous wire assembly without splice shall be provided between the RPRR connector and the transformer or reactor control cabinet. The cable assembly shall terminate at the RPRR with a female Mil Spec pin and sleeve connector. See Exhibit A, A5.03 for approved devices. A straight connector is preferred. The cable from the RPRR to the control cabinet shall be protected from the elements by weatherproof conduit, a weatherproof armored flexible cable, or Sealtite conduit. The conductor shall not be exposed rubber insulated or jacketed.

4.05.03.02. A two (2) inch shut-off valve shall be provided between the tank and the relay on the LTC tank for purposes of isolation and testing. The valve and RPRR assembly should be mounted on the side of the LTC tank. The RPRR shall be mounted or protected in such a manner that it is protected from falling objects.

4.06. Temperature Monitors

4.06.01. The cooling system shall be controlled and monitored by a temperature monitor responsive to the winding hottest spot temperature and to the top oil temperature of the transformer or reactor.

4.06.02. Temperature monitors shall be mounted adjacent to, or within, the ~~transformer's~~ main control cabinet, at an approximate height of 5 ft. to the center of the device above the base of the transformer or reactor (for easy viewing from ground level). All Purchaser required outputs shall be wired out and terminated to terminal blocks located in the ~~transformer's~~ main control cabinet, as shown in the attached Exhibit B~~1~~.

4.06.03. Pick-up set points for the temperature monitors shall be set as indicated below. A temperature set point nameplate shall be provided adjacent to the temperature monitor.

	Pick up ° C Setting
Stage 1 Cooling	55° C
Stage 2 Cooling	65° C
Alarm Hot Spot (49T)	130° C
Alarm Top Oil (26Q)	110° C

For transformers with pumps, the manufacturer may provide alternate recommended settings for consideration.

4.06.04. Electronic Temperature Monitor (ETM)

4.06.04.01. Electronic Temperature Monitors, when specified in the Transformer Detail Sheet, shall be provided. ETMs approved for use are indicated in Exhibit A, A6.01 .

4.06.04.02. Electronic Temperature Monitors shall have the following features:

a) Hot spot CT input for calculated winding temperature - The hot spot CT shall have a rated 5 amp output for input into the ETM. If the available current at 200% of the ~~transformer's~~transformer or reactor maximum nameplate rating exceeds the input rating of the ETM Manufacturer, auxiliary CTs may have to be used to prevent damage to the ETM.
b) Top oil input for top oil temperature - The input shall come from a removable temperature probe mounted on the side the tank in a closed, unheated, dry, thermowell. The dry well shall be located such that it is always at least one (1) inch below the oil level at minimum operating temperature. The dimensions for the thermowell used with the ETM should adhere to the requirements of IEEE Std. C57.12.00. Wet wells are not acceptable.
c) The source to the ETM shall be as specified for the DC control voltage on the Transformer or Reactor Detail Sheet. Set point relays shall be configured such that on loss of DC, all stages of fans (**not pumps** if applicable) shall be

triggered to come on. Set point relays shall also be configured to allow their response to sensor failures to be set by the user.

d) A minimum of six (6) form C dry contact outputs shall be provided to control cooling auxiliaries and alarm initiation. Four of the six output contacts shall be used for 1st and 2nd stage temperature alarm levels on each the top oil and hot spot winding temperatures, with the other contacts used for controlling the cooling system response to the simulated winding hottest spot temperature. The four ~~-~~top oil and hot spot winding temperature outputs shall be 0 to 1mA DC (corresponding to 0 to 200°C) and shall be labeled as such on the control drawings. If the ETM does not have relays with a 125VDC contact make/break rating, interposing relays external to the ETM shall be provided as needed to achieve the higher rating.

e) A weather tight NEMA 3R, or better, enclosure with a digital display shall be provided when the device is installed external to the main ~~transformer~~ control cabinet. If the device is mounted in the main ~~transformer~~ control cabinet, a window shall be provided in the ~~transformer~~ control cabinet door for viewing the monitor screen without opening the control cabinet door. An operator accessible front panel for the temperature monitor shall be provide to allow for manual control of the system.

f) The Seller shall provide the transformer/ETM completely configured with the correct parameters as required by the ETM manufacturer.

g) Transformer ~~Parameters~~or reactor parameters grouped together on one page and identified as temperature monitor input data shall be supplied by the Seller along with Test Reports and other data. This data shall be provided from the actual temperature rise test information or from a thermal duplicate. The following information is required whether or not it is necessary for the particular model of temperature monitor provided:

1) Average winding temperature rise over top oil (average winding temperature gradient) at the transformer or reactor base rating and at the top maximum rating.
2) Average winding temperature rise over ambient at the transformer or reactor base and top maximum rating.
3) Hottest spot winding temperature rise over top oil (Hot spot winding temperature gradient) at the transformer or reactor base and top maximum rating.
4) Hottest spot winding temperature rise over ambient at the transformer base and top maximum rating.
5) Thermal time constants for each winding.
6) Winding exponent.
7) Temperature differential between LTC (when present) and the main tank.

4.06.05. Mechanical Temperature Monitor (MTM)

4.06.05.01. Mechanical Temperature Monitors approved for use are indicated in Exhibit A, A6.02. Mechanical temperature monitors shall be provided when specified on the Transformer or Reactor Detail Sheet.

4.06.05.02. Mechanical Temperature Monitors shall have the following features:

a) Simulated hottest spot thermal input shall come from a removable temperature probe mounted on the **side** of the tank in a closed, heated thermowell. The thermowell heating element shall receive its energy from current drawn from a bushing or other instrumentation CT; proportional to load current. Means shall be provided to calibrate the thermowell such that the indicator will accurately simulate the true winding temperature up to 200% of the ~~transformer~~equipment nameplate rating. Since the dimensions of the probe are unique to its design, thermowells for this input are typically non-standard and are provided by the MTM manufacturer. The thermowell shall be located such that it is immersed in to a minimum depth of one (1) inch when the oil level and operating temperatures are at a minimum. Wet wells are not acceptable.
b) Top oil thermal input shall come from a removable temperature probe mounted on the side of the tank in a closed, unheated thermowell. Since the dimensions of the probe are unique to its design, thermowells for this input are typically nonstandard and are provided by the MTM manufacturer. The thermowell shall be located such that it is immersed in to a minimum depth of one (1) inch when the oil level and operating temperatures are at a minimum.
c) A minimum of four (4) contacts shall be provided to control cooling auxiliaries and alarm initiation. Two (2) of the contacts shall initiate alarms for stages 1 and 2 of the winding or top oil temperature. The remaining two (2) contacts shall control stages 1 and 2 of the cooling auxiliaries. When fans and pumps are used, the fans shall be operated by the stage 1 relay and the pumps shall be operated by the stage 2 relay. If the MTM does not provide contacts with a 125VDC contact make/break rating, interposing relays external to the MTM shall be provided as needed to achieve the higher rating.
d) A weather tight NEMA 3R or better enclosure with outdoor rated dial and controls shall be provided when the devices are installed external to the main ~~transformer~~ control cabinet. If the devices are mounted in the main transformer control cabinet, a window shall be provided in the ~~transformer~~ control cabinet door for viewing the gauges without opening the control cabinet door.
e) Basic temperature error (including probe) to be less than 5 degrees Celsius. Basic error for the temperature monitoring system shall be less than 2% of the full scale reading.
f) In order to properly calibrate the winding temperature MTM, certain data is required to be provided by the transformer or reactor manufacturer. The parameters shall be grouped together on one page and identified as

temperature indicator settings. This data shall be provided from the actual temperature rise test information or from a thermal duplicate.

1) The calibration curve for the heated thermo well which shows the winding temperature rise of the thermo well probe cavity with respect to current flowing in the heating coil.
2) Average winding temperature rise over top oil (average winding temperature gradient) at the transformer or reactor base and top maximum rating.
3) Average winding temperature rise over ambient at the transformer or reactor base and top maximum rating.
4) Hottest spot winding temperature rise over top oil (Hot Spot winding temperature gradient) at the transformer or reactor base and top maximum rating.
5) Hottest spot winding temperature rise over ambient at the transformer or reactor base and top maximum rating.
6) Thermal time constant for each winding.
7) Winding exponent.

4.07. Alarm and Auxiliary Contacts

4.07.01. Alarm and auxiliary contacts shall be Form C, non-grounded, and suitable for operation on ungrounded 125 VDC systems. These contacts shall be furnished on all gauges and relays. Alarm contacts shall be brought out to a terminal board located in the main control cabinet and shall not be wired together at a common side. One side of the Purchaser specified terminal blocks shall be reserved for Purchaser's external cable connections only (See Exhibit B~~1~~).

4.07.02. Mercury-wetted contacts are not allowed.

4.07.03. Downstream switches or breakers except for the "main" AC breaker should not affect alarm 27-1.

4.07.04. Alarm Requirements

The following alarm points shall be provided where applicable:

4.07.04.01. Top Oil Temperature – (26Q/A1 & 26Q/A2).
4.07.04.02. Winding Temperature – ~~Monitor One Winding~~ (49T/A1 & 49T/A2).
4.07.04.03. Liquid Level Indicator - Main Tank/Conservator - Normal High (71Q-1 (MT) High~~/HA~~)
4.07.04.04. Liquid Level Indicator - Main Tank/Conservator - Normal Low – (71Q-1 (MT) Low~~/LA)~~
4.07.04.05. Liquid Level Indicator - Main Tank/Conservator - Emergency Low – (71Q-~~3~~1 (MT) Trip)
4.07.04.06. Liquid Level Indicator - LTC Compartment – High and Low – (71Q-2(LTC)~~/HA~~ High & 71Q-2(LTC)~~/LA~~ Low)
4.07.04.07. ~~Fault~~ Rapid Pressure – Main Tank – (63SP-1 (MT) Trip)

4.07.04.08. ~~Fault~~ Rapid Pressure – LTC – (63SP-1 (LTC) Trip)
4.07.04.09. Transformer or reactor Gas Detection – Buchholz Relay – (71GD (MT))
4.07.04.10. Pressure Relief Device - Main Tank (63P-1(MT), – (63P-2 (MT), etc.)
4.07.04.11. Pressure Relief Device - LTC Compartment. – (63P-1 (LTC), 63P-2 (LTC), & 63P-3 (LTC))
4.07.04.12. Low Oil Flow - 1st Stage of Cooling – (80Q/P (MT)~~/P~~)
4.07.04.13. Low Oil Flow - 2nd Stage of Cooling – (80Q/S (MT)~~/S~~)
~~4.07.04.14.AC Supply – Loss of Main AC Supply, Time delayed (27-1)~~
~~4.07.04.15.~~4.07.04.14. Stage 1 Cooling - Loss of AC Supply, Time delayed – (27-~~2~~1)
~~4.07.04.16.~~4.07.04.15. Stage 2 Cooling - Loss of AC Supply, Time delayed – (27-~~3~~2)
~~4.07.04.17.~~4.07.04.16. Loss of Cooling Control Voltage Supply, Time delayed – AC (27-~~4~~3)
~~4.07.04.18.~~4.07.04.17. Loss of LTC Control, AC Voltage Supply, Time delayed (27-~~5~~4)
~~4.07.04.19.Loss of DC Control Voltage Supply, Time delayed (27-6)~~
~~4.07.04.20.LTC Automatic Controls Blocked Due to Out-of-Step – (78 LTC).~~
~~4.07.04.21.~~4.07.04.18. LTC Lockout Relay – (86/68 (LTC~~ VIPS~~))
~~4.07.04.22.~~4.07.04.19. Inert Gas Bottle Alarm – (74/63 ~~LV~~LC)
~~4.07.04.23.~~4.07.04.20. Inert Air Gas Tank Alarm – High – (74/63 HP)
~~4.07.04.24.~~4.07.04.21. Inert Air Gas Tank Alarm – Low – (74/63 LP)
~~4.07.04.25.~~4.07.04.22. LTC Vacuum Bottle Alarm
~~4.07.04.26.~~4.07.04.23. LTC Off-Position Alarm – (78-LTC)
~~4.07.04.27.~~4.07.04.24. LTC Oil Filter Pressure Alarm
~~4.07.04.28.~~4.07.04.25. Loss of Potential to LTC – (74-DB)
4.07.04.26. LTC First-Protect/Regulator Backup Alarm – (90BU)
4.07.04.27. LTC Regulating Relay (90 Self-Test, 90 User Programmable)
4.07.04.28. Auto-Recharging Dehydrating Breather, when provided, Failure Alarm – ARDB (MT)
4.07.04.29. Auto-Recharging Dehydrating Breather, when provided, Failure Alarm – ARDB (LTC)

4.08. LTC Control/Relaying System

4.08.01. The operator interface control panel in the LTC control cabinet shall be a dead front, hinged type, and shall be so hinged that it can be swung through a 90° arc (minimum) without detaching any wiring or devices mounted on the panel. The control cabinet shall conform to Section 4.01.

4.08.02. An external raise/lower input shall be provided through two non-latching auxiliary relays, denoted as 90/RX and 90/LX auxiliary relays. The Seller shall provide an interlock scheme, which will prevent simultaneous raise and lower control signals being applied to the tap changer mechanism. These relays may also serve as the interface to the automatic controller, if specified. The relay will be DC operated with a "low energy coil" for use on a SCADA system.

4.08.03. A "Auto-Manual" transfer switch and a "Raise-Lower" control switch (Electroswitch Series 24 type) are to be installed in the transformer control compartment. Purchaser indicating contacts shall be included to monitor status of the “Auto/Manual” switch.

4.08.04. A tap position indicator shall be located in such a position that the person operating the "Raise-Lower" switch will have full view of the tap position indicator. The indicator shall be equipped with drag-hands, that can be reset from ground level, to indicate max/min travel.

4.08.05. An LTC position transmitter capable of working with an LTC position display unit shall be provided for remote indication of the LTC position. The five control wires shall be brought to a terminal block for Purchaser connection. See Exhibit A, A7 for the approved LTC position transmitter and display devices.

4.08.06. Provide LTC “on-position” indication as part of the LTC operator. Provide an LTC “off-position” alarm.

4.08.07. Provide a six-digit operation counter.

4.08.08. Limit switches and mechanical stops to prevent travel beyond extreme tap positions with Purchaser use contacts to alarm upper and lower extreme tap positions shall be provided.

4.08.09. LTC Control

~~4.08.09.01.Two winding or Distribution transformers shall include an automatic LTC Controller (90-LTC). Space shall be left available in the control cabinet to allow future installation of a parallel balance module and an excessive circulating current relay. See Exhibit A, A8.01 for approved devices.~~

4.08.09.01. A~~utotransformers shall include a~~n automatic LTC Controller (90-LTC) shall be provided when required on the Transformer Spec Detail Sheet. In addition, a parallel balance module and an excessive circulating current relay shall be supplied when required. See Exhibit A, A8~~.02~~ for approved devices and details.

4.08.09.02. A voltage back-up relay shall be provided on all units.

4.08.09.03. Voltage test terminals shall be provided for the LTC controls.

4.08.09.04. LTC current transformers shall be provided by the Seller on the X1 and X2 bushings and shall be compatible for use with the LTC automatic control devices identified in Exhibit A, A8. The current transformers shall not restrict the overload capability of the power transformer.

~~4.08.09.06.~~4.08.09.05. A current “test switch” for Purchaser use shall be installed in series with the LTC CT circuit into the control.

5. Test Requirements

5.01. General Testing

5.01.01. The transformer or reactor shall be fully assembled prior to factory test.

5.01.02. Tests shall be performed in accordance with IEEE C57.12.00, C57.12.90, and/or C57.21 unless otherwise indicated below. Unless otherwise specified, all tests indicated below are considered routine and are required on all units. The purchaser shall be notified prior to the completion of testing of any test that does not meet minimum requirements identified in IEEE C57.12.00, C57.12.90, and/or C57.21 or this document.

5.01.03. The tank cover shall be welded prior to factory acceptance testing, unless preapproved with the purchaser, and no further production work inside the transformer tank, including retightening of the unit, shall be done after final testing.

5.01.04. Lightning Impulse Tests

a) Units which have one or more windings designed for 350 kV BIL or higher, shall have **all** windings subjected to standard impulse tests in accordance with ANSI C57.12.90, as supplemented by ANSI C57.98. The neutral current method of fault detection shall be employed and digital records (voltage and current waveforms including voltage, times, and current) of all impulse tests, comparison of RFW to FW shots, comparison of CW shots, and transfer function comparisons, if available, for each winding shall be furnished with the test report.
b) All windings shall be individually impulse tested.
c) The neutral shall be impulse tested regardless of the BIL level.

5.01.05. Internal Partial Discharge Test

a) An internal partial discharge test shall be made as part of the induced voltage test consisting of a measurement of radio noise influence at standard induced voltage test on each phase on transformers with a winding rated 350 kV BIL and above.
b) Calibration shall be performed for both pC and microvolt measurements at, or close to, the maximum allowed levels. Comparison of sample input and output readings shall be performed at three levels (maximum allowed level, and one value below and one value above the maximum allowed value).
c) Measurements shall be taken on **all** terminals rated 350 kV BIL or higher. Filters between the transformer and power supply may be necessary to eliminate the noise coming from the power supply and background RIV.
d) Discharge monitoring shall be continuous over the one hour test period to insure the transformer is free of damaging partial discharge in the insulation structure. A test frequency of 120 Hz to 300 Hz is acceptable.
e) Damaging partial discharge shall be defined as RIV exceeding 80 microvolts at test voltage.

f) The Seller shall also supply/perform corona measurements in units of pico coulombs (pC). Damaging partial discharge shall be defined as values exceeding 300pC, increases of more than 150pC over the one-hour duration of the test, and any steady increase in value in the last 20 minutes. If a steady increase in the last 20 minutes is measured, the test shall be extended until a leveling of values for a period of not less than 20 minutes is achieved.

g) The certified test report shall include a report showing all measurements recorded during the partial discharge test; including calibration and verification testing that was done.

5.01.06. Switching Impulse Test

A switching impulse test is required for units with high voltage windings operating at 345 kV and above

5.01.07. Insulation Power Factor Test

5.01.07.01. Insulation power factor testing shall be done on all winding-to-winding and winding-to-ground insulation. Measurements shall not exceed 0.5% corrected to 20°C.

5.01.07.02. Insulation power factor testing shall be done on all bushings. Measurements shall not exceed 0.5% corrected to 20°C. In addition, power factor measurements shall not vary more than 10% from the bushing nameplate value and the capacitance shall not vary more than 2% from the nameplate values.

5.01.07.03. For bushings, the capacitance of both C1 and C2 shall be measured and compared to their respective nameplate values. The measurements and their comparison shall be included in the certified test report.

5.01.08. Oil Tests

5.01.08.01. Dissolved Gas-in-Oil Test

a) Dissolved gas-in-oil tests are required as follows:
  i) before any testing is started
  ii) after **each** temperature rise test (Base and Top MVA)
  iii) after the overload temperature rise test
  iv) after dielectric testing

b) The maximum allowed change in gas-in-oil values from test to test is as follows:

Gas	**Max. Change (ppm) before & after Dielectric Tests & after Temp. Rise Test**	**Max. Change (ppm) after Overload Temp. Test**
Hydrogen (H_2)	15	20
Methane(CH_4)	2	2
Ethane (C_2H_6)	2	2
Ethylene (C_2H_4)	1	1
Acetylene (C_2H_2)	0	0
Carbon Monoxide (CO)	25	50
Carbon Dioxide (CO_2)	250	300

If the values listed above are exceeded, the Seller is to notify the Purchaser to jointly determine what action, if any, is required. The certified test report shall indicate if the transformer oil has been filtered or processed between tests. If the oil is filtered or processed, an oil test prior to and after filtering shall be provided for reference.

5.01.08.02. Oil Particle Count Test

A particle count shall be performed before start of temperature rise testing and at the completion of all temperature rise testing. Particle counts must be less than or equal to 15,000 particles per 100 ml using a 5 micron filter. Particle counts using a 5 micron filter must meet the following:

Particles per 100ml	**Voltage Class**
≤ 15,000	≤ 230 kV
≤ 10,000	> 230 kV

A copy of the particle count test results shall be provided with the final certified transformer test report. If the particle count value exceeds the 15,000/100ml value, results will be discussed.

5.01.08.03. Bulk Oil Test

A test of the bulk oil supply just prior to filling TR shall be performed. The testing shall include PF of oil, water content, breakdown voltage, and corrosive sulfur. The corrosive sulfur test shall be in compliance with ASTM 1275, Method B. A copy of the bulk oil test report shall be provided with the final certified transformer test report.

5.01.09. Audible Sound Level Test

5.01.09.01. The transformer sound level test shall be performed on the first unit of a design and shall be conducted according to the provisions of ANSI C57.12.90 or C57.21 and NEMA Standard TR 1.

5.01.09.02. Calculated sound power values shall be provided in the certified test report in addition to the actual sound test results.

5.01.09.03. The Purchaser reserves the right to request this test any time prior to final testing.

5.01.10. Impedance Tests

5.01.10.01. Impedance Test and Load Losses

DC Winding resistances in ohms corrected to 85°C (also indicate temperature at which the resistance was measured).

1) Binary short-circuit measurements

a) Positive Sequence Short-Circuit Tests:

1. Three-phase MVA base used for each test.
2. Short-circuit impedance in percent on test MVA base.
3. Load losses at test MVA.

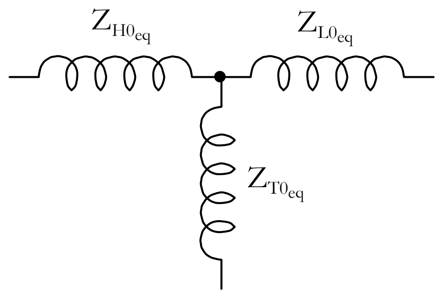
Impedance and load losses corrected to 85°C shall be measured for each set of windings for each no-load tap position at rated current on the rated voltage connection at the ONAN rating. The impedance shall also be provided for the 16R and 16L positions on LTC transformers at the rated no-load position. The positive sequence impedance, resistance, and reactance shall be furnished by Seller as part of the test report.

b) Zero Sequence Short-Circuit Tests:

1. Three-phase MVA base used for each test.
2. Short-circuit impedance in percent on test MVA base.
3. Load losses at test MVA.

Zero phase sequence impedance tests shall be made between all windings at rated taps. The zero sequence impedances, reactance, and resistances corrected to 85°C shall be furnished by the Seller as part of the test reports. The zero sequence impedance shall be measured without the neutral reactor (when supplied) connected and the test report shall explicitly indicate this. The Z_H equivalent impedance shall be a positive quantity under all conditions.

An equivalent zero sequence model shall be provided with the certified test report. Below is an example for an autotransformer.



5.01.10.02. EMTP Modeling

EMTP modeling information shall be submitted with certified test reports for EMTP modeling purposes.

1) Core Construction
   a) Three-legged, 5-legged, shell type, etc.
   b) Core material
      - Manufacturer
      - Catalog #
      - Lamination thickness
      - Stacking (lamination) factor
   c) Core Dimensions
      - Window dimensions
      - Leg and yoke dimensions
2) Coil Design
   a) Number of windings per leg
   b) Arrangement diagram including dimensions

3) Open Circuit Tests

a) Positive Sequence Data

1. Calculate the exciting current at voltage levels from 50% to 120% (and higher if possible, depending on the test source) of the rated voltage using 10% increments in voltage up to 90%, 5% increments thereafter.

Provide waveform plots of the phase voltages and phase currents (i.e. calculate the line current for Y-connected windings and, if possible, calculate the phase current for delta-connected windings). Provide plots of the RMS current as a function of the RMS voltage for each phase.

For transformers with delta windings, make note of whether the delta connections were open or closed during the measurements.

2. Excitation losses in kW at each excitation level.

b) Zero Sequence Data: Zero Sequence measurements are not required on transformers with a delta tertiary unless four leads are brought out. Calculated data shall be supplied when measurement due to a closed delta winding is not possible.

1. Calculate the exciting current at voltage levels from 50% to 120% (and higher if possible, depending on the test source) of the rated voltage using 10% increments in voltage up to 90%, 5% increments thereafter.

Provide waveform plots of the phase voltages and phase currents (i.e. calculate the line current for Y-connected windings and, if possible, calculate the phase current for delta-connected windings). Provide plots of the RMS current as a function of the RMS voltage for each phase.

2. Excitation losses in kW at each excitation level.

5.01.11. Complete function testing of controls shall be performed by the Supplier prior to shipment.

5.01.12. Ratio and polarity testing of all bushing current transformers shall performed by the Supplier prior to shipment.

5.01.13. The operation of the gas accumulation system for conservator type transformers shall be checked by injecting 1000cc of dry air into the transformer tank through a valve at the bottom and farthest away from the gas accumulation (Buchholz) relay. The gas accumulation relay must send an alarm signal within 10 minutes after injecting the dry air or the test will be considered as failed. It the test fails, subsequent tests may be performed, but only after all of the trapped air injected in the previous test has been bled off.

5.01.14. A plot of the voltage vs. time curve (V/Hz) shall be provided with the certified test report.

5.01.15. Sweep Frequency Response Analysis (SFRA) Test

5.01.15.01. The SFRA test shall be performed on the HV, LV, and TV windings as applicable using the “Sweep” Method. It is preferred that the manufacturer uses the Doble M5100 or M5200 test equipment. If the FRAMIT test equipment is used, the vendor shall be required, in the event that shipping damage is suspected, to perform the FRAMIT test on site for comparison purposes at no additional charge to the Purchaser.

5.01.15.02. The SFRA test shall be performed with the transformer in the condition in which the Purchaser will receive it. The test shall be done with the transformer set at the extreme raise position on the LTC (if present) and at the nominal position on the DETC (if present). Both an open-circuit and short-circuit test of each winding shall be performed. The purpose of the test in the “as-shipped” condition is to be able to perform an on site comparison test in the event shipping damage is suspected. If variations on bushing lead positions would adversely affect the comparison of test results, then the manufacturer should use test bushings in the factory and ship the unit with the test bushings in place.

5.01.15.03. If a Doble test set is used the SFRA test report shall be provided electronically in a CSV (comma separated values) or other Doble test equipment recognizable format for import into the Purchaser’s Doble test equipment.

5.02. Power Transformer Testing

5.02.01. Losses and Excitation Current Tests

5.02.01.01. Results of no-load losses and excitation current tests shall be made at rated frequency at 90 percent, 100 percent and 110 percent of rated voltage referenced to 20°C.

5.02.01.02. For units containing either a preventive auto (PA) transformer or an LTC reactor, the no-load losses are to be measured on an odd numbered tap position. PA and or LTC reactor losses are to be added to the temperature rise losses. Guaranteed no-load losses shall include loss contributions from the PA or LTC reactor when present.

5.02.01.03. No load losses shall be measured before and after dielectric testing. The losses measured after dielectric testing shall be compared to the guaranteed value.

5.02.01.04. If load losses are not specifically guaranteed, they will be calculated by subtracting the guaranteed no-load losses from the guaranteed total losses. For load loss test requirements, see Section **Error! Reference source not found.**.

5.02.01.05. Auxiliary losses shall be verified by actual test measurements. Estimated auxiliary losses are not acceptable.

5.02.01.06. If the individual tested no-load, load, and auxiliary losses exceed the individual guaranteed loss values by **less** than 5%, the **sum** of the tested losses multiplied by their individual penalty factors minus the sum of the guaranteed values of the losses will be subtracted from the transformer purchase price. If the tested no-load, load, or auxiliary losses exceed the guaranteed loss values by **more** than 5%, the loss value that exceeds the 5% will be penalized at a rate of three (3) times the specified factor.

5.02.01.07. No credit will be given for tested losses that are less than guaranteed. There are no allowed tolerances from the quoted guarantee.

5.02.02. Core Insulation Resistance Test

The insulation between the core and the tank shall be checked using a 2500 volt megger between the tank of the transformer and the intentional core ground terminal. This test shall be done prior to Dielectric testing and at the conclusion of the induced potential test while the transformer is still filled with oil. The resistance shall be 1000 Mega ohms (corrected to 20°C) or greater after one minute of application of 2500 volts in order for the transformer to pass this test.

5.02.03. Temperature Rise Tests

5.02.03.01. The transformer temperature monitor shall be activated during the temperature rise test. The actual top oil temperature at the end of each temperature rise test for both the test probe and the temperature monitor shall be documented in the test report. The test probe and the WTI probe shall be in close enough proximity to each other such that the results are within 2°C.

5.02.03.02. The following information shall be included in the certified test report:

a) Ambient temp at end of total loss run (cutback)
b) Top Oil Temperature at end of total loss run
c) Top radiator temp at end of total loss run
d) Bottom radiator temp at end of total loss run
e) Ambient temp at shutdown
f) Top Oil Temperature at shutdown
g) Top radiator temp at shutdown
h) Bottom radiator temp at shutdown
i) Hot spot factors from engineering for HV and LV
j) Hot resistance value used for HV and LV

k) Hot resistance temperature
l) Shutdown hot resistance measurements and times
m) Hot resistance versus time curves
n) Cold resistance measurement and associated temperature
o) Calculated Gradient for each winding for each temperature rise test

5.02.03.03. The temperature rise tests shall be done in the configuration that would produce the highest temperature rise for the winding. For two winding transformers, this would be the lowest HV tap and the lowest LV tap position for full capacity taps below neutral, or the lowest HV tap and the rated LV tap for reduced capacity below neutral. If an LTC is present and includes a PA or an LTC reactor, then the next bridging position should be used. For autotransformers, the highest series and common winding currents occur in opposite HV tap positions; therefore the temperature rise must be corrected to actual winding currents if the shutdown is done in one tap position only.

5.02.03.04. An infrared scan of each Segment of the transformer shall be taken at the peak of the top MVA and the Overload Temperature Rise tests. The test scans shall be provided, in color, with the certified test report.

5.02.03.05. Standard Temperature Rise Test

a) The temperature rise test shall be performed on the first unit only of a design. Test reports from similar thermal duplicates are not acceptable. This test shall be made at the self-cooled rating and at the maximum forced cooled rating. The temperature rise test, when required, shall be performed prior to dielectric testing.
b) Temperature take-off readings for the self-cooled rating, when within 2 degrees of the maximum allowed values, shall be taken on all three windings.
c) Temperature take-off readings for the test at the maximum forced cooled rating shall be taken on all three phases with separate shutdowns for each phase.
d) The results (top oil temperature, winding temperatures, hottest spot temperature, and load losses) of the temperature rise test shall be documented in the certified test report. In addition, all readings taken for the duration of the test shall be provided in the certified test report.

5.02.03.06. Overload Temperature Rise Test

a) The overload temperature rise test shall be performed on the first unit only of a design. Test reports from similar thermal duplicates are not acceptable.
b) The overload temperature rise test take-off measurements shall be taken on the phase with the highest readings during the maximum forced cooled rating test.
c) This test shall be performed, at the conclusion of the standard temperature rise test while the transformer is still filled with oil. Prior to the start of the 8 hour overload test, the top oil temperature should be brought back up to the top oil temperature achieved during the standard ONAF temperature rise test.

d) All "Distribution and Small System Transformers" shall be tested for satisfactory performance at the "Single-Cycle" overload condition specified in Table 1.

e) All "Large System Transformers" shall be tested for satisfactory performance at the "Multi-Cycle" overload condition specified in Table 1.

f) The results (top oil temperature, winding temperatures, hottest spot temperature, and load losses) of the overload temperature rise test shall be documented in the certified test report. In addition, the winding temperatures, top oil temperature, hottest spot temperature, and load loss information for all of the overload cases identified in Table 1, shall be calculated with respect to the overload conditions of the table, and documented in the transformer's certified test report.

g) The calculated temperature performance numbers shall not exceed the maximum temperature performance numbers specified.

5.02.03.07. Temperature Rise Test for duplicate units

a) A temperature rise test shall be performed at the maximum forced cooled rating on all duplicate transformers as a quality control test in place of the standard temperature rise test.

b) The temperature rise test for duplicate units shall be performed prior to dielectric testing.

c) The temperature rise test for duplicate units shall be performed on all three phases.

d) The winding rises over mean oil from the temperature rise test for the duplicate unit shall be compared with the results from the transformer for which the standard temperature rise test was performed. The plot of both of these curves shall be provided along with the Factory Test results (including the reference Serial Number for the original unit). Any winding rise over mean oil exceeding the results of the transformer which had the full temperature rise test shall be reported immediately to the Purchaser and the discrepancy shall be resolved with the Purchaser.

5.02.04. Single-phase excitation tests on each phase shall be performed using Doble test equipment and procedures.

5.03. Shunt Reactor Testing

5.03.01. Temperature Rise testing shall be performed as a routine test on all units.

5.03.01.01. The temperature rise test shall be performed at 115% of the rated voltage.

5.03.01.02. The transformer temperature monitor shall be activated during the temperature rise test. The actual top oil temperature at the end of each temperature rise test for both the test probe and the temperature monitor shall be documented in the test report. The test probe and the WTI probe shall be in close enough proximity to each other such that the results are within 2°C.

5.03.01.03. The following information shall be included in the certified test report:

a) Ambient temp at end of total loss run (cutback)
b) Top Oil Temperature at end of total loss run
c) Top radiator temp at end of total loss run
d) Bottom radiator temp at end of total loss run
e) Ambient temp at shutdown
f) Top Oil Temperature at shutdown
g) Top radiator temp at shutdown
h) Bottom radiator temp at shutdown
i) Hot spot factor from engineering
j) Hot resistance value and temperature
k) Shutdown hot resistance measurements and times
l) Hot resistance versus time curves
m) Cold resistance measurement and temperature
n) Calculated Gradient

5.03.01.04. Temperature take-off readings shall be taken on all three phases on the first unit of a design. On duplicate units, the take-off reading shall be taken on the hottest phase identified from testing of the first designed unit. If the winding rise is within 2 degrees of the maximum allowed value, readings shall be taken on all three phases.

5.03.01.05. An infrared scan of each Segment of the reactor shall be taken at the peak of the Temperature Rise test. The test scans shall be provided, in color, with the certified test report.

5.03.02. Losses

5.03.02.01. If the tested load losses exceed the guaranteed loss values by **more than** 5%, the losses will be penalized at a rate of three (3) times the specified factor.

5.03.02.02. No credit will be given for tested losses that are less than guaranteed. There are no allowed tolerances from the quoted guarantee.

5.03.03. The Audible Sound Test shall be performed at the maximum specified operating voltage identified on the Spec Detail Sheet.

5.03.04. A Vibration Test is required on all units.

5.03.05. A Magnetic Characteristics (Linearity) Test is required on the first unit of a design.

5.04. Test Reports

5.04.01. Four (4) certified copies of all test reports shall be furnished to the Purchaser within 2 weeks after test completion.

5.04.02. Test reports shall be furnished by the Seller **on all tests requested**, and shall include but are not limited to:

- Impulse and Switching Surge test results, waveforms, and shot logs
- Partial Discharge test results including calibration testing verification
- No-Load losses
- Excitation current curves for the main core-coil assembly
- Impedance and Load loss measurements
- EMTP modeling
- Insulation Power Factor
- Oil tests including DGA, Corrosive Sulfur, Particle Count, and other standard oil tests
- Audible Sound Level test results including measurement logs and data
- Temperature Rise and Overload Temperature Rise test details including resistance take-off measurements, the data required in Section 5.02.03.02, Infra-Red scans, and the resistance measurement readings and curves
- Function Testing of controls
- CT Ratio and Polarity tests
- SFRA
- V/Hz curve
- Single-Phase Excitation Test
- Vibration Test (Power Reactors)
- Magnetic Characteristic (Linearity) Test (Power Reactors)
- Test reports for all components such as bushings and neutral grounding reactors. Test equipment shall be traceable to NIST (National Institute of Standards and Technology). Test data shall be referenced to 1000 meters altitude.

5.04.03. The Purchaser reserves the right to witness tests performed by the Seller. The Seller shall notify the Purchaser a minimum of two weeks prior to test.

5.04.04. Test Failures/Non Conformances

5.04.04.01. **Failure to meet any test or the Transformer or Reactor Detail Sheet requirements of the transformer during factory tests or test results that for any reason exceed acceptance criteria or standard tolerances shall be reported immediately by phone to the contact listed in the Drawing Coordinator Section of the Transformer or Reactor Detail Sheet**, unless an authorized Purchaser's representative is present during testing. A written report shall be prepared with color photographs, documenting any test floor failures, the reason for the failure, and the corrective action to be taken prior to retest. Photographs both before and after any repairs shall be provided.

5.04.04.02. The Purchaser shall have the option to inspect such damages and/or test failures.

5.04.04.03. The Purchaser reserves the right to witness retests performed by the Seller. If the Purchaser has opted to witness tests, it shall be the Seller's responsibility to pay full travel costs, expenses, and labor, associated with the Purchaser's *return* to rewitness testing if the delay to retest after a failure is greater than 24 hours from the time the transformer or reactor failed test.

5.04.04.04. For any internal failure or flashover during dielectric testing, at a minimum, all dielectric tests shall be performed again after necessary repairs or corrections are made, regardless of when in the sequence of dielectric tests the failure occurred.

5.04.04.05. For any failure during testing that requires complete more that untanking to repair, at a minimum a duplicate unit temperature rise test shall be performed to verify that the cooling system has not been compromised during reassembly.

5.05. Factory Assembly

Factory Assembly (complete assembly) of the transformer or reactor with all accessories and components supplied, (surge arresters, bushings, tap changers, conservator tanks, radiators, fans, coolers, reactors, etc.) shall be performed prior to shipment to ensure proper fit of all components, adequate electrical clearances are maintained, and parts are available for successful field assembly of the transformer. Color photographs of the completely assembled transformer or reactor at the factory shall be provided with the instruction manuals. See Section 7.07.06.02 for details.

6. Field Installation and Testing

The Purchaser will determine on a case-by-case basis whether field assembly, oil processing, and testing by the Seller will be required and will identify the requirement on the purchase order or contract. Xcel Energy reserves the right to cancel this requirement prior to it being scheduled without penalty.

6.01. Field Assembly

Field assembly, when required in the Purchase Requisition/Contract shall include: offloading of the transformer onto the foundation; an internal inspection; installation of the radiators, bushings, arresters, etc.; all auxiliary equipment furnished by the Seller; vacuum oil fill; and pre-energization testing in accordance with ANSI Standard C57.93, and with testing and checks identified in Section 6.02. If field installation is performed by a Subcontractor to the Seller, the Subcontractor must be approved by the Purchaser prior to installation. The field installer is responsible for providing all equipment and electrical power required for complete installation. The Seller shall at all times throughout the process of field installation, keep work areas neat and orderly. Waste materials from the installation work shall be removed and disposed of by the Seller.

6.02. Field Oil Processing

Oil processing procedures shall, at a minimum, follow the procedures in the Seller's instruction manual.

6.03. Field Testing/Checks

6.03.01. Field testing, when required in the Purchase Requisition/Contract to be performed by the Seller, shall include all the tests listed below unless otherwise agreed to by Seller and Purchaser. All field testing may be witnessed by the Purchaser's Field Representative.

6.03.02. An internal and external inspection shall be performed on the transformer or reactor, when possible, after assembly and prior to oil filling. See Exhibit F for the minimum internal inspection requirements. The Seller shall be responsible for ensuring that all applicable safety requirements for workers, including air monitoring measures, are met. Only tools necessary for the inspection shall be taken into the transformer or reactor and any tools taken into the ~~transformer~~equipment must be adequately tethered to allow retrieval if dropped. In the event that an inspection must be held in inclement weather, and temporary enclosure must be constructed to prevent the entrance of contaminants into the transformer and its associated compartments. The Seller shall provide a copy of the completed checklist with any comments with the final field test report documentation.

6.03.03. All testing shall be done on the specified equipment after it is fully assembled and installed at its permanent location, unless otherwise directed by the Purchaser. The Seller shall maintain a written record of all tests showing date, personnel performing test, results, and type of testing equipment used by manufacture, model type, and model serial number. The test sheets must show all equipment nameplate data (including all bushings and surge arresters). The testing shall be performed by using a Doble Model M4000 test set and a Doble M4110 leakage reactance interface. The field tester is responsible for providing all equipment and electrical power required to complete the electrical testing requirements.

6.03.04. A copy of the original written test report results shall be provided to the Purchaser's Field Representative after completion of the testing and before leaving the site. Two (2) additional bound field test reports and CD ROM with the information in a Doble M4000 format shall be provided to the Purchaser no later than (30) calendar days after completion of the field testing.

6.03.05. Questionable test results/readings shall be immediately reported to the Purchaser with recommendations for correction, as soon as practical. All revisions and changes found on field drawings should be shown on the Seller's drawings and copies provided to the Purchaser.

6.03.06. Photographs shall be taken of all issues/defects identified during the internal and external inspections. Copies of all photographs shall be included in the final bound test report as well as in the electronic CD ROM format.

6.03.07. The following field tests and checks shall be performed:

6.03.07.01. Initial Tests/Checks

a) Verify instruction manual in control cabinet.
b) Check impact recorder results (See Section 3.05**Error! Reference source not found.** for impact limits).
c) Perform an internal inspection before oil filling. The Seller is responsible for notifying the Purchaser's representative prior to performing the internal inspection so that he/she may be present. See Exhibit F for check list to be completed and included in the test report packet. When practical, color photographs of the bottom connection of the HV and LV bushing connections shall be taken. Provide color copies of photographs and internal inspection report with the written field-test report.
d) Verify positive pressure in the main tank.
e) Perform a dew point test.
f) Equipment ground verification/visualization.
g) Perform (2500V) core to ground megger test.

6.03.07.02. Insulating Oil Tests/Checks

a) Provide certified test report of oil delivered in the transformer or reactor or for each tanker of oil delivered. The following tests shall be included on the certified test report and resultant values shall comply with C57.106 guidelines where provided.
   i) Power factor 25°C & 100°C per ASTM D924
   ii) Dissolved gas-in-oil test per ASTM D3612
   iii) Moisture content per ASTM D1533B
   iv) Dielectric breakdown per ASTM D1816
   v) Interfacial tension per ASTM D971
   vi) Acidity per ASTM D974
   vii) Color per ASTM D1500
   viii) Furanic compound per ASTM D5837
   ix) Specific gravity per ASTM D1298.
   x) PCB test
   xi) Inhibitor content
   xii) Perform a visual and sediment examination per ASTM D1524 (look for contaminants).
   xiii) Corrosive Sulfur test per ASTM D1275 Method B.
b) Check all oil levels after filling.
c) Check valve positions.

d) Perform a dielectric test per ASTM D877 during installation and ASTM D1816 for final acceptance prior to energization. Values shall comply with C57.106 guidelines.
e) Perform Doble power factor test on insulating oil prior to and after filling transformer.
f) Perform a dissolved gas analysis test and a Karl Fischer test on the transformer or reactor and LTC compartment after all processing and testing is complete.

6.03.07.03. Equipment Tests per ANSI C57.12.90; Method II
a) Perform Doble power factor test of bushings, prior to installation if shipped separately.
b) Perform Doble capacitance test of bushings.
c) Perform Doble hot collar test of bushings.
d) Perform Doble test of surge arresters.

6.03.07.04. CT Tests (all tests shall be done from the CT terminal blocks in the control cabinet)
a) Polarity Test all CTs.
b) Megger Test to ground all CTs.
c) Perform CT ratio test – all taps.
d) Perform saturation (secondary excitation) tests on all CTs (check tests against curve test data).
e) All CT terminal block wiring shall be verified to match Seller's drawings.

6.03.07.05. Winding Tests (Per Doble transformer winding test sheet)
a) Perform Doble power factor test.
b) Perform single-phase, low-voltage excitation tests (i.e., 10 kV excitation current test) at all LTC taps at rated DETC tap.
c) Perform turns ratio test (TTR) on all DETC taps with LTC in Neutral and on all LTC taps (16R-1L), when applicable, with the DETC on the highest voltage tap.
d) Perform winding resistance test on each DETC tap with the LTC in neutral and on all LTC taps (16R-1L), when applicable, with the DETC on the highest voltage tap.
e) Set taps control as required by the Purchaser. After final tap is set, Seller shall perform a final TTR at that setting.

6.03.07.06. SFRA Tests
a) In the event that damage incurred during shipping is suspected, an SFRA test shall be done by the Seller with Doble M5100 or M5200 test equipment in the as received condition (prior to assembly or oil filling, if not shipped oil filled) with the transformer set to the same tap positions used for the factory test. This shall then be compared to the test done by the Seller at the factory. If Doble SFRA test equipment was not used by the Seller at the factory, the

Seller shall supply the same test equipment at the site in order to compare results.

b) An SFRA test shall be done with Doble M5100 or M5200 test equipment after the transformer has been fully assembled and oil filled. The test shall be done with the transformer set at the extreme raise position on the LTC (if present) and at the nominal position on the DETC (if present). Both an open-circuit and short-circuit test of each winding shall be performed.

6.03.07.07. Nitrogen Gas Equipment Checks

a) Check regulator operation.
b) Check valve positions.
c) Test moisture content of N_2 gas per ASTM D3283.

6.03.07.08. Control/Cooling Equipment Functional Test

All control and cooling equipment shall be functional tested. Functional testing means applying the appropriate inputs (voltage, current, pressure, temperature, etc.) to a device and verifying all required responses or outputs. The types of tests usually included, but not limited to, are the following:

a) Fault pressure relays (main tank, tap changer, fault flow). Full calibration test performed with enough points tested and plotted to compare with manufacture's curves.
b) Motor starting current on pumps
c) Fan and/or pump rotation checking air/oil flow.
d) Alarm checkout.
e) Alarm sensors tests (top oil temperature, winding temperature, low oil, etc.) (function and calibration tests).
f) 90 LTC voltage controller verification including all auxiliary contacts, remote control and indication.
g) All control and cooling terminal block wiring should be verified to match the Seller's drawings.

7. Drawings/Documentation

7.01. Required Documentation

Drawings, manuals, and other documentation shall be provided in accordance with the documentation schedule below. Documentation shall be sent to the Drawing Coordinator address identified in the Transformer or Reactor Detail Sheet or Purchase Order. Each document submittal must identify the Xcel Energy purchase order number, Supplier's work or shop order number, and the equipment serial number (if applicable).

7.02. Approval Drawing Review

The Seller shall allow the time specified in the documentation schedule below for Purchaser's review of the approval drawings without affecting the ship date. Upon review of the drawings by the Purchaser, one scanned copy of marked-up drawings will be returned to the Seller. Acceptance of the approval drawings by the Purchaser, with or without any changes noted, shall not relieve the Seller of its responsibility for meeting all requirements of the Purchase Order, Transformer or Reactor Detail Sheet and Material Standard or for the proper design and construction of the equipment. If the Approval Drawing changes are determined by the Purchaser to be significant enough to require further review cycles, the Seller shall revise and resubmit the Approval Drawings for approval. Seller shall provide the final full serial number as it will be engraved on the nameplate at the time of the approval drawing review.

7.03. Drawing Revisions

Each drawing shall have a specific revision number associated with each revision. All Seller-generated changes or modifications occurring after the return of the Approval Drawings shall be clouded on a separate set of non-reproducible drawings. These drawing revisions shall be provided with the Final drawing packages. Any revisions to the Final Drawings after submittal of the Final Drawings must be identified and approved by the Purchaser prior to proceeding with the drawing changes.

7.04. Format of Documentation

7.04.01. Paper drawings shall be blue-line or black-line prints provided in ANSI Standard sizes "A" (8.5" x 11"), "B" (11" x 17"), or "D" (24" x 36") only.

7.04.02. Electronic drawing data shall be provided for all paper drawings submitted in Microstation Integraph ISIF ASCII command format (.dgn) or AutoCad (.dwg or .dxf) format, as well as in Portable Document Format (PDF) format.

7.04.03. Electronic versions of all other paper documentation (including Manuals) and other textual documentation shall be provided in addition to the paper versions. These electronic documents shall be provided in PDF format. Whenever possible, if PDF format is provided, it shall be a searchable PDF file not a scanned document.

7.04.04. Electronic versions of all documents shall be submitted electronically for the Approval Drawing submittals and on a CD ROM disk for Final Drawing submittals. The Instruction Manual, photographs, test reports, and SFRA test data shall be included on the Final Drawing CD ROM. If multiple PDF files are submitted for the Instruction Manual, the documents must be non secured such that they can be combined with other PDF documents. It is highly preferred that the Instruction Manual be one electronic document with electronic bookmarks marking each section or equipment brochure. The Seller supplied drawings should not be included in the electronic version of the Instruction Manual. Separate CAD **and** PDF versions of **each** drawing are to be provided. A combined PDF of individual CAD generated drawings is not acceptable.

7.04.05. Information on all drawings or documentation supplied shall be fully legible when printed on 11” x 17” paper.

7.05. Manuals

7.05.01. Instruction manuals shall be bound ~~and have~~ or in binders with a durable cover and locking rings to prevent them from inadvertently opening up. Each manual shall include:

7.05.01.01. detailed equipment installation, operation, and maintenance instructions,

7.05.01.02. a complete set of full size drawings~~ contained in envelopes or bound in the manual~~. **If reduced size prints are provided in the manual**, then two separate folded copies of each full size print~~s~~ are ~~also required~~to be provided, and should **not** be inserted into plastic sleeves or envelopes.

7.05.01.03. certified test reports, **a warranty certificate with warranty duration and limitations clearly identified**, a list of required information from the Purchaser to the Seller in order to validate the Seller's warranty (if required), and a list of recommended special tools and spare parts (including type and manufacturer) required to assemble, operate, and maintain the equipment.

7.05.02. The instruction manuals shall be sent to the Purchaser no later than seven (7) calendar days after the transformer or reactor ship date. One~~, of the seven,~~ complete instruction manual~~s~~ and all attachments **shall be shipped with the transformer or reactor** in the control cabinet.

7.06. Document Reproduction

The Purchaser requests permission from the Seller to reproduce his drawings and other data as required. Acceptance of the Purchase Order/Contract by the Seller grants such permission. The Purchaser shall not use the Seller's drawings in any way detrimental to the Seller's interest.

7.07. Document Types and Content

7.07.01. The Purchaser's Location, Project WO Number, ~~Transformer ID~~UTC Number, ~~Project number,~~ Purchase Order/Contract Release Number, and the Seller's Serial Number shall appear on all drawings. The ~~Transformer ID Number and~~ Location and Project WO Number will be identified on the Purchaser's Purchase Order/Contract. The UTC number will be identified at the approval drawing stage.

7.07.02. When the Seller utilizes the same design~~/specification~~ as on previous~~for multiple transformer~~ orders, the Approval/Final drawings shall also list on all of the drawings, the Location, Project WO Number, Transformer ~~ID~~ UTC Number, and Serial Number for the original unit, which utilized~~apply to~~ that design, and for which the original temperature rise and sound testing was performed. ~~In addition, each transformers's Final drawing set, shall uniquiely identify the transformer's specific ID number.~~ On multiple transformer orders,~~ this requirement may be met by providing~~ a table showing the information requested in Section 7.07.01 shall be included on all of the drawings~~all orders for this design on each drawing~~.

7.07.03. The Seller shall provide production schedules on a monthly basis after receipt of order (ARO) and ~~on~~ at a minimum of a bi-weekly basis once ~~the~~a ~~transformer~~ unit has gone into actual production.

7.07.04. All drawing dimensions, weights, and volumes shall be first provided in U.S. standard units of measure. Metric (SI) units may be provided as **secondary** units of measurement in parenthesis or brackets.

7.07.05. Drawings furnished shall be unique to the transformer or reactor being furnished and shall clearly indicate the physical parameters, electrical characteristics, and auxiliary equipment. These drawings include but are not limited to the following:

7.07.05.01. Nameplate Drawings - The information supplied shall be in accordance with the ANSI Standard requirements.

a) Transformer or Reactor Nameplate
b) Bushing Nameplate
c) Reactor Nameplate
d) Arrester Nameplate
e) Current Transformer Nameplate
f) Tap Changer Nameplate
g) Temperature Alarm Set-Point Nameplate

7.07.05.02. Dimensioned Elevations and Outline Drawings including the following:

a) elevations of all four sides, the base and the top plan labeled as “HV-LV”, “HV”, “LV-HV”, “LV”, “Top Plan”, and “Base”
b) dimensions (including untanking)
c) dimensioned location of all parts and accessories including the bushings, surge arresters, radiators, control cabinets (to top and to bottom) and centers of gravity (in three dimensions) of the completely assembled transformer with oil and for shipment without oil
d) weights (shipping and completely assembled) with gallons of oil and weights separately provided for the main tank, conservator, radiators, and LTC compartment.
e) volumes
f) identify all items to be removed for shipment and provide weight information
g) Shipping restrictions shall be noted on the transformer or reactor outline drawing. ~~For example, “Transformer not designed for rail shipment.”~~ Parts and accessories shall be identified on a Bill of Material.
h) Item descriptions should include quantities, manufacturer, and part or catalog numbers, where appropriate. In addition to the above, bushing descriptions are to also include at BIL and ampere ratings, and whether the bushing is

draw-lead, draw-rod, or bottom connected. Items that are called out on both the outline drawing and control drawings shall have a common designation.

i) Fan stages shall be adequately identified such that each fan is identified as stage 1 or stage 2, as appropriate.

7.07.05.03. Internal Assembly Drawings (with final drawings) including the following:

a) bushing pockets (fully dimensioned sectional and top views of the bushing pockets with and without bushings installed.)
b) flanges
c) current transformer pockets
d) all minimum clearances
e) leads

7.07.05.04. A Shipping Outline shall be provided. The drawing shall include location and routing of all conduits, junction boxes, impact recorder type and mounting provisions, dry air canister and mounting, as well as all other devices, brackets, etc. not removed for shipment. A top view and all four segments shall be provided.

7.07.05.05. Bushing Outlines showing physical and electrical parameters.

7.07.05.06. Reactor Outlines showing physical and electrical parameters.

7.07.05.07. Surge Arrester Outlines showing physical and electrical parameters.

7.07.05.08. Gasket Information Drawings or information shall be provided showing gasket dimensions and materials to allow the Purchaser to purchase or field fabricate replacement gaskets.

7.07.05.09. Schematic and Wiring Diagrams - LTC control and elementary which shall be used by the Purchaser in preparing interconnection diagrams between the various items of equipment. The wiring diagrams shall use "point-to-point" method; i.e. terminal points on devices are labeled with the destination device and terminal point, and shall include auxiliary power requirements and fuse and breaker sizes. Wire diagrams that make use of wire lists, are not acceptable. The Seller shall use the terminal numbers indicated on the Purchaser's schematic diagram (see Exhibit B~~1~~), when furnished, on all terminal points leaving his equipment. Associated terminal points shall be grouped together to facilitate the use of multi-conductor control cables for interconnecting equipment. Terminal blocks shall be shown on the same sheet with internal devices to which they are connected.

7.07.05.10. CT Curves - secondary excitation, ratio correction factor, and TRF for all current transformers, including LDC and WTI current transformers shall be provided.

7.07.05.11. Conservator Tank Oil Fill Table – A drawing containing the conservator tank oil fill table data shall be provided to allow the Purchaser to determine the distance to the oil level below the top flange or opening in the top of the conservator at 25ºC. In addition, the table shall provide the oil temperature for nine step increases in 2” increments and for nine step decreases in 2” increments. A formula for calculating the distance from the top of the conservator tank to the top of the oil level for varying oil temperatures shall also be provided on this drawing so that the Purchaser may verify measurements or extend the table if necessary.

7.07.05.12. Items that are common to both physical drawings and control drawings should be identified with the same designation.

7.07.06. Color photos

7.07.06.01. Color photos (8” x 10”) or color copies of all four sides (complete views) and top view of the transformer internal assembly immediately prior to tanking and before protective wraps, if possible, are applied shall be provided. The Seller’s Serial Number shall be displayed in each photo **without** obstructing the view of the core and coils. Digital photographs must be a minimum of *3 megapixel resolution* **and** provide clear, quality pictures when printed at an 8” x 10” size. Digital files in JPEG or TIF file format shall be provided in addition to the 8” x 10” printed photos.

7.07.06.02. Color photos of each side of the completely assembled transformer or reactor shall be ~~provided~~taken **prior** to ~~shipping~~testing.

7.08. Documentation Schedule

The Purchaser will examine all approval drawings and return one copy of the drawings within 3 weeks (21 calendar days) after receipt.

Documentation Schedule and Requirements

Drawing / Document	**Approval Drawings**	**Final Drawings**
	Quantity Format[a]/Schedule [b]	**Qty Format [a]/Schedule**
Production Schedule	Electronic - See Section 7.07.02	-
Drawing List	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Nameplate Drawing	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Dimensioned Elevations, Outline, and Base Drawings	1 E / 16 – 20 wks prior to ship	1 P, 1 E / 2 wk ASO
Shipping Outline	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Neutral Reactor Outline Drawing	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Bushing Outline Drawings	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Surge Arrester Outline Drawings	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Conservator Tank Oil Fill Table	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Internal Assembly Drawing	1-E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Control Cabinet layout Drawing	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Control Schematics & Connection Drawings	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
CT Excitation Curve & Ratio Correction ~~Factor~~Factor Drawings	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Detailed Factory Test Plan	1 E / 16–20 wks prior to ship	
All other drawings	1 E / 16–20 wks prior to ship	1 P, 1 E / 2 wk ASO
Gasket Dimensions and Materials		1 P, 1 E / 2 wk ASO
Test reports [c]		1 P, 1 E / 2 wk ASO
EMTP Modeling Information		1 P, 1 E / 2 wk ASO ~~See Section~~ See Section **Error! Reference source not found.**
Photographs of Core and Coils		1 E within 48 hrs of photographing & 1 P, 1 E (on CD)/2 wk ASO. See Section 7.07.06.01
Photographs of Assembled ~~Transf.~~Unit.		1 P, 1 E / 2 wk ASO See Section 7.07.06.02
Manuals (delivered to dwg coordinator)		4 B, 1 E / 2 wk ASO 5B for units delivered to WI & MI
Manuals (incl. with equip. in control cabinet)		1 B / with equipment delivery

[a] Format of drawing / document: P) paper format – Full Size Print (separate from those included in the manuals if manuals contain reduced size prints)
E) electronic format
B) bound manuals including all drawings and test reports

Documentation Schedule and Requirements

[b] Certain drawings may be required earlier to support foundation or physical design needs.

[c] Seller to supply Test Report data to Purchaser for approval prior to transformer shipment. Purchaser contact information will be supplied on the purchase order. Data files for Factory SFRA testing shall be provided in electronic format (.sfra or .csv).

Definitions: ARO – After Receipt of Order/Contract
ASO – After Shipment of Order

Note: For multiple purchase orders, one set of all electronic documentation is acceptable as long as the equipment is identical and all orders are referenced

8. Warranty Period

~~8.01.The Seller shall warranty the transformer against defects in materials and workmanship for a minimum of three (3) years from the date the transformer is delivered.~~

~~8.02.The warranty shall cover, as a minimum, for the first year (in/out) costs for rigging; oil removal, filling, storage and processing (see Section 6.02); transformer removal, dismantling, assembly and re-assembly; and field testing (including any investigative testing and acceptance testing after reinstallation) per Section 6.03. Transportation costs to and from the factory during the first year shall be fully covered, but not included in any limitation or cap on first year in/out costs.~~

~~8.03.~~8.01. The warranty period shall start on energization of the transformer or reactor or 6 months after receipt, whichever is earlier.

~~8.04.~~8.02. The Seller shall provide a warranty certificate in the Instruction Manual identifying the warranty expiration date, and any special terms or conditions.

8.03. During the warranty period, gas generation levels above Condition 2, as defined in C57.104-2008, Clause 6.5.1 and Table 2, shall be an indication of transformer failure. and shall require immediate action by the Seller.

9. Shipment

9.01. General

9.01.01. Each transformer or reactor shall be filled with dry air under positive pressure or oil filled for shipment to the Purchaser's destination point. The transformer shall be clearly marked as shipped with dry air when shipped without oil. Dry air cylinders shall be manufactured to US DOT type 3AA high-pressure cylinder specifications and the Supplier shall comply with the transportation requirements of the Federal Regulations, 49 CFR.

9.01.02. The transformer or reactor and any components which are packaged separately shall be fastened so that they will not shift, tip, or drop during shipment. All railroad cars or trailers used in the shipment of the transformer or reactor and accessories shall be marked for careful handling.

9.01.03. Transformer or reactor equipment and accessory shipping containers and packing lists are to be clearly labeled identifying job title, destination, and Purchase Order/Contract number. The small accessories, assembling components and their shipping containers are to be packaged such that they are easily identified as to the specific transformer assembly for which they are part..

9.01.04. All parts and accessories shall arrive at the destination point within 24 hours of the transformer or reactor delivery. These items are to be shipped to the substation/project job site or to the Purchaser's storeroom specified by the Purchaser.

9.01.05. Radiators shall be shipped detached filled with dry air and with steel, gasket-sealed blind-flanges in place.

9.01.06. All parts removed for shipment shall be match marked and identified.

9.01.07. Control cabinets shall be shipped in place and as completely wired as possible.

9.01.08. Purchaser to be notified by telephone the day the transformer or reactor leaves the factory indicating railroad car or carrier numbers, routing, actual shipping height, and actual shipping weight of the transformer as listed on the freight bill. In addition, the Purchaser shall be notified forty-eight (48) hours prior to the transformer or reactor arrival at the final destination.

9.01.09. If the transformer or reactor is shipped without insulating oil, the oil shall be furnished by bulk shipment in truck-trailers, for arrival at the construction site at the time designated by the Purchaser. After oil arrives at the construction site, a testing period of up to 24 hours may be required before oil is transferred to the Purchaser's handling or storage equipment.

9.01.10. Units shipped to NSP or PSC operating companies, between November 1 and April 30, must be covered in some manner to prevent road dirt/salt from coating the transformer or reactor and parts.

9.02. Impact Recorders

9.02.01. Two three-way impact recorders providing continuous record of all impacts (all 3-axis) during the entire period of shipment shall be installed on the transformer or reactor tank for ocean or rail transportation. One impact recorder shall be placed within one foot of the transformer base and the other impact recorder shall be placed within one foot of the transformer cover or on the cover. At least one of the impact recorders shall be an electronic type recorder with GPS tracking capability.

9.02.02. One three-way, electronic, impact recorder providing continuous record of all impacts (all 3-axis) during the entire period of shipment shall be installed on the transformer or reactor tank for ~~transformers~~units shipped entirely by truck.

9.02.03. A report shall be provided to the Purchaser identifying all impacts or recorder failures within two weeks after delivery of the transformer or reactor.

9.02.03.01. In the event a transformer or reactor arrives at its destination with an inoperable impact recorder, dead battery, insufficient paper, or with indicated recordings of Zone 3 impacts or higher, the Seller shall determine at his expense and to the Purchaser's satisfaction, the true condition of the transformer by performing at a minimum, the following inspection and tests:

a) A complete comprehensive internal inspection with the Purchaser's representative before oil filling. Color photographs shall be taken documenting the existing condition, and a report documenting the inspection shall be prepared by the Seller.
b) Frequency Response Analysis (FRA) Tests shall be performed on each winding using the "Sweep" Method.

9.02.03.02. If the Purchaser is not satisfied with the results of the transformer or reactor condition assessment performed as a result of the ~~transformer~~equipment experiencing a Zone 3 impact or higher, the Purchaser has the right not to accept the ~~transformer~~equipment and to require additional field testing or the transformer or reactor to be shipped back to the factory for additional testing at the Seller's expense.

9.03. Rail Shipment

9.03.01. If the transformer or reactor and accessories are shipped by rail, the Purchaser requires that the freight cars carrying the transformer and the accessories be shipped together. In addition, the Purchaser requests that the Seller put the following on the Bill of Lading:

"The transformer (or reactor) car No. ________ and accessories car(s) No. _________ are to travel together".

9.04. Ocean or Barge Shipment

9.04.01. If the transformer or reactor and accessories are shipped by ocean vessel or barge, the Purchaser requires that the vessels carrying the transformer or reactor and the accessories be shipped together.

9.04.02. It is the Seller's responsibility to verify whether impact recorders, dry air cylinders, and any pressure sealed accessories are still in operable or sealed prior to transfer from the ship or barge to the next transportation stage. It may be necessary to replace dry air cylinders, batteries, or re-pressurize accessories before transportation can continue. If an impact recorder is found to be inoperable at this point, it must be repaired or replaced before the next segment of transportation can begin.

Exhibit A

Approved Suppliers

A1. Bushing Suppliers

ABB
Lapp/PCORE
Passoni and Villa
Trench

A2. Surge Arresters

ABB
Cooper
General Electric
Ohio Brass
Siemens

A3. Gas-in-Oil Monitor

The transformer shall be fitted with a suitable connection for the future addition of a Morgan Schaffer Calisto, General Electric Hydran or similar sensor for dissolved gas-in-oil monitoring.

A4. Terminal Blocks

A4.01. Control terminal blocks shall be 12-point, 600V, 30A class minimum, Marathon type 1512, GE type EB-25, or Buchanan type 2B112.

A4.02. Current transformer (CT) terminal blocks shall be 6 point, shorting type, 600V, 30A class minimum, Marathon type 1506, GE type EB-27, or Penn Union type 606.

A4.03. DC power blocks shall be 600 V class, GE type EB-1 or equivalent.

A5. Fault Pressure Relay Devices

A5.01. Conservator Type Transformers

Type	**Manuf.**	**Model #**
~~SPRR~~ RPRR Buchholz	VEM Buchholz	Type BF80-10, Twin-Float relay DR80, Model 09-236, with Form C contacts or approved equivalent
Seal-in relay	Qualitrol	Model No. 909-300-01 (Provide when required on the Transformer or Reactor Spec Detail Sheet)

A5.02. Gas-Blanketed Type Transformers

Type	Manuf.	Model #
~~SPRR~~ RPRR - Oil Type, Flange Mounted	Qualitrol	Model No. 900-003-62 with a male Mil Spec pin and sleeve connector Cannon Cat. No. MS-3102E-16-10P
Seal-in relay	Qualitrol	Model No. 909-300-01 (Provide when required on the Transformer or Reactor Spec Detail Sheet)
Female Mil Spec pin and sleeve connector - Straight	Cannon	MS-3106F16-10S (straight)
Female Mil Spec pin and sleeve connector – 90 degree	Bendix	10-72817-10S (90 degree)

A5.03. LTC Compartments

Type	Manuf.	Model #
~~SPRR~~ RPRR - Oil Type, Flange Mounted	Qualitrol	Model No. 900-003-62 with a male Mil Spec pin and sleeve connector Cannon Cat. No. MS-3102E-16-10P
Seal-in relay	Qualitrol	Model No. 909-300-01 (Provide when required on the Transformer or Reactor Spec Detail Sheet)
Female Mil Spec pin and sleeve connector - Straight	Cannon	MS-3106F16-10S (straight)
Female Mil Spec pin and sleeve connector – 90 degree	Bendix	10-72817-10S (90 degree)

A6. Temperature Monitor Devices:

A6.01. Electronic Temperature Monitor Devices

Manuf.	**Model**	**Part #**
Weschler Instruments	Transformer Advantage CT (Use this model when there is no LTC or for when three 1PH in-tank type LTCs are provided.)	**Two Winding TRs**: G4EF * * 50WR * XBXX or G4EF * * 50WR * XNXX **Auto or Three Winding TRs:** G4EF * * 50WR * PBXX or G4EF * * 50WR * PNXX
Weschler Instruments	Transformer Advantage CT/LTC (Use this type when 3PH LTC in a separate compartment is provided)	**Two Winding TRs:** G8EF * * 50WR * XBXX or G8EF * * 50WR * XNXX **Auto or Three Winding TRs:** G8EF * * 50WR * PBXX or G8EF * * 50WR * PNXX

Notes:
1. The CT input for the ETM provided must be capable of operation up to 10A with no degradation of ETM accuracy.
2. Seller to determine configuration for part number blanks above designated with an *,.

A6.02. Mechanical Temperature Monitor Devices:

Manuf.	Model #
Qualitrol	104-400 Series – Mechanical **with** analog outputs
Messko	Compact Series MT-ST160SK/TT and MT-ST160W/TT both w/signal converter

A7. LTC Position Transmitter and Display Devices

LTC Position Transmitter: Selsyn INCON 1292 (120 VAC)

LTC Position Display (provided by Purchaser): Selsyn INCON 1250B-1

A8. LTC Control Devices

~~A8.01.Two Winding or Distribution Transformers~~

Option	Description	Manuf.	Model #
1	Voltage Back-up Relay only, provide space only for additional items in Options 2 & 3	Beckwith	M-0329B
2	Automatic Voltage Control with Voltage Back-up Relay, provide space only for additional items in Option 3	Beckwith	▪ M-2001B or newer in a M-2067 panel ▪ M-2029 TapTalk communications sofware ▪ M-0329B
3	Automatic Voltage Control with Voltage Back-up Relay, Parallel Balance Module, and Excessive Circulating Current Relay.	Beckwith	▪ M-2001B or newer in a M-2067 panel ▪ M-2029 TapTalk communications sofware ▪ M-0329B ▪ M-0115A ▪ M-0127A

~~**A8.02.Autotransformers**~~

A9. Terminal Blocks

A9.01. Control terminal blocks shall be 12-point, 600V, 30A class minimum, Marathon type 1512, GE type EB-25, or Buchanan type 2B112.

A9.02. Current transformer (CT) terminal blocks shall be 6 point, shorting type, 600V, 30A class minimum, Marathon type 1506, GE type EB-27, or Penn Union type 606.

A9.03. DC power blocks shall be 600 V class, GE type EB-1 or equivalent.

MAIN LEGEND

SYMBOL	DESCRIPTION	MANUFACTURER	CATALOG NUMBER
4-1	MOTOR CONTACTOR FOR FIRST STAGE FANS	SQUARE D	8910DPA-12V02
4-2	MOTOR CONTACTOR FOR SECOND STAGE FANS	SQUARE D	8910DPA-12V02
8-1	20 AMP BREAKER FOR FIRST STAGE FANS	SQUARE D	QOUR220VH
8-2	20 AMP BREAKER FOR SECOND STAGE FANS	SQUARE D	QOUR220VH
8-3	10 AMP BREAKER FOR FAN CONTROL RELAY,	SQUARE D	QOUR 110
27-1	240 VAC LOSS OF 1ST STAGE FAN SUPPLY POWER RELAY,	OMRON	H3CR-H8L 200-240AC M
27-2	240 VAC LOSS OF 2ND STAGE FAN SUPPLY POWER RELAY,	OMRON	H3CR-H8L 200-240AC M
27-3	120 VAC LOSS OF COOLING CONTROL	OMRON	H3CR-H8L 100-120AC M
33-1	AUTO-OFF-MANUAL SWITCH FOR FIRST STAGE FANS	ALLEN BRADLEY	800T-J2A
33-2	AUTO-OFF-MANUAL SWITCH FOR SECOND STAGE FANS	ALLEN BRADLEY	800T-J2A
43-1	FAN TRANSFER SWITCH	ALLEN BRADLEY	800T-H2B
88-1	FIRST STAGE FAN MOTOR, 208/240 VOLT, 850 RPM, 26 INCH DIA., 1 FLA, 192 WATTS	KRENZ	F26D-A9770-9
88-2	SECOND STAGE FAN MOTOR, 208/240 VOLT, 850 RPM, 26 INCH DIA., 1 FLA, 192 WATTS	KRENZ	F26D-A9770-9
8-4	20 AMP BREAKER FOR LIGHT AND CONVIENCE OUTLET	SQUARE D	QOUR120VH
8-9	10 AMP BREAKER FOR HEATERS IN MAIN CAB. AND INERT GAS	SQUARE D	QOUR 110
33-3	HEATER SWITCH	ALLEN BRADLEY	800T-H2A
33-5	HEATER SWITCH (INERT AIR)	ALLEN BRADLEY	800T-H2A
63P-1 (MT)	PRESSURE RELIEF DEVICE (MAIN TANK)	VIAT	3051004
63P-2 (LTC)	PRESSURE RELIEF DEVICE (LTC)	VIAT	3051004
63SP (MT)	SUDDEN PRESSURE RELAY (MAIN TANK)	QUALITROL	900-003-62
63SP (LTC)	SUDDEN PRESSURE RELAY (LTC)	QUALITROL	900-003-62
71Q-1(MT)	LIQUID LEVEL GAUGE (MAIN TANK)	MESKO	MTO-ST160RM/3U/AF
71Q-2(LTC)	LIQUID LEVEL GAUGE (LTC)	MESKO	MTO-ST160RM/1U/AF
74/63HP	PRESSURE SWITCH-TRANSFORMER TANK	BARKSDALE	96211-BB6-W24
74/63LP	VACUUM SWITCH-TRANSFORMER TANK	BARKSDALE	D2S-H18SS-W36
74/63LV	PRESSURE SWITCH FOR NITROGEN CYLINDER	McMASTER	46995K6
BCT	BUSHING CURRENT TRANSFORMER	MERIMEC	
BCT-A THRU X2WTI	6 PIN TERMINAL BLOCK (SHORTING TYPE)	GENERAL ELECTRIC	EB27B06S
CO1	20 AMP 120V GFCI RECEPTACLE	LEVITRON	6899-1
CTB1, CTB2, CTB3	CURRENT TRANSFORMER BLOCK	CENTRAL MALONEY	
ETM	ELECTRONIC TEMPERATURE MONITOR	WESCHLER	
GB1	GROUND BAR (CONTROL CABINET SEGMENT)	KUHLMAN	
GB2	GROUND BAR (POWER CABINET SEGMENT)	KUHLMAN	
PH1,2	HEATER, 120 VOLTS, 65 WATTS (MAIN)	HIGH VOLTAGE	PTC-B00
H3	HEATER, 120 VOLTS, 65 WATTS (INERT AIR)	HIGH VOLTAGE	PTC-B00
HT-2	HEATER THERMOSTAT (INERT AIR)	DAYTON	2E815
JB	JUNCTION BOX TERMINAL BLOCK		
LS	LIGHT SWITCH-DOOR ACTIVATED	NEWARK	BZ-2RQ1-A2
LT	CONTROL CABINET LIGHT, 130 VOLT, 75 WATTS	EPCO	15055
PB	4 PIN POWER TERMINAL BLOCK	GENERAL ELECTRIC	EB25B04
TB	12 PIN TERMINAL BLOCK	GENERAL ELECTRIC	EB-25B12C
TB-B	6 PIN TERMINAL BLOCK	PENN UNION	6006
TBG	TERMINAL BLOCK (INERT AIR)	PENN UNION	6012
TSW	TEST SWITCH (LDC)	STATES	20K02-G

FAN TRANSFER SWITCH (43-1)	LOCAL-REMOTE SWITCH (43LR)
MANUFACTURER TO ADD SWITCH CONTACT CALLOUT CHART	MANUFACTURER TO ADD SWITCH CONTACT CALLOUT CHART
FAN SWITCH (33-1, 33-2)	LOWER-OFF-RAISE SWITCH (CS, CS-1)
MANUFACTURER TO ADD SWITCH CONTACT CALLOUT CHART	MANUFACTURER TO ADD SWITCH CONTACT CALLOUT CHART
HEATER SWITCH (33-3, 33-4, 33-5)	AUTO-MANUAL SWITCH (____)
MANUFACTURER TO ADD SWITCH CONTACT CALLOUT CHART	MANUFACTURER TO ADD SWITCH CONTACT CALLOUT CHART

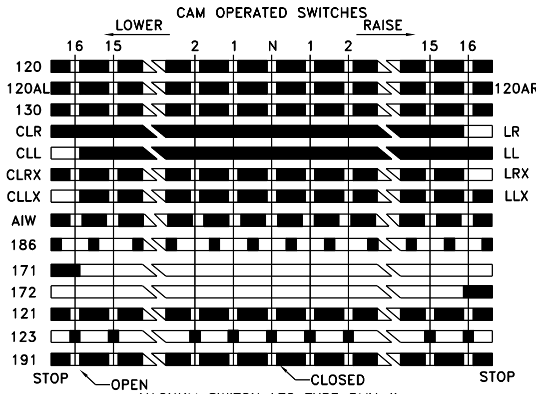
LTC LEGEND

SYMBOL	DESCRIPTION	MANUFACTURER	CATALOG NUMBER
8-5	10 AMP BREAKER FOR 120V MONITORING AND CONTROL CIRCUIT	SQUARE D	QOUR 110
8-6	10 AMP BREAKER FOR HEATERS IN MOTOR DRIVE UNIT	SQUARE D	QOUR 110
8-7	6 AMP BREAKER FOR LTC MOTOR	SIEMENS	3RV1021-1HA10
8-8	10 AMP BREAKER FOR 120V POTENTIAL	SQUARE D	QOUR 110
23-1,23-2	THERMOSTAT-(CAM SWITCH COMPARTMENT)	REINHAUSEN	____
26Q	HOT OIL THERMOSTAT LTC LOW TEMP.	REINHAUSEN	____
26QB	LOCKOUT RELAY LTC	ALLEN BRADLEY	700-NX-123
26QBRL	LOCKOUT LOW TEMP. LIGHT (RED)	ALLEN BRADLEY	800T-Q11R
27-4	RELAY, 120 VAC LOSS OF LTC VOLTAGE POWER	OMRON	H3CR-H8L 100-120AC M
33-4	HEATER SWITCH (MAIN CONTROL CABINET)	ALLEN BRADLEY	800T-H2A
43LR	LOCAL-REMOTE SWITCH THERMAL RELAY	ALLEN BRADLEY	800T-H2BW/LP
49	LTC MOTOR THERMAL RELAY (LTC MOTOR OVERLOAD)	ALLEN BRADLEY	700-NX-123
49AL	LIGHT - AMBER	ALLEN BRADLEY	800T-Q11A
52a	LTC AUXILIARY BLOCK CONTACT	____	____
60	LTC PARALLEL BALANCE MODULE	BECKWITH	M-0115A
78LTC	OFF POSITION AUXILIARY RELAY (TIME DELAY)	TYCO	CNS-35-92
74/62RL	OFF POSITION ALARM LIGHT (RED)	ALLEN BRADLEY	800T-Q11R
74AM	AUTO-MANUAL SWITCH (LTC)	BECKWITH	M2067
74DB	LOSS OF POTENTIAL RELAY	OMRON	H3CR-H8L 100-120AC M
84H-1	HANDCRANK INTERLOCK SWITCH	REINHAUSEN	____
84L	MOTOR CONTROL LOWER RELAY	ALLEN BRADLEY	700-NX-124
84M	MOTOR 240V SINGLE PHASE	REINHAUSEN	____
84R	MOTOR CONTROL RAISE RELAY	ALLEN BRADLEY	700-NX-124
86-68	LOCKOUT AUXILIARY RELAY	ALLEN BRADLEY	700-NX-123
86-L,C,R	SEQUENCE MONITOR RELAYS	REINHAUSEN	____
86GL	SUPERVISORY POWER CONTROL LIGHT (GREEN)	ALLEN BRADLEY	800T-Q11G
86RL	LOCKOUT LIGHT (RED)	ALLEN BRADLEY	800T-Q11R
86XL	LOCKOUT RUN BACK RELAY (LOWER)	ALLEN BRADLEY	700-NX-123
86XR	LOCKOUT RUN BACK RELAY (RAISE)	ALLEN BRADLEY	700-NX-123
88	BRAKE RELAY	REINHAUSEN	____
90	LTC REGULATING RELAY	BECKWITH	M-2067/M-2001C
90BU	LTC REGULATOR BACK-UP RELAY	BECKWITH	M-0329B
120	REMOTE OFF POSITION LIGHT CAM SWITCH	REINHAUSEN	____
121	OPERATION COUNTER CAM SWITCH	REINHAUSEN	____
120AL	MOTOR CONTROL RELAY CAM SWITCH	REINHAUSEN	____
120AR	MOTOR CONTROL RELAY CAM SWITCH	REINHAUSEN	____
123	ON POSITION CAM SWITCH	REINHAUSEN	____
123X	ON POSITION AUXILIARY RELAY	REINHAUSEN	____
123WL	ON POSITION LIGHT (WHITE)	ALLEN BRADLEY	800T-Q11W
130	LOSS OF POWER CAM SWITCH	REINHAUSEN	____
171	LOWER LIMIT CAM SWITCH	REINHAUSEN	____
172	RAISE LIMIT CAM SWITCH	REINHAUSEN	____
186	MONITORING CONTROL SWITCH	REINHAUSEN	____
191	OFF POSITION CAM	REINHAUSEN	____
ACT	AUXILIARY CURRENT TRANSFORMER	REINHAUSEN	____
AIW	LIGHT PIPE VERIFICATION SWITCH	REINHAUSEN	____
C-1,2,3	CAPACITOR COURSE LIMIT CAM SWITCH	REINHAUSEN	____
CLL	COURSE LIMIT CAM SWITCH	REINHAUSEN	____
CLLX	VERNIER LOWER LIMIT CAM SWITCH	REINHAUSEN	____
CLR	COURSE LIMIT CAM SWITCH	REINHAUSEN	____
CLRX	VERNIER RAISE LIMIT CAM SWITCH	REINHAUSEN	____
CS	LOWER-OFF-RAISE SWITCH (LTC MOTOR DRIVE COMPARTMENT)	REINHAUSEN	____
CS-1	LOWER-OFF-RAISE SWITCH (MAIN CONTROL CAB.)	BECKWITH	M2067
DPRS	RESET SWITCH	REINHAUSEN	____
EPI	ELECTRONIC POSITION INDICATOR	INCON	1250B-4
FU	FUSE 3AG, 0.25A	REINHAUSEN	____
HTR-1,2,3	HEATER-CAM SWITCH COMPARTMENT	REINHAUSEN	____
JT	JUNCTION PLATE TERMINAL	REINHAUSEN	____
LE-1,2,3	LIGHT EMITTER	REINHAUSEN	____
LL	COURSE LIMIT CAM SWITCH	REINHAUSEN	____
LLX	VERNIER LOWER LIMIT CAM SWITCH	REINHAUSEN	____
LP	LIGHT PIPE	REINHAUSEN	____
LR	COURSE LIMIT CAM SWITCH	REINHAUSEN	____
LR-1,2,3	LIGHT RECEIVER	REINHAUSEN	____
LRX	VERNIER RAISE LIMIT CAM SWITCH	REINHAUSEN	____
MPI	MECHANICAL POSITION INDICATOR	REINHAUSEN	____
OC	OPERATION COUNTER, MECHANICAL	REDINGTON	R2-4816, P2-4816
P	MONITORING SYSTEM POWER SUPPLY	REINHAUSEN	____
PC	PARALLEL BALANCER--M-0115 (FUTURE)	REINHAUSEN	____
PL	EIGHT-PIN PLUG	REINHAUSEN	____
PLC	EIGHT-PIN PLUG CONNECTION	REINHAUSEN	____
PTR	LTC TAP POSITION TRANSMITTER	REINHAUSEN	____
RC	ELEC. RESET COIL (MAX.-MIN. HANDS)	REINHAUSEN	____
RSM	MONITORING RESET SWITCH-PUSH BUTTON (RED)	REINHAUSEN	____
SP	SUPERVISION POWER	REINHAUSEN	____
t°	MOTOR THERMOSTAT	REINHAUSEN	____
T1-60	TERMINAL BOARD IN MOTOR DRIVE UNIT	REINHAUSEN	____
TSM	MONITORING TEST SWITCH-PUSH BUTTON (GREEN)	REINHAUSEN	____
TT	TEST TERMINAL	NEWARK	35N845
VIM	VACUUM INTERRUPTER MONITOR (CSC)	REINHAUSEN	____
VIM1-17	TERMINAL BOARD IN MONITORING CABINET (CSC)	REINHAUSEN	____

INCLUDE ALL LEGEND AND MISC INFO ON THIS LEAD SHEET(S) AS SHOWN. THIS DWG IS AN EXAMPLE OF TYPICAL INFO TO BE INCLUDED.

LTC SYMBOL LEGEND

- □ TERMINAL BLOCK POINT INSIDE CONTROL CABINET
- ○ DEVICE TERMINAL POINT
- ⊡ LTC MANUFACTURE FURNISHED TERMINAL BLOCK POINT
- ⊗ DEVICE TERMINAL POINT INSIDE LTC MOTOR DRIVE COMPARTMENT



VACUUM SWITCH LTC TYPE RMV-II
SEQUENCE CHART
(33 POS. 32 STEP)

SWITCH SETTINGS

TOP OIL THERMOMETER (26Q) (LTC)
SW1 CLOSES AT TEMPERATURES BETWEEN
-35°C & -40°C
SW2 & 3 ARE NOT USED. ADDITIONAL CONTACTS ARE FOR FUTURE HEATER APPLICATIONS (IF NEED)

PRESSURE RELIEF DEVICE (63P-1(MT), 63P-2(LTC)
SW OPERATES AT +10.0 P.S.I.G.

TANK PRESSURE SWITCH (74/63HP)
SW OPERATES AT +8.5 P.S.I.G.

TANK VACUUM SWITCH (74/63LP)
SW OPERATES AT -3.0 P.S.I.G.

NITROGEN CYLINDER PRESSURE SWITCH (74/63LV)
SW OPERATES AT 200 P.S.I.G.

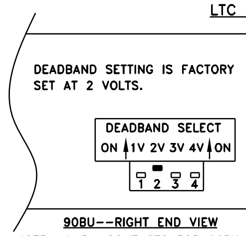
SWITCH RATINGS

26/49 ELECTRONIC TEMPERATURE MONITOR
6.25 AMPS AT 48 VDC
1.00 AMPS AT 125 VDC

LIQUID LEVEL GAGE (71Q-1(MT), 71Q-2(LTC)
10.00 AMPS AT 125, 250 VAC
0.50 AMPS AT 110 VDC } NON-INDUCTIVE
0.25 AMPS AT 250 VDC
1.30 AMPS AT 48 VDC

PRESSURE RELIEF DEVICE (63P-1(MT), 63P-2(LTC)
SUDDEN PRESSURE RELAY (63SP(MT), 63SP(LTC)
15.00 AMPS AT 125, 250 AND 480 VAC
0.50 AMPS AT 48 VDC } NON-INDUCTIVE
1.30 AMPS AT 48 VDC

LTC BACK-UP RELAY (90BU)



90BU--RIGHT END VIEW

NOTE: ALARM CONTACTS FOR 90BU RELAY ARE SHOWN ENERGIZED.

DEADBAND SETTING	1	2	3	4
1V	UP	DOWN	DOWN	DOWN
2V	DOWN	UP	DOWN	DOWN
3V	DOWN	DOWN	UP	DOWN
4V	DOWN	DOWN	DOWN	UP

CAUTION:
IF MORE THAN ONE SWITCH IS IN THE "UP" POSITION, THE CONTROL'S OPERATION AND DEAD BAND SETTING WILL BE UNPREDICTABLE.

EXHIBIT B

********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS
Xcel Energy® — XCEL ENERGY COMPANY WIDE
POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2
FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD

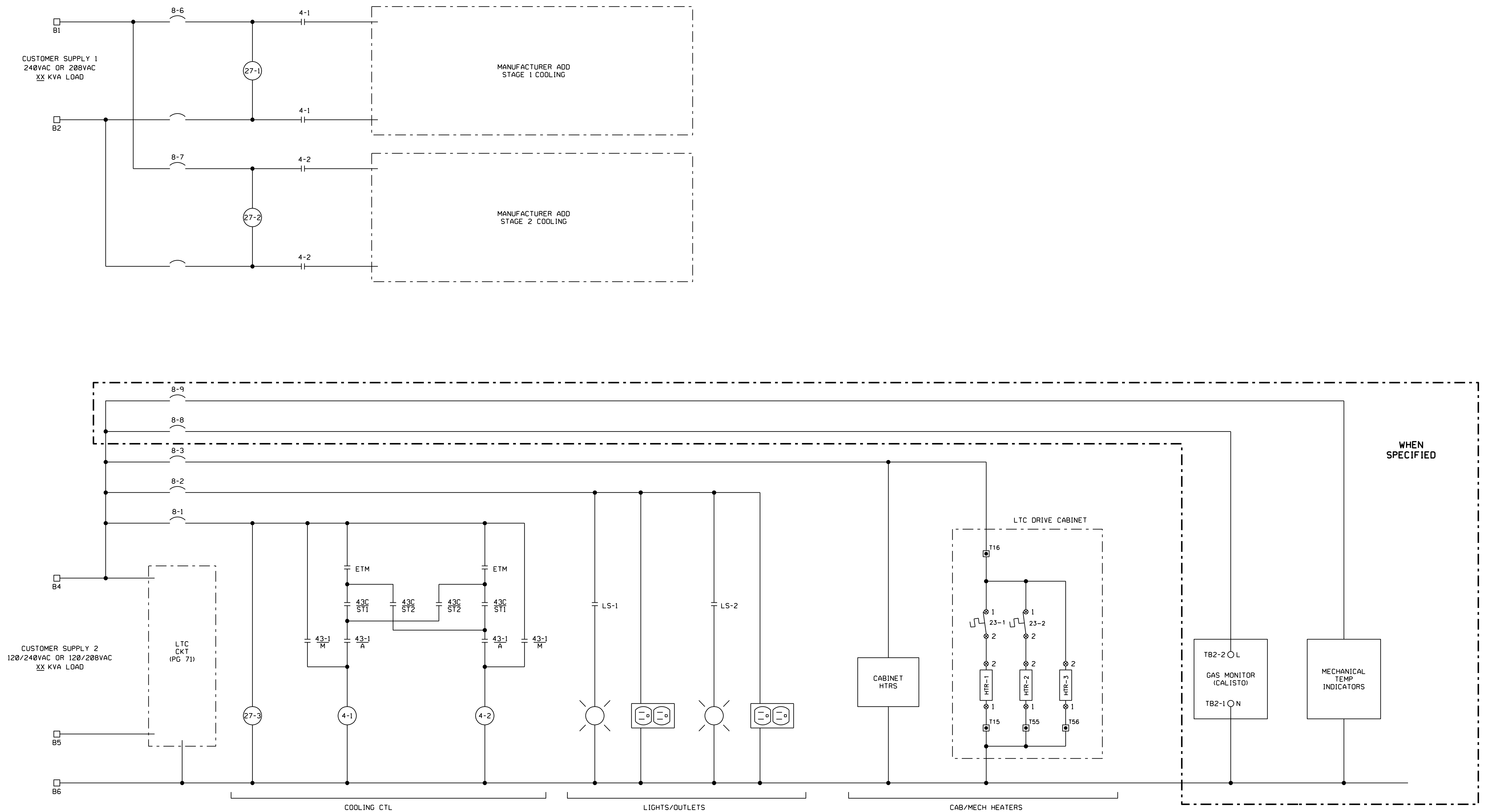


EXHIBIT B

********	********	********	********	********
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XCEL ENERGY				

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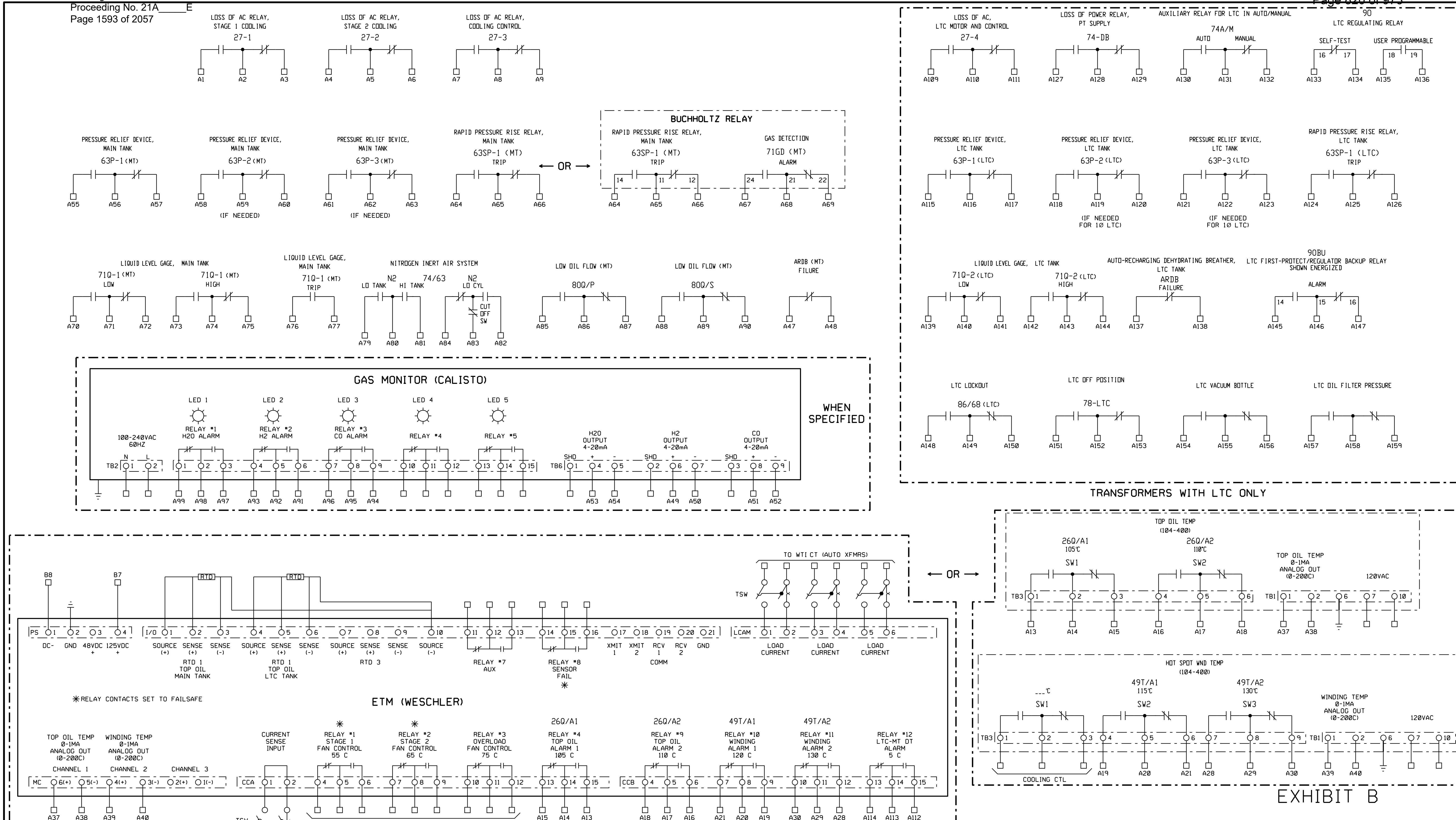
Xcel Energy | XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2

FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD



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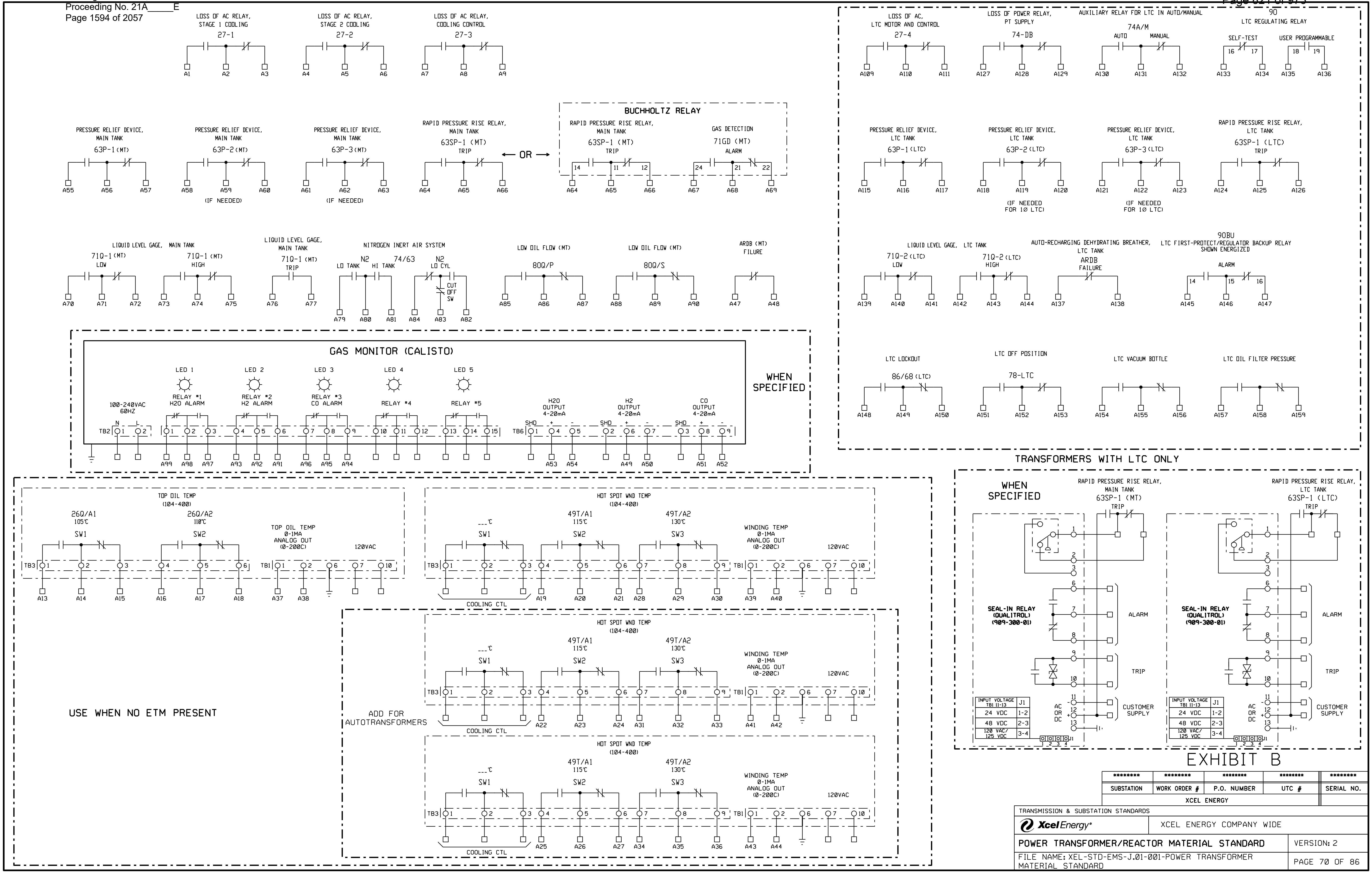
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

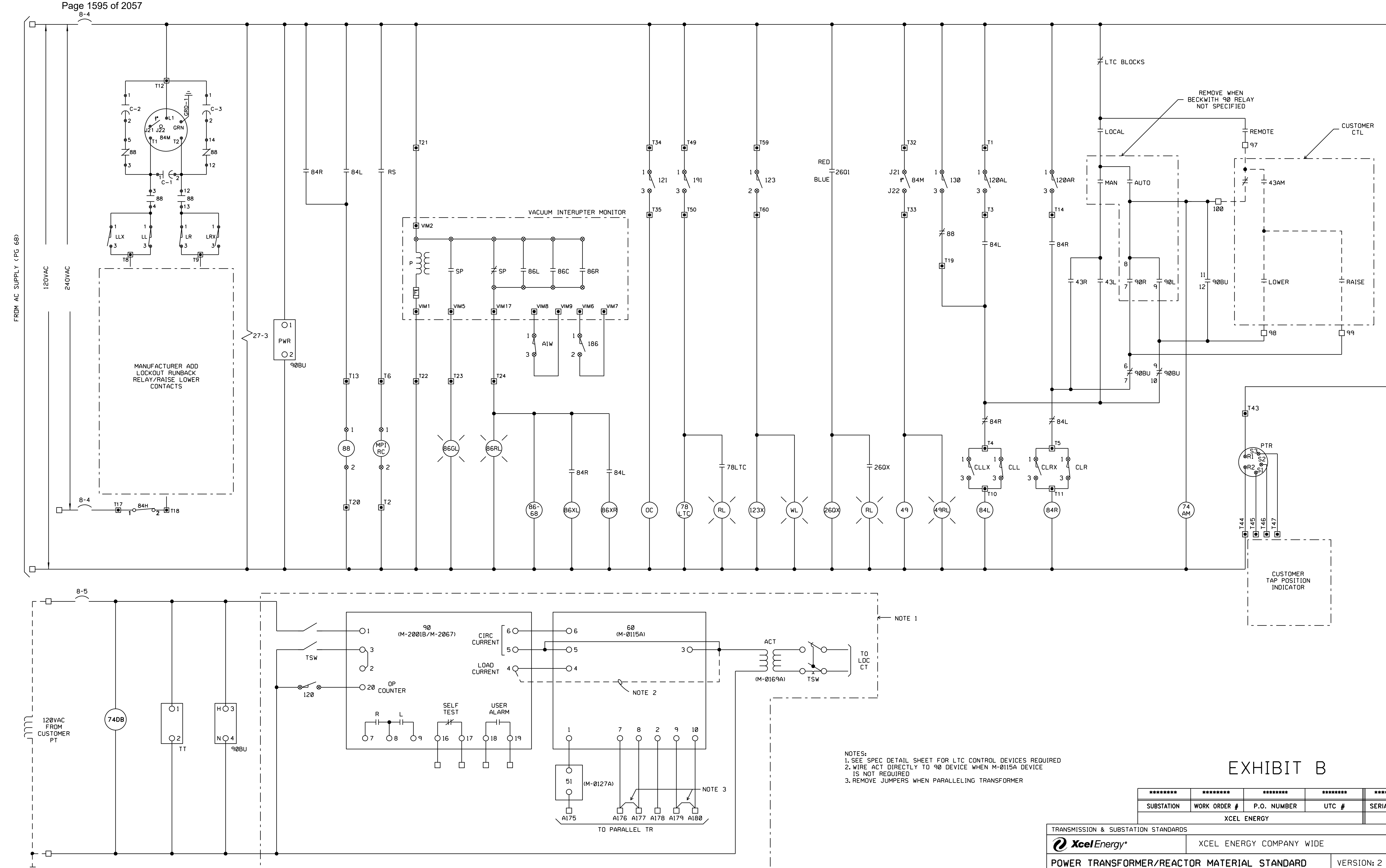
TRANSMISSION & SUBSTATION STANDARDS

Xcel Energy — XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2

FILE NAME: XEL-STD-EMS-J.Ø1-ØØ1-POWER TRANSFORMER MATERIAL STANDARD — PAGE 69 OF 86


LOSS OF AC RELAY, STAGE 1 COOLING
27-1
LOSS OF AC RELAY, STAGE 2 COOLING
27-2
LOSS OF AC RELAY, COOLING CONTROL
27-3
LOSS OF AC, LTC MOTOR AND CONTROL
27-4
LOSS OF POWER RELAY, PT SUPPLY
74-DB
AUXILIARY RELAY FOR LTC IN AUTO/MANUAL
74A/M
AUTO
MANUAL
90
LTC REGULATING RELAY
SELF-TEST
USER PROGRAMMABLE
BUCHHOLTZ RELAY
RAPID PRESSURE RISE RELAY, MAIN TANK
63SP-1 (MT)
TRIP
GAS DETECTION
71GD (MT)
ALARM
OR
PRESSURE RELIEF DEVICE, MAIN TANK
63P-1 (MT)
63P-2 (MT)
63P-3 (MT)
(IF NEEDED)
PRESSURE RELIEF DEVICE, LTC TANK
63P-1 (LTC)
63P-2 (LTC)
63P-3 (LTC)
(IF NEEDED FOR 1Ø LTC)
RAPID PRESSURE RISE RELAY, LTC TANK
63SP-1 (LTC)
LIQUID LEVEL GAGE, MAIN TANK
71Q-1 (MT)
LOW
HIGH
TRIP
NITROGEN INERT AIR SYSTEM
N2
74/63
LO TANK
HI TANK
LO CYL
CUT OFF SW
LOW OIL FLOW (MT)
80Q/P
80Q/S
ARDB (MT) FILURE
LIQUID LEVEL GAGE, LTC TANK
71Q-2 (LTC)
AUTO-RECHARGING DEHYDRATING BREATHER, LTC TANK
ARDB
FAILURE
90BU
LTC FIRST-PROTECT/REGULATOR BACKUP RELAY SHOWN ENERGIZED
LTC LOCKOUT
86/68 (LTC)
LTC OFF POSITION
78-LTC
LTC VACUUM BOTTLE
LTC OIL FILTER PRESSURE
GAS MONITOR (CALISTO)
LED 1
LED 2
LED 3
LED 4
LED 5
100-240VAC 60HZ
RELAY #1 H2O ALARM
RELAY #2 H2 ALARM
RELAY #3 CO ALARM
RELAY #4
RELAY #5
H2O OUTPUT 4-20mA
H2 OUTPUT 4-20mA
CO OUTPUT 4-20mA
WHEN SPECIFIED
TRANSFORMERS WITH LTC ONLY
TOP OIL TEMP (104-400)
26Q/A1 105℃
26Q/A2 110℃
SW1
SW2
TOP OIL TEMP 0-1MA ANALOG OUT (0-200C)
120VAC
HOT SPOT WND TEMP (104-400)
49T/A1 115℃
49T/A2 130℃
SW3
WINDING TEMP 0-1MA ANALOG OUT (0-200C)
COOLING CTL
USE WHEN NO ETM PRESENT
ADD FOR AUTOTRANSFORMERS
SEAL-IN RELAY (QUALITROL) (909-300-01)
ALARM
TRIP
CUSTOMER SUPPLY
AC OR DC
INPUT VOLTAGE TB1 11-13
J1
24 VDC 1-2
48 VDC 2-3
120 VAC/125 VDC 3-4
EXHIBIT B
SUBSTATION
WORK ORDER #
P.O. NUMBER
UTC #
SERIAL NO.
XCEL ENERGY
TRANSMISSION & SUBSTATION STANDARDS
Xcel Energy
XCEL ENERGY COMPANY WIDE
POWER TRANSFORMER/REACTOR MATERIAL STANDARD
VERSION: 2
FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD
PAGE 70 OF 86



NOTES:
1. SEE SPEC DETAIL SHEET FOR LTC CONTROL DEVICES REQUIRED
2. WIRE ACT DIRECTLY TO 90 DEVICE WHEN M-0115A DEVICE IS NOT REQUIRED
3. REMOVE JUMPERS WHEN PARALLELING TRANSFORMER

EXHIBIT B

********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
		XCEL ENERGY		

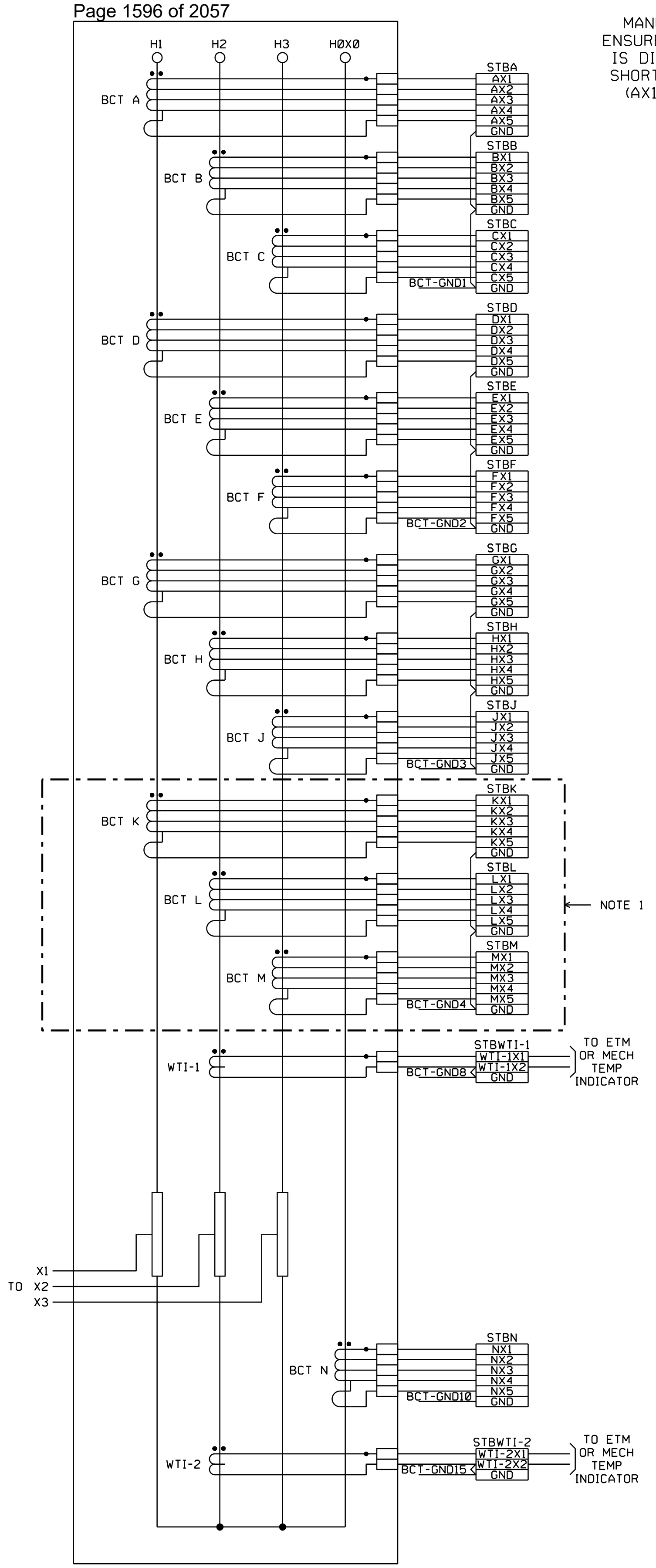
TRANSMISSION & SUBSTATION STANDARDS

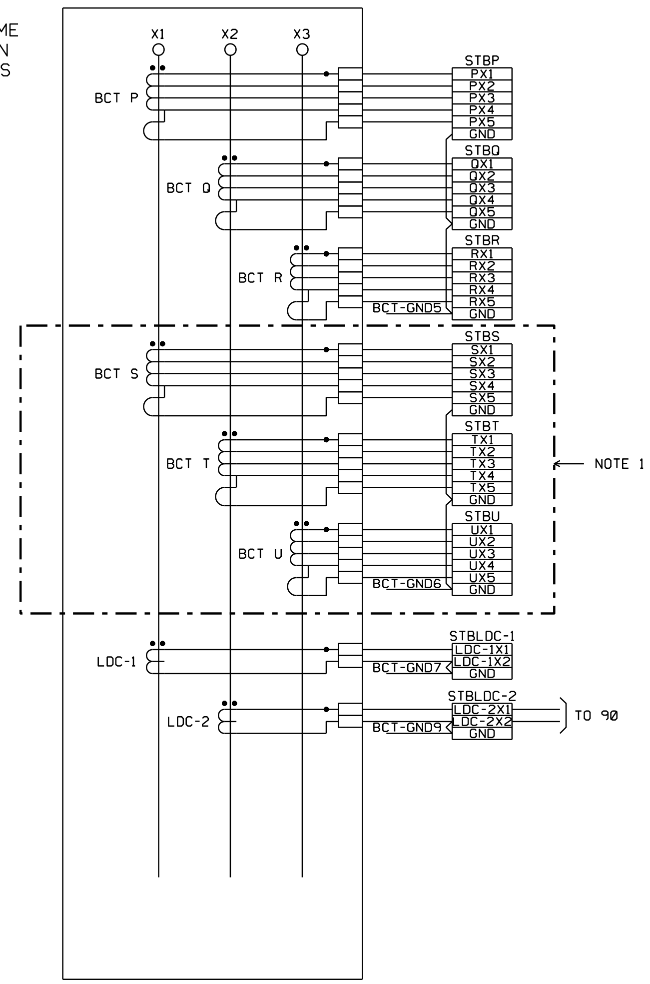
Xcel Energy — XCEL ENERGY COMPANY WIDE

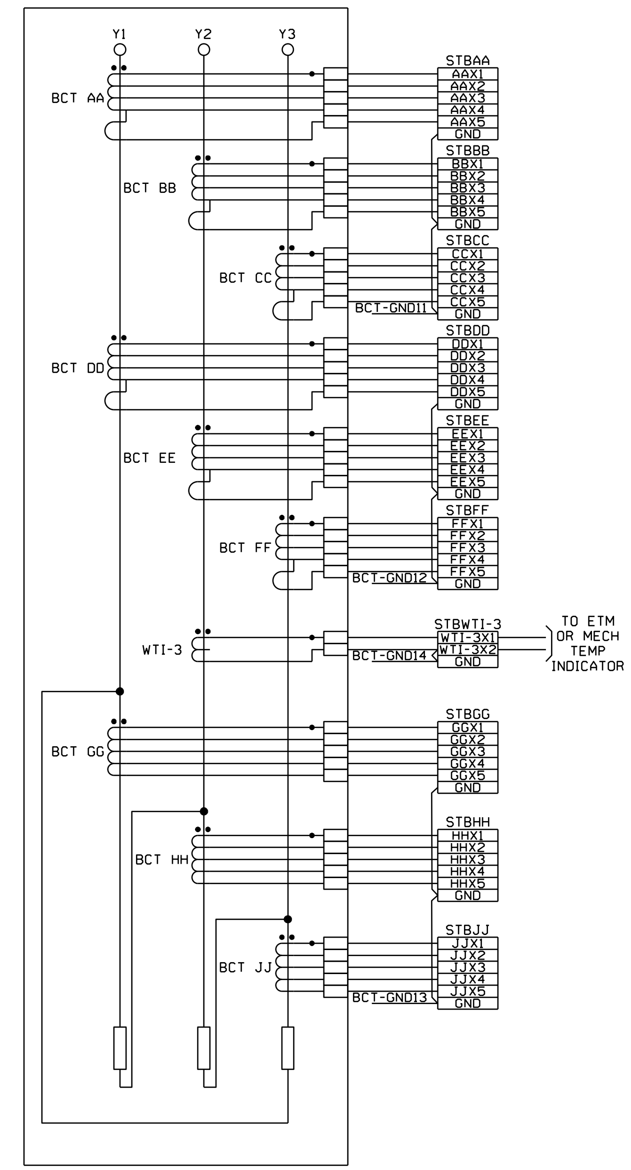
POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2

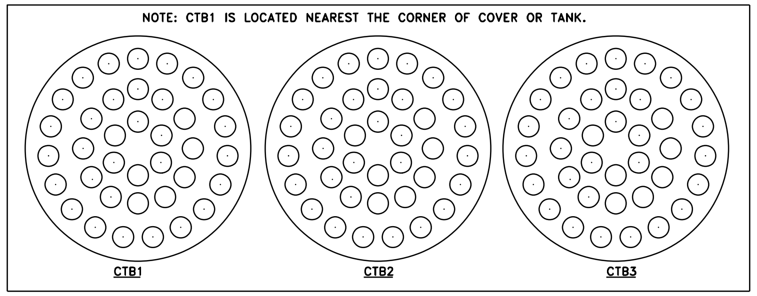
FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD — PAGE 71 OF 86

MANUFACTURER ENSURE FULL NAME IS DISPLAYED ON SHORTING BLOCKS (AX1, AX2, ETC)









CT JUNCTION BOX

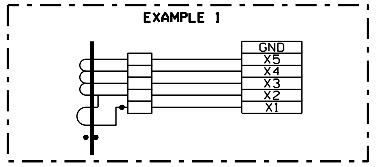
CTB1	BCT LEAD	TERMINAL BLOCK
1	AX1	BCT-A-1
2	AX2	BCT-A-2
3	AX3	BCT-A-3
4	AX4	BCT-A-4
5	AX5	BCT-A-5
6	BX1	BCT-B-1
7	BX2	BCT-B-2
8	BX3	BCT-B-3
9	BX4	BCT-B-4
10	BX5	BCT-B-5
11	CX1	BCT-C-1
12	CX2	BCT-C-2
13	CX3	BCT-C-3
14	CX4	BCT-C-4
15	CX5	BCT-C-5
16	DX1	BCT-D-1
17	DX2	BCT-D-2
18	DX3	BCT-D-3
19	DX4	BCT-D-4
20	DX5	BCT-D-5
21	EX1	BCT-E-1
22	EX2	BCT-E-2
23	EX3	BCT-E-3
24	EX4	BCT-E-4
25	EX5	BCT-E-5
26	FX1	BCT-F-1
27	FX2	BCT-F-2
28	FX3	BCT-F-3
29	FX4	BCT-F-4
30	FX5	BCT-F-5
31	GX1	BCT-G-1
32	GX2	BCT-G-2
33	GX3	BCT-G-3
34	GX4	BCT-G-4
35	GX5	BCT-G-5
36	BLANK	BLANK
37	BLANK	BLANK

CTB2	BCT LEAD	TERMINAL BLOCK
1	HX1	BCT-H-1
2	HX2	BCT-H-2
3	HX3	BCT-H-3
4	HX4	BCT-H-4
5	HX5	BCT-H-5
6	JX1	BCT-J-1
7	JX2	BCT-J-2
8	JX3	BCT-J-3
9	JX4	BCT-J-4
10	JX5	BCT-J-5
11	KX1	BCT-K-1
12	KX2	BCT-K-2
13	KX3	BCT-K-3
14	KX4	BCT-K-4
15	KX5	BCT-K-5
16	LX1	BCT-L-1
17	LX2	BCT-L-2
18	LX3	BCT-L-3
19	LX4	BCT-L-4
20	LX5	BCT-L-5
21	MX1	BCT-M-1
22	MX2	BCT-M-2
23	MX3	BCT-M-3
24	MX4	BCT-M-4
25	MX5	BCT-M-5
26	NX1	BCT-N-1
27	NX2	BCT-N-2
28	NX3	BCT-N-3
29	NX4	BCT-N-4
30	NX5	BCT-N-5
31	WTIX1	WTI-1
32	WTIX2	WTI-2
33	LDC-1X1	LDC-1-1
34	LDC-1X2	LDC-1-2
35	LDC-2X1	LDC-2-1
36	LDC-2X2	LDC-2-2
37	BLANK	BLANK

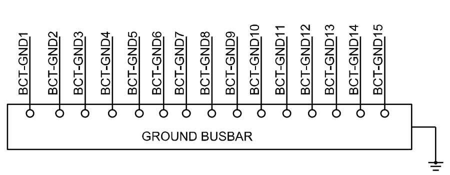
CTB3	BCT LEAD	TERMINAL BLOCK
1	PX1	BCT-P-1
2	PX2	BCT-P-2
3	PX3	BCT-P-3
4	PX4	BCT-P-4
5	PX5	BCT-P-5
6	QX1	BCT-Q-1
7	QX2	BCT-Q-2
8	QX3	BCT-Q-3
9	QX4	BCT-Q-4
10	QX5	BCT-Q-5
11	RX1	BCT-R-1
12	RX2	BCT-R-2
13	RX3	BCT-R-3
14	RX4	BCT-R-4
15	RX5	BCT-R-5
16	SX1	BCT-S-1
17	SX2	BCT-S-2
18	SX3	BCT-S-3
19	SX4	BCT-S-4
20	SX5	BCT-S-5
21	TX1	BCT-T-1
22	TX2	BCT-T-2
23	TX3	BCT-T-3
24	TX4	BCT-T-4
25	TX5	BCT-T-5
26	UX1	BCT-U-1
27	UX2	BCT-U-2
28	UX3	BCT-U-3
29	UX4	BCT-U-4
30	UX5	BCT-U-5
31	BLANK	BLANK
32	BLANK	BLANK
33	BLANK	BLANK
34	BLANK	BLANK
35	BLANK	BLANK
36	BLANK	BLANK
37	BLANK	BLANK

NOTES:
1. WHEN SPECIFIED REVERSE POLARITY OF BCT'S K,L,M & S,T,U (SEE EXAMPLE 1)

EXAMPLE 1



MANUFACTURER ADD BCT TAP CHARTS



SPECIFICATION OF BUSHING CURRENT TRANSFORMER

BUSHING CURRENT TRANSFORMER				
TYPE	RATIO (A)	CLASS	TRF	REMARK

EXHIBIT B

********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS

Xcel Energy® — XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2

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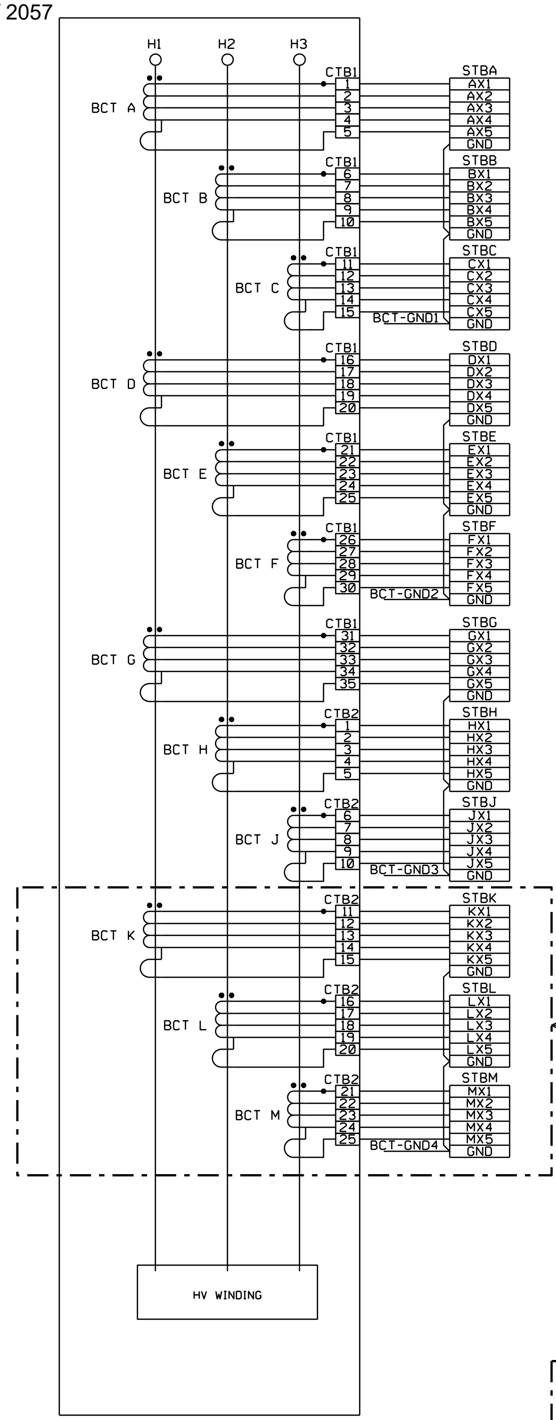
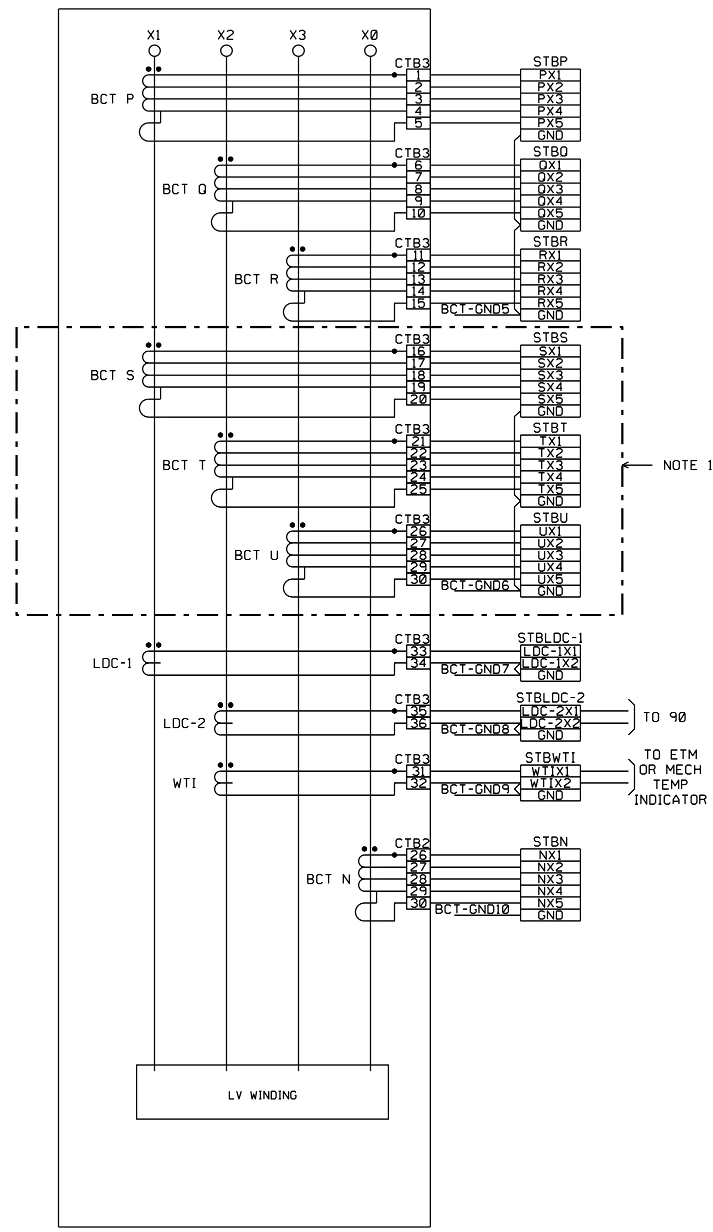
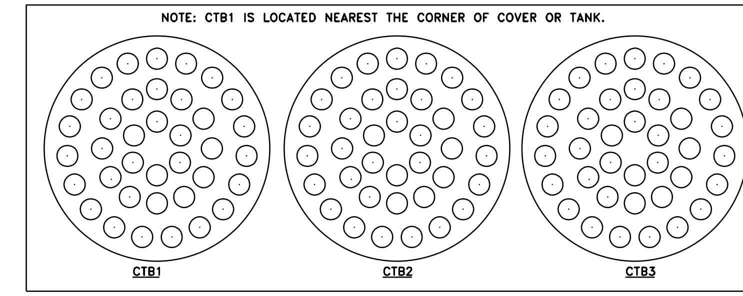


MANUFACTURER
ENSURE FULL NAME
IS DISPLAYED ON
SHORTING BLOCKS
(AX1, AX2, ETC)





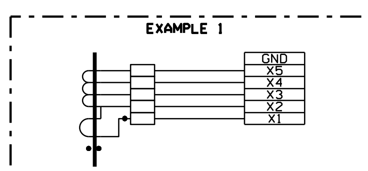
CT JUNCTION BOX

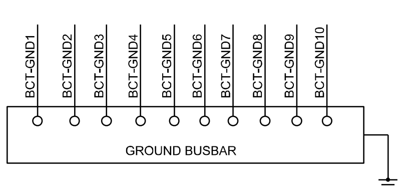
CTB1	BCT LEAD	TERMINAL BLOCK
1	AX1	BCT-A-1
2	AX2	BCT-A-2
3	AX3	BCT-A-3
4	AX4	BCT-A-4
5	AX5	BCT-A-5
6	BX1	BCT-B-1
7	BX2	BCT-B-2
8	BX3	BCT-B-3
9	BX4	BCT-B-4
10	BX5	BCT-B-5
11	CX1	BCT-C-1
12	CX2	BCT-C-2
13	CX3	BCT-C-3
14	CX4	BCT-C-4
15	CX5	BCT-C-5
16	DX1	BCT-D-1
17	DX2	BCT-D-2
18	DX3	BCT-D-3
19	DX4	BCT-D-4
20	DX5	BCT-D-5
21	EX1	BCT-E-1
22	EX2	BCT-E-2
23	EX3	BCT-E-3
24	EX4	BCT-E-4
25	EX5	BCT-E-5
26	FX1	BCT-F-1
27	FX2	BCT-F-2
28	FX3	BCT-F-3
29	FX4	BCT-F-4
30	FX5	BCT-F-5
31	GX1	BCT-G-1
32	GX2	BCT-G-2
33	GX3	BCT-G-3
34	GX4	BCT-G-4
35	GX5	BCT-G-5
36	BLANK	BLANK
37	BLANK	BLANK

CTB2	BCT LEAD	TERMINAL BLOCK
1	HX1	BCT-H-1
2	HX2	BCT-H-2
3	HX3	BCT-H-3
4	HX4	BCT-H-4
5	HX5	BCT-H-5
6	JX1	BCT-J-1
7	JX2	BCT-J-2
8	JX3	BCT-J-3
9	JX4	BCT-J-4
10	JX5	BCT-J-5
11	KX1	BCT-K-1
12	KX2	BCT-K-2
13	KX3	BCT-K-3
14	KX4	BCT-K-4
15	KX5	BCT-K-5
16	LX1	BCT-L-1
17	LX2	BCT-L-2
18	LX3	BCT-L-3
19	LX4	BCT-L-4
20	LX5	BCT-L-5
21	MX1	BCT-M-1
22	MX2	BCT-M-2
23	MX3	BCT-M-3
24	MX4	BCT-M-4
25	MX5	BCT-M-5
26	NX1	BCT-N-1
27	NX2	BCT-N-2
28	NX3	BCT-N-3
29	NX4	BCT-N-4
30	NX5	BCT-N-5
31	WTIX1	WTI-1
32	WTIX2	WTI-2
33	LDC-1X1	LDC-1-1
34	LDC-1X2	LDC-1-2
35	LDC-2X1	LDC-2-1
36	LDC-2X2	LDC-2-2
37	BLANK	BLANK

CTB3	BCT LEAD	TERMINAL BLOCK
1	PX1	BCT-P-1
2	PX2	BCT-P-2
3	PX3	BCT-P-3
4	PX4	BCT-P-4
5	PX5	BCT-P-5
6	QX1	BCT-Q-1
7	QX2	BCT-Q-2
8	QX3	BCT-Q-3
9	QX4	BCT-Q-4
10	QX5	BCT-Q-5
11	RX1	BCT-R-1
12	RX2	BCT-R-2
13	RX3	BCT-R-3
14	RX4	BCT-R-4
15	RX5	BCT-R-5
16	SX1	BCT-S-1
17	SX2	BCT-S-2
18	SX3	BCT-S-3
19	SX4	BCT-S-4
20	SX5	BCT-S-5
21	TX1	BCT-T-1
22	TX2	BCT-T-2
23	TX3	BCT-T-3
24	TX4	BCT-T-4
25	TX5	BCT-T-5
26	UX1	BCT-U-1
27	UX2	BCT-U-2
28	UX3	BCT-U-3
29	UX4	BCT-U-4
30	UX5	BCT-U-5
31	BLANK	BLANK
32	BLANK	BLANK
33	BLANK	BLANK
34	BLANK	BLANK
35	BLANK	BLANK
36	BLANK	BLANK
37	BLANK	BLANK

NOTES:
1. WHEN SPECIFIED REVERSE POLARITY OF BCT'S K,L,M & S,T,U (SEE EXAMPLE 1)





MANUFACTURER ADD
BCT TAP CHARTS

SPECIFICATION OF BUSHING CURRENT TRANSFOMER

BUSHING CURRENT TRANSFORMER				
TYPE	RATIO (A)	CLASS	TRF	REMARK

EXHIBIT B

********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS

Xcel Energy® | XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD | VERSION: 2

FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD | PAGE 73 OF 86

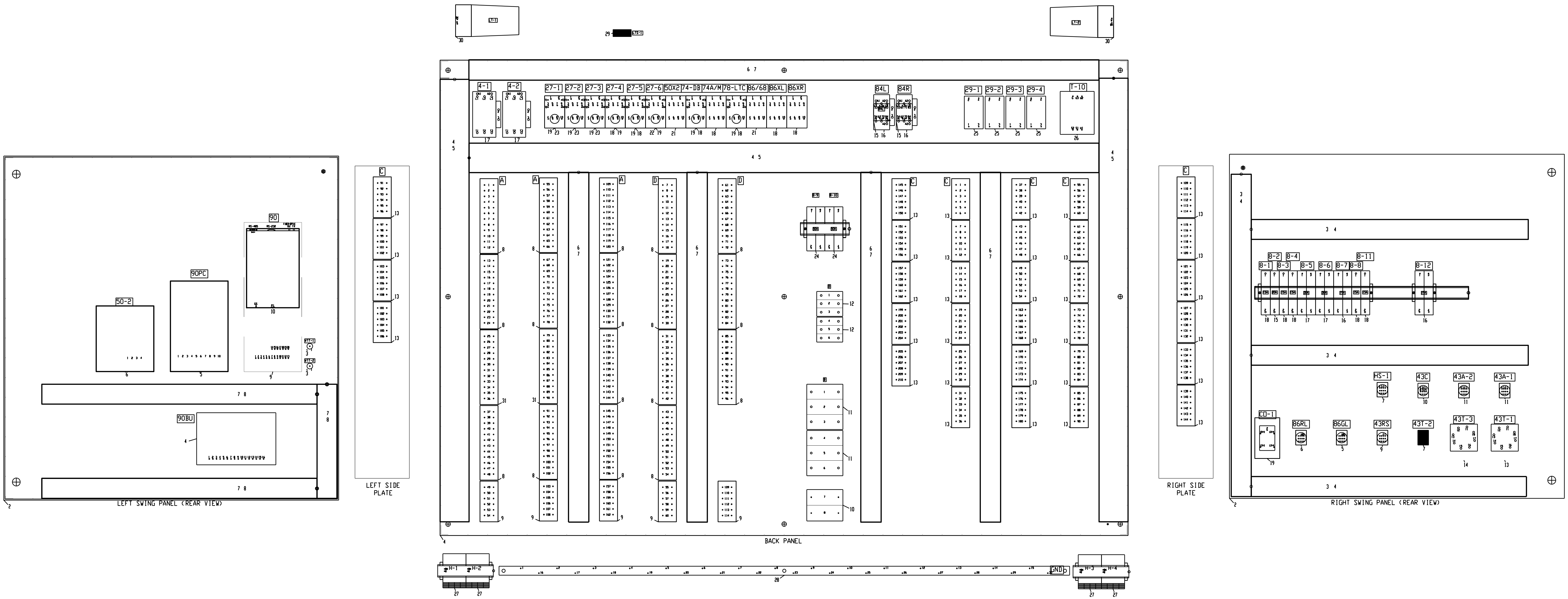


EXHIBIT B

********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS

Xcel Energy — XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2

FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD — PAGE 74 OF 86

☆

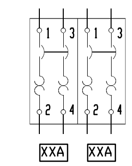
A				A	
1	NO	27-1 LOSS OF AC VOLTAGE COOLING GROUP #1 AL	63P-1 (MT) MECH PRD MAIN TANK AL1	55	NO
2	COM			56	COM
3	NC			57	NC
4	NO	27-2 LOSS OF AC VOLTAGE COOLING GROUP #2 AL	63P-2 (MT) MECH PRD MAIN TANK AL2 (IF NEEDED)	58	NO
5	COM			59	COM
6	NC			60	NC
7	NO	27-3 LOSS OF AC VOLTAGE COOLING CONTROL	63P-3 (MT) MECH PRD MAIN TANK AL3 (IF NEEDED)	61	NO
8	COM			62	COM
9	NC			63	NC
10	NO	27-5 LOSS OF DC VOLTAGE	63SP-1 (MT) RAPID PRES RELAY TRIP	64	NO
11	COM			65	COM
12	NC			66	NC
13	NO	26Q/A1 TOP OIL TEMP AL	71GD (MT) GAS DETECTION CONS-ALARM	67	NO
14	COM			68	COM
15	NC			69	NC
16	NO	26Q/A2 TOP OIL TEMP AL	71Q-1 (MT) LIQ LEV LOW AL	70	NO
17	COM			71	COM
18	NC			72	NC
19	NO	49T/A1 HS WND TEMP AL (ETM OR MECH 1)	71Q-1 (MT) LIQ LEV HIGH AL	73	NO
20	COM			74	COM
21	NC			75	NC
22	NO	49T/A1-LV HS WND TEMP AL (MECH 2)	71Q-1 (MT) LIQ LEV CRIT LOW-TRIP	76	NO
23	COM			77	
24	NC			78	
25	NO	49T/A1-TV HS WND TEMP AL (MECH 3)	N2 INERT AIR LOW/HIGH AL	79	NO
26	COM			80	COM
27	NC			81	NO
28	NO	49T/A2 HS WND TEMP AL (ETM OR MECH 1)	N2 INERT AIR LOW CYL AL	82	NO
29	COM			83	CO SW
30	NC			84	NC
31	NO	49T/A2-LV HS WND TEMP AL (MECH 2)	80Q/P PUMP LOW OIL FLOW-AL	85	NO
32	COM			86	COM
33	NC			87	NC
34	NO	49T/A2-TV HS WND TEMP AL (MECH 3)	80Q/S PUMP LOW OIL FLOW-AL	88	NO
35	COM			89	COM
36	NC			90	NC
37	RTX1(+)	TOP OIL TEMP ANALOG OUT	GAS MONITOR H2 ALARM	91	NO
38	RTX1(-)			92	COM
39	RTX2(+)	WND TEMP ANALOG OUT (ETM OR MECH 1)		93	NC
40	RTX2(-)		GAS MONITOR CO ALARM	94	NO
41	RTX3(+)	WND TEMP ANALOG OUT (MECH 2)		95	COM
42	RTX3(-)			96	NC
43	RTX4(+)	WND TEMP ANALOG OUT (MECH 3)	GAS MONITOR H2O ALARM	97	NO
44	RTX4(-)			98	COM
45	RTX5(+)	LOAD AMP 0-1 mA ANALOG		99	NC
46	RTX5(-)			100	
47	NC	AUTORECHARGING DEHYDR. BREATHER MT- FAILURE		101	
48				102	
49	+	GAS MONITOR H2 ANALOG OUT		103	
50	-			104	
51	+	GAS MONITOR CO ANALOG OUT		105	
52	-			106	
53	+	GAS MONITOR H2O ANALOG OUT		107	
54	-			108	

☆

A				A	
109	NO	27-4 LOSS OF AC LTC MTR & CTRL	LTC REMOTE CONTROL	163	REMOTE
110	COM			164	LOWER
111	NC			165	RAISE
112	NO	ETM LTC-MT TEMP DIF AL		166	AUTO
113	COM		SELSYN TRANSMITTER LTC TAP POSITION	167	T1
114	NC			168	T2
115	NO	63P-1 (LTC) MECH PRD LTC AL1		169	M1
116	COM			170	M2
117	NC			171	M3
118	NO	63P-2 (LTC) MECH PRD LTC AL2		172	
119	COM			173	
120	NC			174	
121	NO	63P-3 (LTC) MECH PRD LTC AL3	M-0115A IF SPECIFIED	175	1
122	COM			176	7
123	NC			177	8
124	NO	63SP-1 (LTC) RAPID PRES RELAY-TRIP		178	2
125	COM			179	9
126	NC			180	10
127	NO	74-DB LOSS OF POWER PT SUPPLY- AL		181	
128	COM			182	
129	NC			183	
130	NO	74A/M LTC AUTO/ MANUAL		184	
131	COM			185	
132	NC			186	
133	NO	90 LTC REG RLY SELF TEST		187	
134				188	
135	NO	90 LTC REG RLY USER PROGRAMABLE		189	
136				190	
137	NC	AUTORECHARGING DEHYDR. BREATHER LTC- FAILURE		191	
138				192	
139	NO	71Q-2 (LTC) LIQ LEV LOW		193	
140	COM			194	
141	NC			195	
142	NO	71Q-2 (LTC) LIQ LEV HIGH		196	
143	COM			197	
144	NC			198	
145	NO	90BU LTC FIRST PROT/ RE BACK UP RELAY			
146	COM				
147	NC				
148	NO	86/68 LTC LOCKOUT AL			
149	COM				
150	NC				
151	NO	78-LTC LTC OFF POSITION AL			
152	COM				
153	NC				
154	NO	LTC VACUUM BOTTLE AL			
155	COM				
156	NC				
157	NO	LTC OIL FILTER PRESSURE AL			
158	COM				
159	NC				
160					
161					
162					

IF NO LTC, DO NOT NEED TO INSTALL THIS ROW

☆



*** MANUFACTURER TO FILL IN CT RATIOS

D
1
2
3
4
5
6

	B
PURCHASER'S AC SUPPLY 1 FAN SUPPLY 208/240VAC, 1PH 9.2KVA MAX	1
	2
	3
PURCHASER'S AC SUPPLY 2 CONTROLS 120/240VAC OR 120/208VAC 1PH 6.4 KVA W/OUTLET	4
	5
	6
PURCHASER'S DC SUPPLY XXVDC 0.15 KW, MIN	7
	8

☆

C					C	
145	WTIX1 <>	X2 WTI ***: 5 CXXX HOT SPOT CT		H1 CTA	1	<> AX1
146	WTIX2 <>				2	AX2
147	WTIX3				3	AX3
148	WTIX4				4	AX4
149	WTIX5				5	<> AX5
150	GND <>		***: 5 CXXX MRCT'S UPPER		6	<> GND
151	LDC-1X1 <>	X1 LDC-1 ***: 5 CXXX LDC CT		H2 CTB	7	<> BX1
152	LDC-1X2 <>				8	BX2
153	LDC-1X3				9	BX3
154	LDC-1X4				10	BX4
155	LDC-1X5				11	<> BX5
156	GND <>				12	<> GND
157	LDC-2X1 <>	X2 LDC-2 ***: 5 CXXX LDC CT		H3 CTC	13	<> CX1
158	LDC-2X2 <>				14	CX2
159	LDC-2X3				15	CX3
160	LDC-2X4				16	CX4
161	LDC-2X5				17	<> CX5
162	GND <>				18	<> GND
199	NX1	X0 CTN ***: 5 CXXX MRCT'S NEUTRAL		H1 CTD	19	<> DX1
200	NX2				20	DX2
201	NX3				21	DX3
202	NX4				22	DX4
203	NX5				23	<> DX5
204	GND		***: 5 CXXX MRCT'S MIDDLE 1		24	<> GND
				H2 CTE	25	<> EX1
					26	EX2
					27	EX3
					28	EX4
					29	<> EX5
					30	<> GND
				H3 CTF	31	<> FX1
					32	FX2
					33	FX3
					34	FX4
					35	<> FX5
					36	<> GND

LAYOUT SET FOR TWO WINDING TRANSFORMER.
IF AUTOTRANSFORMER OR THREE WINDING TR MOVE NEUTRAL BCT TO PG 76 AND ADD ADDITIONAL HOT SPOT CT'S

☆

C					C	
37	GX1 <>	H1 CTG		X1 CTP	55	<> PX1
38	GX2				56	PX2
39	GX3				57	PX3
40	GX4				58	PX4
41	GX5 <>				59	<> PX5
42	GND <>	***: 5 CXXX MRCT'S MIDDLE 2	***: 5 CXXX MRCT'S UPPER		60	<> GND
43	HX1 <>	H2 CTH		X2 CTQ	61	<> QX1
44	HX2				62	QX2
45	HX3				63	QX3
46	HX4				64	QX4
47	HX5 <>				65	<> QX5
48	GND <>				66	<> GND
49	JX1 <>	H3 CTJ		X3 CTR	67	<> RX1
50	JX2				68	RX2
51	JX3				69	RX3
52	JX4				70	RX4
53	JX5 <>				71	<> RX5
54	GND <>				72	<> GND
163	KX1 <>	H1 CTK		X1 CTS	73	<> SX1
164	KX2				74	SX2
165	KX3				75	SX3
166	KX4				76	SX4
167	KX5 <>				77	<> SX5
168	GND <>	***: 5 CXXX MRCT'S LOWER	***: 5 CXXX MRCT'S LOWER		78	<> GND
169	LX1 <>	H2 CTL		X2 CTT	79	<> TX1
170	LX2				80	TX2
171	LX3				81	TX3
172	LX4				82	TX4
173	LX5 <>				83	<> TX5
174	GND <>				84	<> GND
175	MX1 <>	H3 CTM		X3 CTU	85	<> UX1
176	MX2				86	UX2
177	MX3				87	UX3
178	MX4				88	UX4
179	MX5 <>				89	<> UX5
180	MGND <>				90	<> GND

☆

BACK PANEL TERMINAL BLOCK ROW LAYOUT

EXHIBIT B

☆ CUSTOMER'S CONNECTIONS THIS SIDE

BCT SHORTING FOR SHIPMENT (WITH SHORTING-TYPE BCT BLOCKS)
<> SHORT ALL BCTS FOR SHIPMENT FROM #1 TO #5 OR #2 TO 'G' SHORTING BLOCK TERMINALS WITH PROVIDED SHORTING BARS AND PIN SCREWS.
BEFORE PLACING TRANSFORMER INTO SERVICE, REMOVE THE PIN SCREWS FROM THE WTI BCT SHORTING BAR.

********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS	
Xcel Energy®	XCEL ENERGY COMPANY WIDE
POWER TRANSFORMER/REACTOR MATERIAL STANDARD	VERSION: 2
FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD	PAGE 75 OF 86

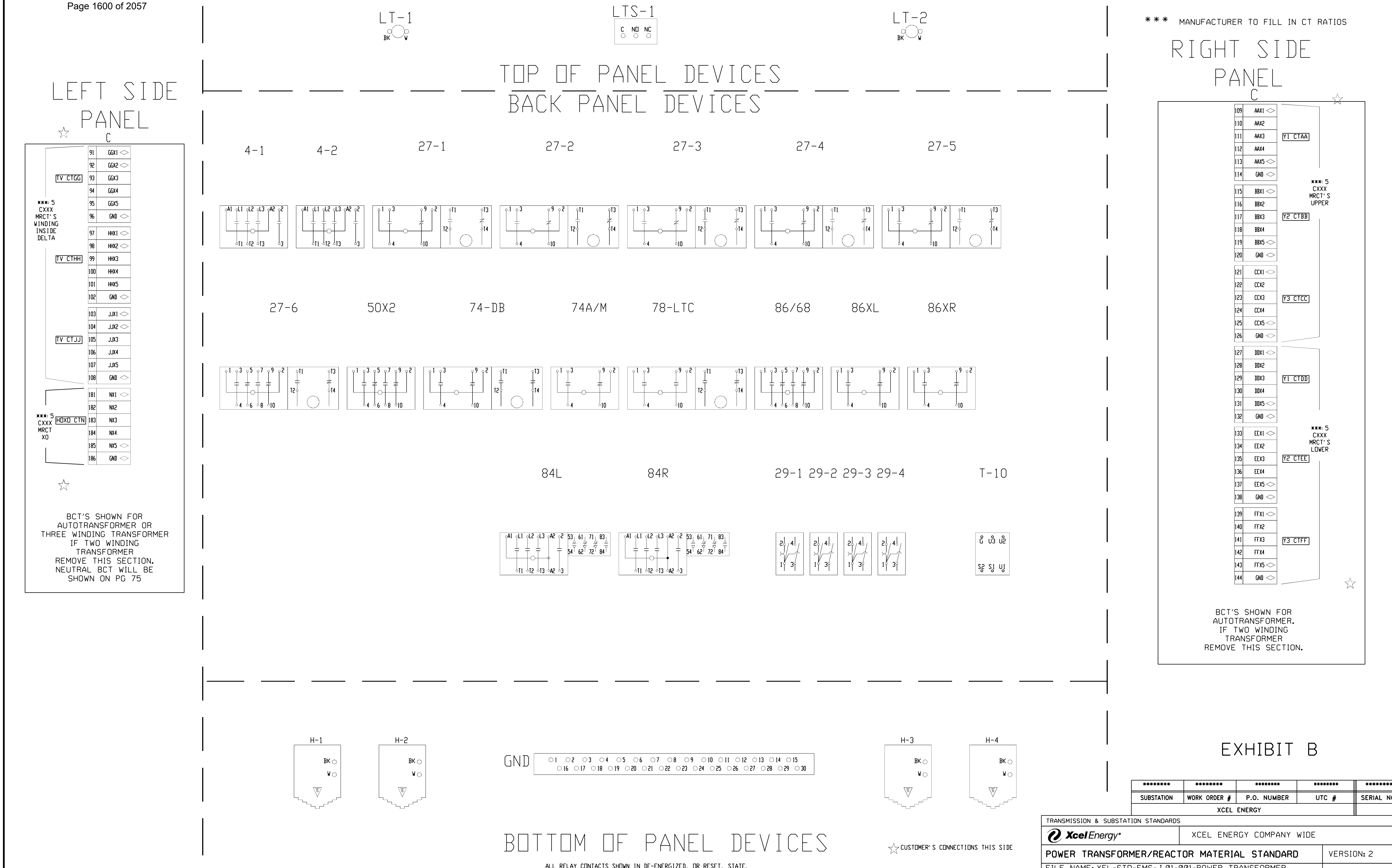


EXHIBIT B

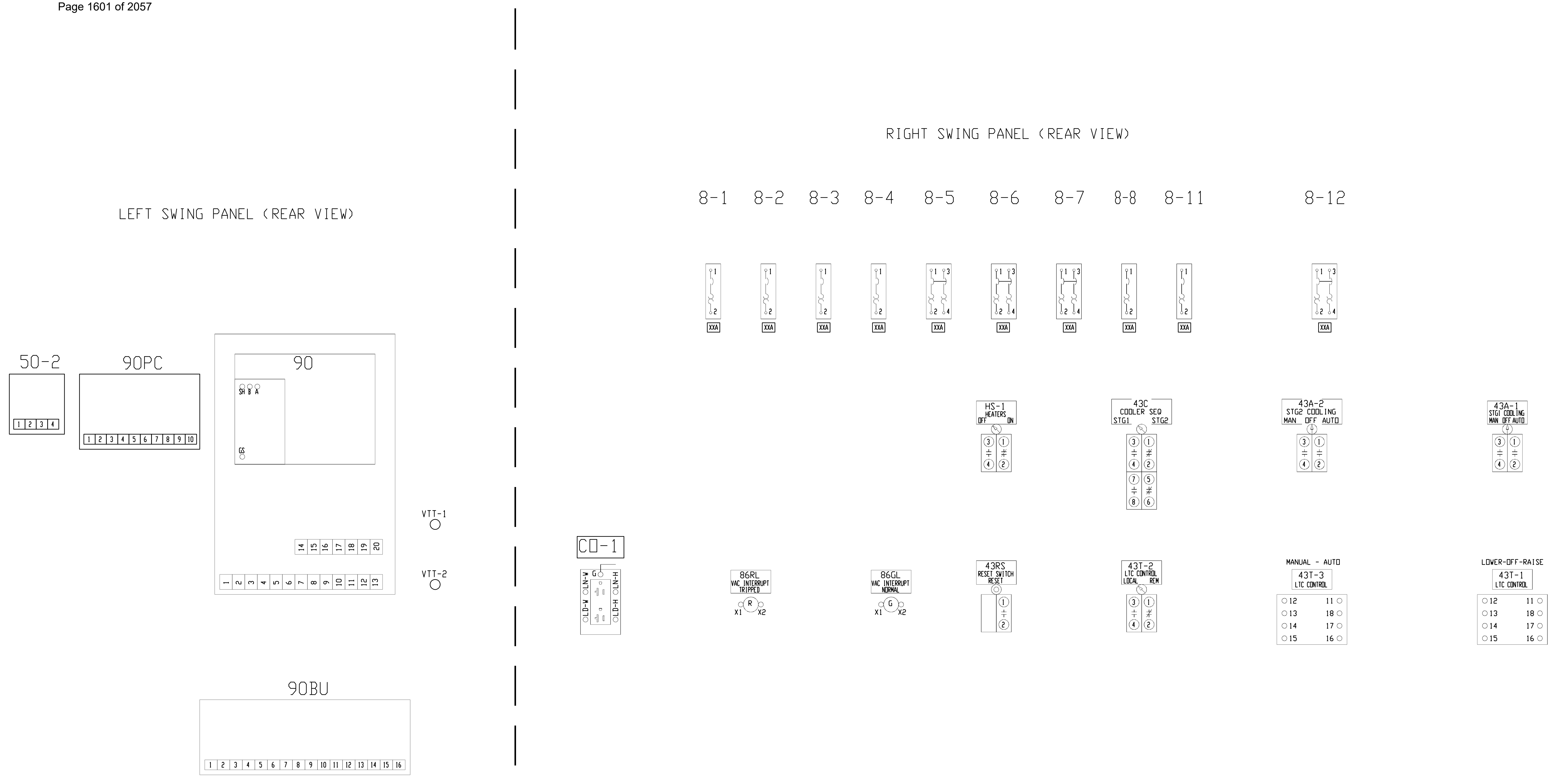
********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS

Xcel Energy — XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2

FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD



SWING PANEL WIRING NOTES:
1- SEE BACK WIRING DIAGRAM FOR GENERAL WIRING NOTES.

ALL RELAY CONTACTS SHOWN IN DE-ENERGIZED, OR RESET, STATE.

EXHIBIT B

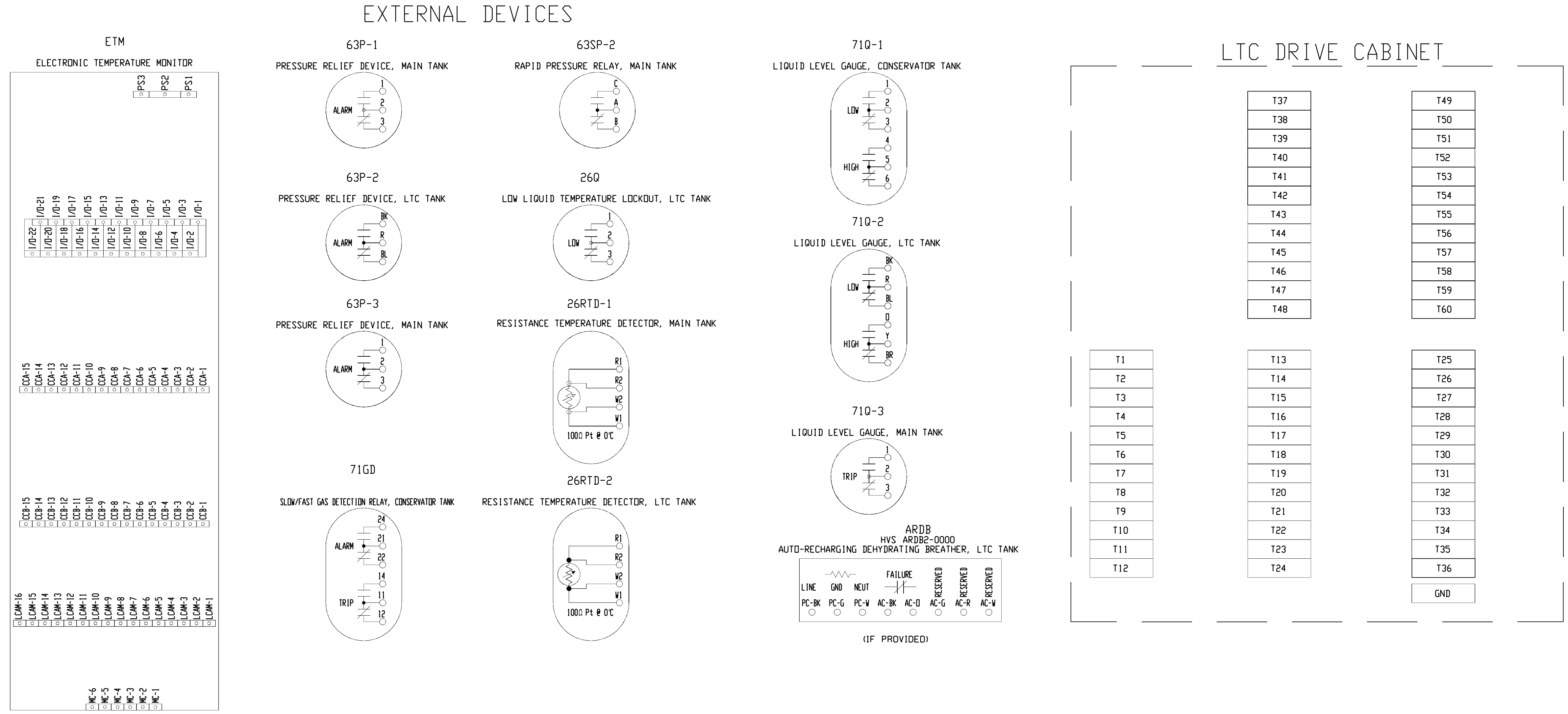
********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS

Xcel Energy® | XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD | VERSION: 2

FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD | PAGE 77 OF 86



FAN WIRING

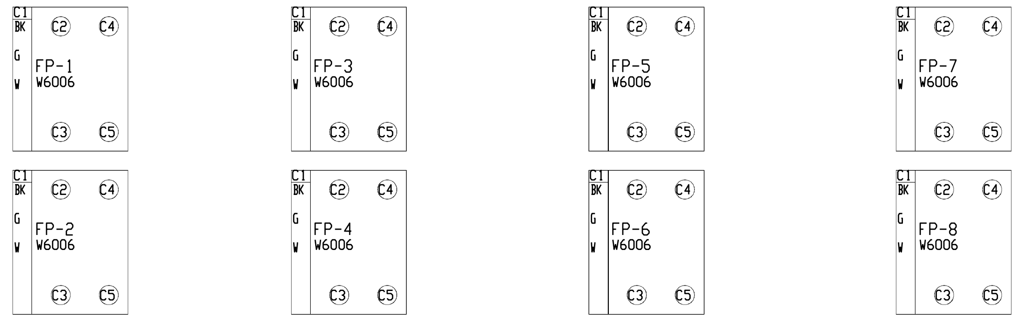


EXHIBIT B

ALL RELAY CONTACTS SHOWN IN DE-ENERGIZED, OR RESET, STATE.

********	********	********	********	********
SUBSTATION	WORK ORDER #	P.O. NUMBER	UTC #	SERIAL NO.
XCEL ENERGY				

TRANSMISSION & SUBSTATION STANDARDS

Xcel Energy® — XCEL ENERGY COMPANY WIDE

POWER TRANSFORMER/REACTOR MATERIAL STANDARD — VERSION: 2

FILE NAME: XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD

Exhibit C

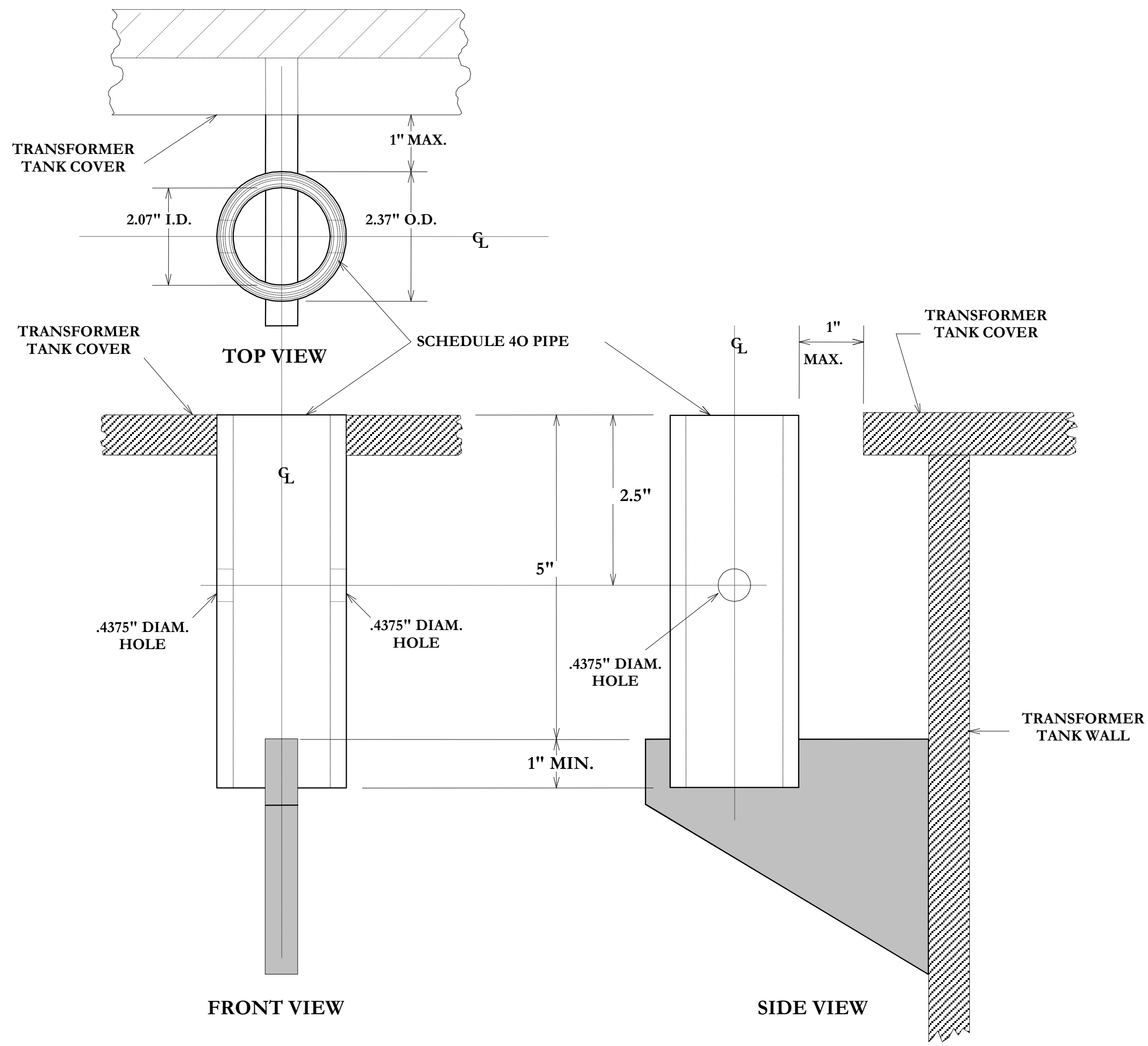


Figure 1

Safety Rail Pocket Detail

Exhibit C

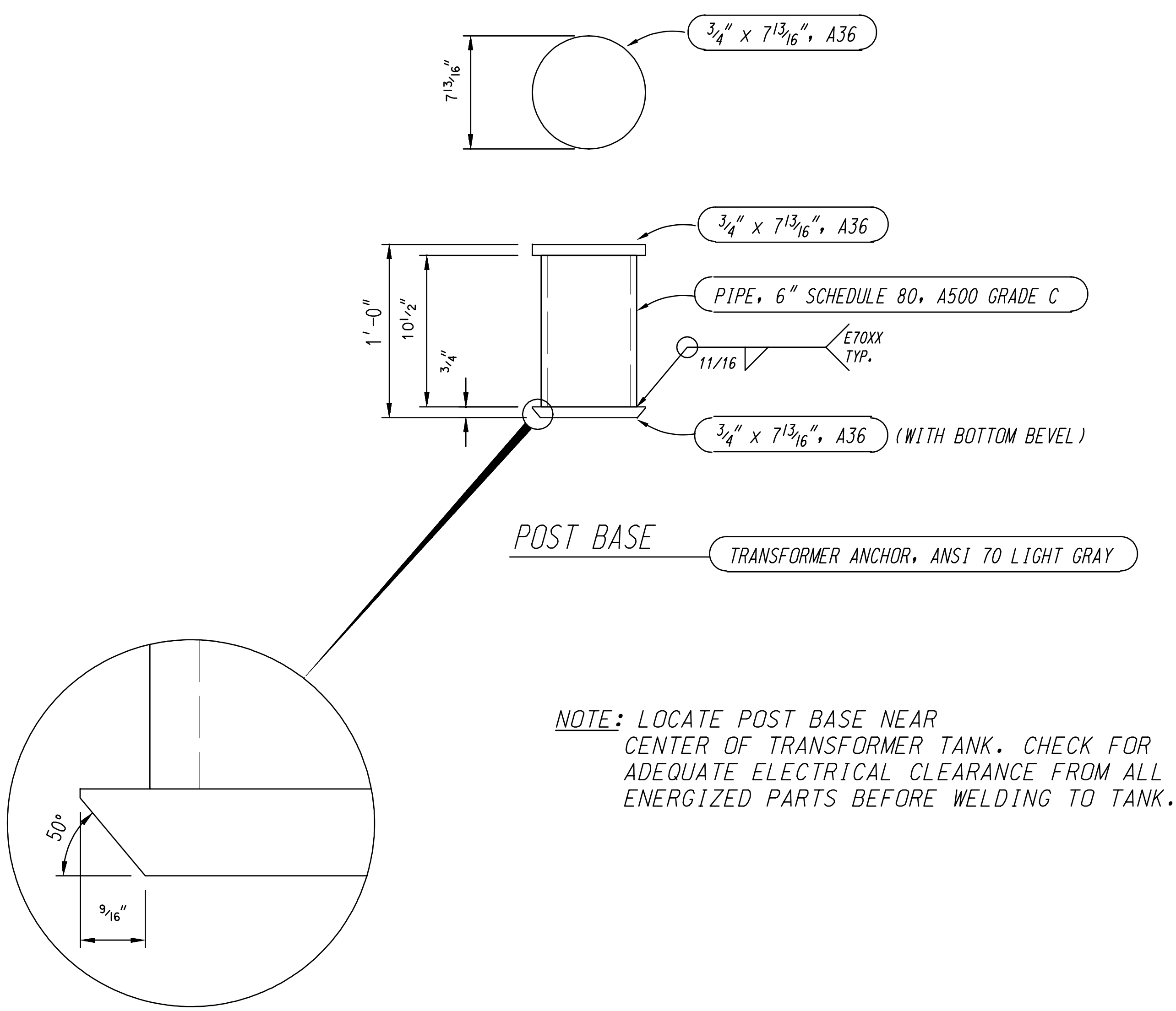


Figure 2

Tether Pole Base Plate Detail

Transmission & Substation Standards	
Xcel Energy	Xcel Energy Company Wide
Power Transformer/Reactor Material Standard	Version: 2
File Name : XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD	Page 81 of 86

Exhibit C

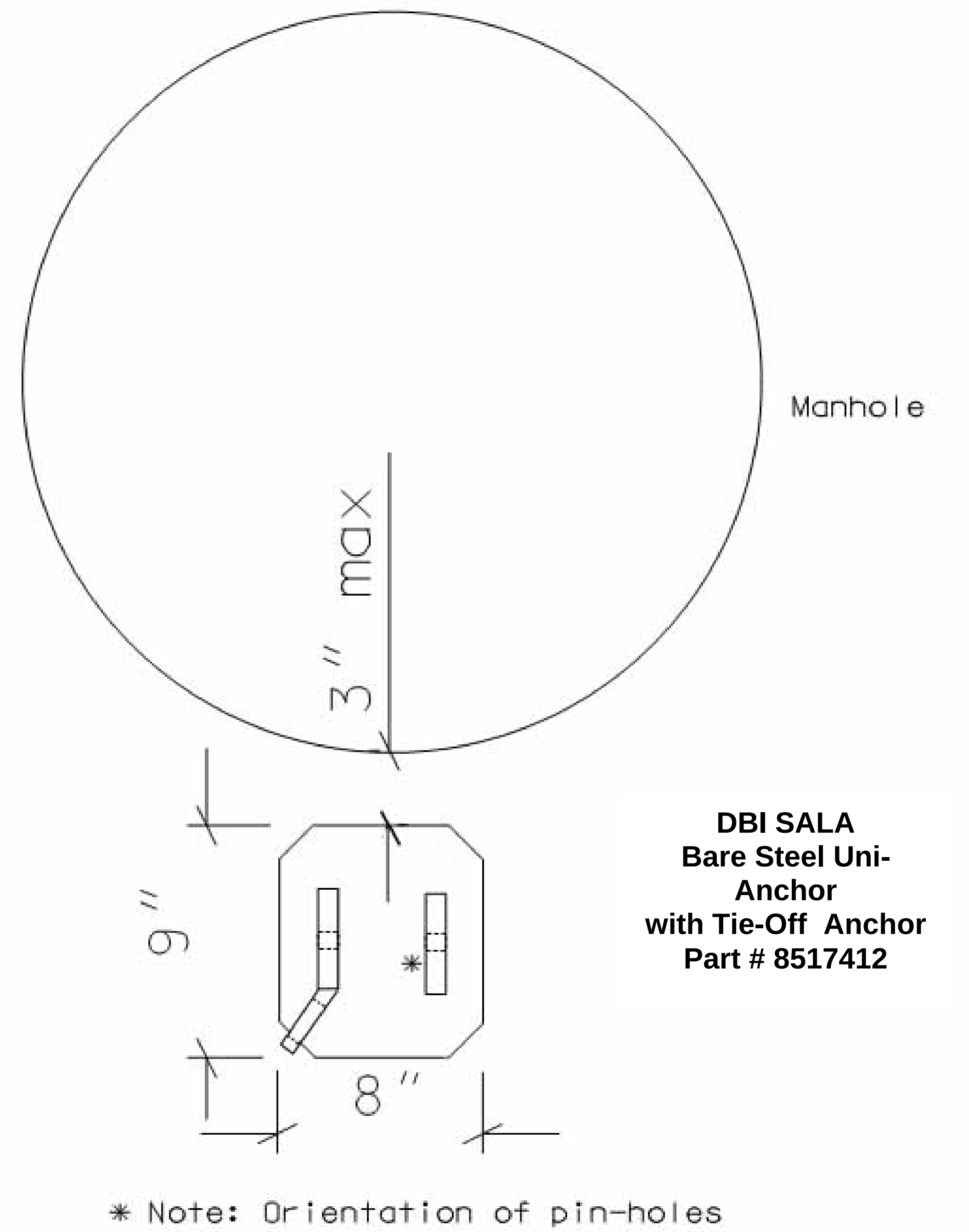
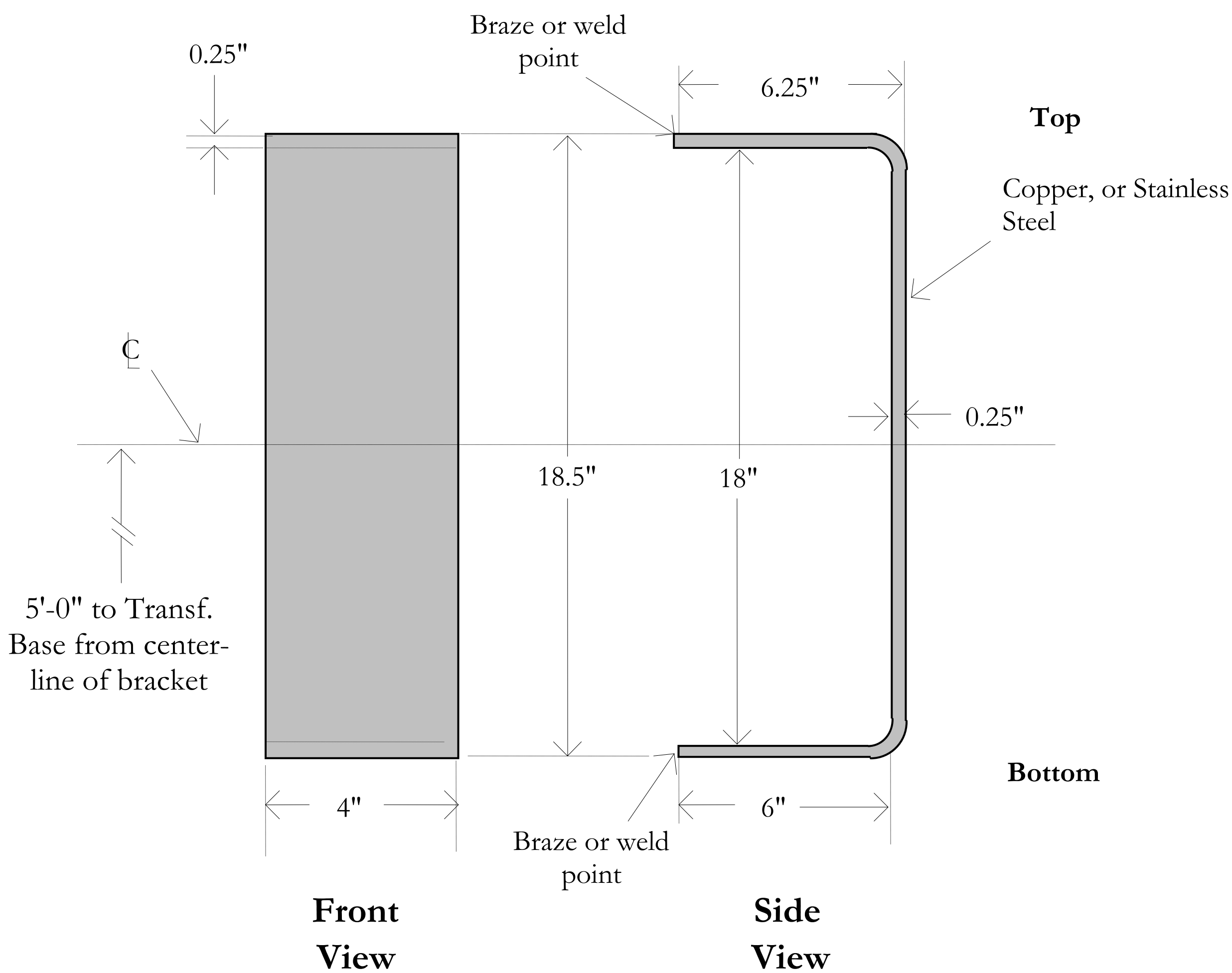


Figure 3
Portable Fall Arrest - Weld-on Base Detail

Exhibit D

Personal Protective Grounding Bracket Detail



Transmission & Substation Standards	
Xcel Energy	Xcel Energy Company Wide
Power Transformer/Reactor Material Standard	Version: 2
File Name : XEL-STD-EMS-J.01-001-POWER TRANSFORMER MATERIAL STANDARD	Page 83 of 86

Exhibit E

Nitrogen Blanket System

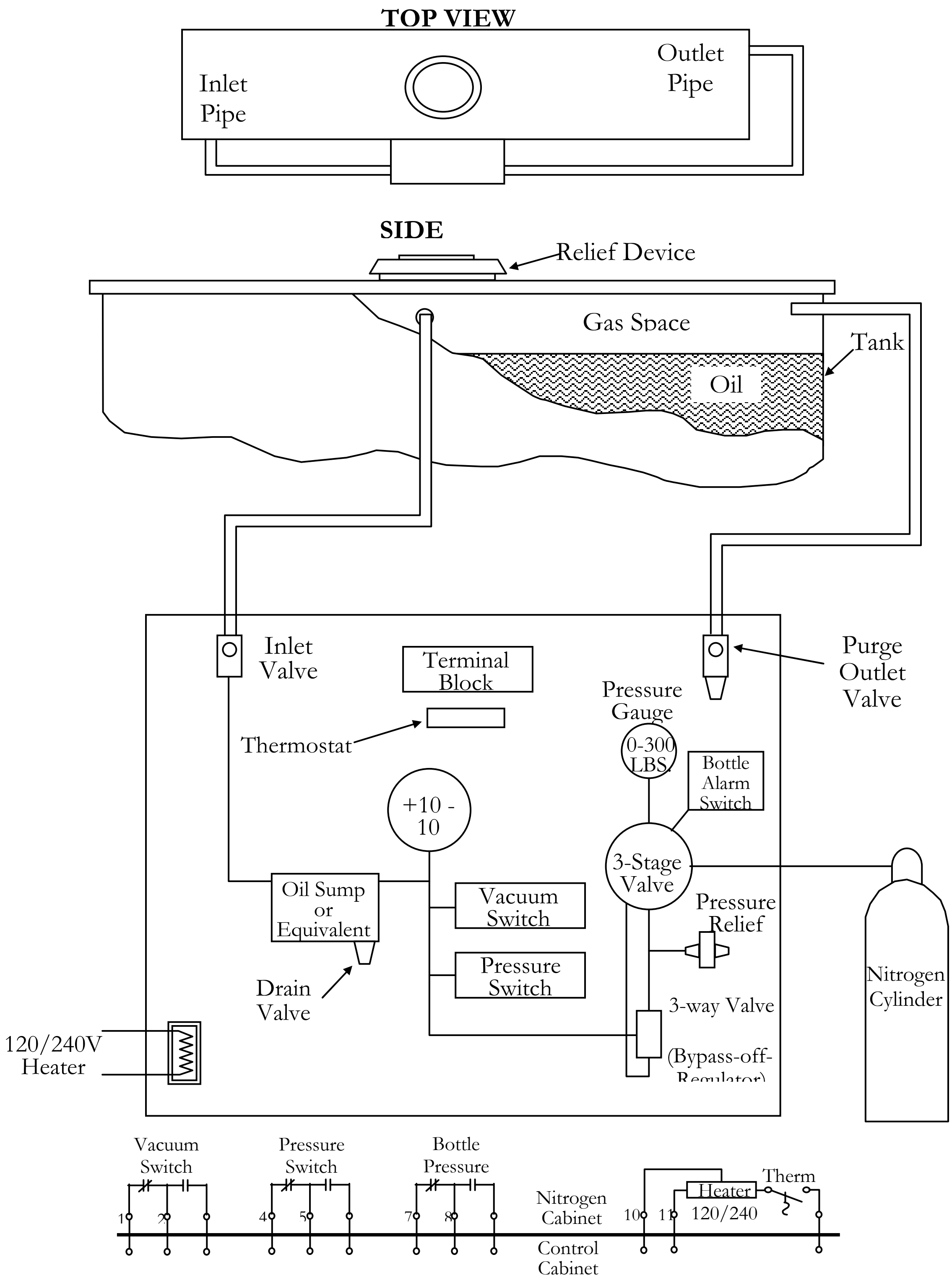


Exhibit F

Field Receipt - Internal Inspection Checklist

A check mark in front of each item indicates that the item was checked. Any condition other than normal shall be identified in the details blank for each item as applicable. If additional space is required, please reference an attached sheet with expanded detail provided.

1. ☐ Check all accessible bolted connections for tightness (including washers)
Details:

2. ☐ Check all current transformer splices for tightness
Details:

3. ☐ Check current transformer mounting brackets for movement
Details:

4. ☐ Check current transformer polarity markings and NPC-ratings
Details:

5. ☐ Check current transformer wire harnesses for proper routing and clearances
Details:

6. ☐ Operate float gauges from inside tank while someone outside verifies correct movement
Details:

7. ☐ Operate DETC and visually and physically confirm each internal contact for proper wipe, location and pressure
Details:

8. ☐ Check low- and high-voltage lead exits from coil assemblies
Details:

9. ☐ Check random axial and radial spacers for tightness
Details:

10. ☐ Check coil blocking for symmetry and tightness
Details:

11. ☐ Check LTC barrier board connections for connection tightness, gaskets and overall integrity
Details:

12. ☐ Check all lead support structures for tightness and cracks
Details:

13. ☐ Check preventive autotransformer, series transformers and associated clamping structure hardware for tightness
Details:

14. ☐ Check main and PA/series transformer core grounds with 5-kV megger
Details:

15. ☐ Check routing of main and PA/series transformer core grounds for proper clearances
Details:

16. ☐ Check symmetry of cores, especially, joints
Details:

17. ☐ Check radiator valve seats
Details:

18. ☐ Check bushing end-terminal and corona ring tightness and clearances to tank walls
Details:

19. ☐ Check hardware on tank shields for tightness
Details:

20. ☐ Photograph core ground terminations, bushings and core for future reference by maintenance and repair crews
Details:

21. ☐ Check symmetry between winding turns and vertical alignment
Details:

22. ☐ Check for debris in core cooling channels
Details:

23. ☐ Check oil box construction if unit is equipment with pumps
Details:

24. ☐ Check tank paint for peeling
Details:

25. ☐ Check bottom of tank for debris of any kind
Details:

26. ☐ Check for foreign objects inside clamping structure beams if hollow in spots (wrenches, bolts, washers, welding rods)
Details:

27. ☐ Check core and coil clamping assembly for proper terminations of grounding straps
Details:

28. ☐ Check core insulation for damage or movement
Details:

29. ☐ Check PA/series transformers core insulation for damage or movement
Details:

30. ☐ Check turn transition point workmanship on windings
Details:

31. ☐ Check top and bottom coil clamping rings and static rings for symmetry workmanship and general condition
Details:

32. ☐ Perform an internal inspection of the LTC, if unit was shipped without oil (remove shipping braces if used).
Details:

33. ☐ Check for nylon tie-raps (these have a habit of loosening over time - replace with linen ties)
Details:

34. ☐ Check shields if so equipped
Details:

35. ☐ Check core clamping structure spaces for symmetry and tightness
Details:

36. ☐ Check barrier tubes for damage
Details:

37. ☐ Check angle rings and support washers
Details:

38. ☐ Check collar insulation if accessible
Details:

39. ☐ Check lock plates and wedges for tightness
Details:

1.0 PURPOSE

- This document is the methodology developed by Xcel Energy to state methods used in calculating equipment ratings.

2.0 APPLICABILITY AND RESPONSIBILITIES

- This policy is applicable to all Xcel Energy Transmission facilities, including transmission lines and substations. A facility rating determined from this policy shall respect the most limiting applicable equipment rating of the individual equipment that comprises that facility.

3.0 APPROVERS

Name	Title
Benson, Ian R	AVP*TRANS STRAT & PLNG
Craig, Byron R	DIRECTOR*SUBS/TRANS ENG & DES
Hargreaves, Roger D	DIRECTOR*SR SYSTEM OPERATIONS

4.0 VERSION HISTORY

Date	Version Number	Change
04/19/2007	1.0	• Was written as rev. 3 in document
07/08/2009	4.0	• Clarify transmission to substation jumper ratings • AAC and ACAR conductor temperature maximum updates
07/01/2010	5.0	• Removed Appendices • Condensed descriptions • Provided clarity to Transmission Line Emergency Ratings
07/01/2011	5.1	• Added CAPX IEEE 738 assumptions • Modified winter season for NSP • Removed solar heat gain assumption for indoor conductors
08/31/2012	6.0	• Revised to Comply with FAC-008 • Replaced Dynamic Line Ratings with Ambient-Adjusted Ratings • Added Operational Guidelines
08/01/2013	6.1	• Removed NSP and SPS Unnecessary Assumptions • Added Current Split Methodology • Minor Rewording for Clarification
11/01/2014	7.0	• Added Strain Bus Rating Cases • Added Conservative Rating • Removed SPP CT Rating Criteria
11/01/2015	8.0	• Relocated Ambient Assumptions to General • Relocated Operational Guidelines to General • Added ACCR Rating • Relocated formulation under Proximity Effect of Conductors section to Supplement • Improved Substation Rating Diagram and removed duplicated information
07/18/2016	9.0	• Fixed Header • Revised Table of Contents • Renamed Section 5 title to avoid using “Purpose” twice • Added Default Ambient Temperature table • Modified ACSS 30 Minute Emergency Rating

9/5/2017	10.0	• Section 6.2 - Clarified split path applicability where there are three or more paths. • Section 6.9 – Added table for altitude adjusted ambient temperatures. • Section 9.2 - Changed NSP Winter Day used for Substation calculations to 90.
12/1/2017	10.1	• Section 4.0 – corrected version number for 9/5/2017 • Section 7.1 – Changed maximum operating temperatures for ACCC and ACCR conductor
9/1/2018	11.0	• Section 6.9 – revised wording to allow for use of altitude adjusted ambient temperatures for all equipment. • Section 7.1 – added ZTACSR conductor to the conductor table.
10/1/2019	12.0	• Section 7.0 – added year to IEEE 738 reference and removed PLS CAD reference. • Section 9.9 – rewrite section on line trap ratings to remove differentiation between epoxy and dry type. • Section 9.16 – added statement to assume 5 amp rating if secondary device rating is unknown.
01/01/2020	13.0	• Table of Contents – renumbered sections in 6.0 General Information • Section 6.3 – removed reference to split path method • Section 6.4 – removed reference to split path method • Section 6.5 – removed – split path method no longer used • Section 9.9 – corrected reference to section 6.8

Policy

Xcel Energy

Transmission

Facility Rating Methodology

Version 13.0

January 1, 2020

Table of Contents

5.0 Objective

The objective of this document is to describe the methodologies employed when determining the ratings of transmission facilities on the Xcel Energy Bulk Electric Transmission Systems. The rating methodology includes both Normal and Emergency Ratings. For tables of equipment ratings and example calculations please refer to the Xcel Energy Rating Methodology Supplement. The Supplement is not considered part of the Rating Methodology, because all information pertaining to the method of the calculation is included in the Rating Methodology. The Supplements are in two parts; there are Excel Spreadsheets, which contain tables of calculated ratings, along with word documents explaining the development of the Rating Methodology and example calculations. Xcel Energy is currently developing software to calculate all bulk electric system facility ratings as the primary system. Once the published facility ratings are created with the software, the Supplement tables and example calculations will be secondary.

The Xcel Energy Bulk Electric Transmission Systems includes the combined Northern States Power Company Minnesota and Northern States Power Company Wisconsin (NSPM and NSPW) Transmission System, Public Service Company of Colorado (PSCo) Transmission System, and the Southwestern Public Service (SPS) Transmission Systems.

6.0 General Information

6.1. Updates

Once a revised Facility Rating Methodology has been approved, Xcel Energy will review and update rating information and issue new ratings (if needed) within 18 months.

6.2. Facility Ratings

The Facility Rating shall respect the most limiting applicable Equipment Rating of the individual equipment that comprises that Facility. Ratings of the equipment that comprise the Facility shall be consistent with at least one of the following:

- Ratings provided by equipment manufacturers or obtained from equipment manufacturer specifications such as nameplate rating.
- One or more industry standards developed through an open process such as Institute of Electrical and Electronics Engineers (IEEE) or International Council on Large Electric Systems (CIGRE).
- A practice that has been verified by testing, performance history or engineering analysis. The equipment shall include, but not be limited to, transmission conductors, transformers, relay protective devices, terminal equipment, and series and shunt compensation devices. The rating for each individual piece of equipment considers the (a) Equipment Rating standard(s) used in development of this methodology; (b) Ratings provided by equipment manufacturers or obtained from equipment manufacturer specifications; (c) Ambient conditions (for particular or average conditions or as they vary in real-time); and (d) Operating limitations; in accordance with good utility practice. Operational limitations may result in a de-rating based on good utility practice. The Facility Rating will include both Normal and Emergency Ratings.

Xcel Energy develops a 30-minute emergency facility rating for all Transmission Lines. The emergency rating timeframes available for transformers are published in the Criteria for Power Transformer Loading. IEEE equipment standards have varying time frames for equipment emergency ratings. If the emergency rating developed for a piece of equipment is for a longer duration than that of the reported rating, then the equipment's emergency rating is utilized in determining the Facility's Emergency Rating. For example, it is acceptable to use a switch's four-hour emergency rating when determining the 30-minute emergency rating of a transmission line. However, when the duration of an emergency rating of a piece of equipment is less than the duration of the rating being reported, then the equipment's normal ratings will be utilized. For example, it is not acceptable to use a switch's 4-hour emergency rating when determining the 8-hour emergency rating for a transformer facility. Instead, the switch's normal continuous rating will be used in determining the 8-hour emergency rating for the transformer facility.

6.3. Transmission Line Facility Ratings

When developing a Transmission Line Facility Rating, the set of equipment that comprises the Facility includes:

a. The transmission line.

b. All of the equipment that is used to operate or disconnect the line and operated as part of the line. This includes, but is not limited to adjacent circuit breakers, disconnect switches, conductor, relays, and meters that as a result of switching could be operated in series with the line.

The Transmission Line Facility Rating is calculated as the minimum rating of the equipment described above.

6.4. Transformer Facility Ratings

When developing a Transformer Facility Rating, the set of equipment that comprises the Facility includes:

a. The transformer equipment.

b. All of the equipment that is used to operate or disconnect the transformer and operated as part of the transformer. This includes, but is not limited to adjacent circuit breakers, disconnect switches, conductor, relays, and meters that as a result of switching could be operated in series with the transformer.

The Transformer Facility Rating is calculated as the minimum rating of the equipment described above.

6.5. SPP, WECC and MRO

Where SPP, WECC and MRO have requirements for facility ratings, the more conservative rating should be used.

6.6. Jointly-Owned Facilities

Equipment ratings on Jointly-Owned facilities will be communicated between the owners. The Jointly-Owned Facility Rating shall equal the most limiting applicable Equipment Rating of the individual piece(s) of equipment that comprise the Jointly-Owned Facility.

In cases where a facility is owned in segments (such as a line terminal being owned by one party and the line conductor by another party), Xcel Energy rates only those portions of the line/terminal/transformer that it owns and provides that information to the owner(s) of the other segment(s). Xcel Energy takes into account rating data provided by the owner(s) of the other segment(s) of the line or transformer, and applies the most limiting rating as the Facility Rating.

6.7. Conservative Ratings

A limited number of pieces of equipment may not have all the information necessary for developing an equipment rating. However, in order to provide system ratings, a conservative rating may be applied to this equipment. The conservative rating for the equipment must be documented in the equipment attributes. Conservative ratings are defined as those, which produce an ampacity on the low end of the possible range for that equipment and are based upon engineering judgment. A Rating Exception Form must be on file for all conservative ratings developed.

6.8. Default Ambient Temperature

Design Ambient Temperature	NSP	PSCo	SPS
Summer Ambient Design Temperature	40 °C 104 °F	40 °C 104 °F	40 °C 104 °F
Winter Ambient Design Temperature (used for winter peaking circuits – these circuits peak at very low temps)	0 °C 32 °F	24 °C 75 °F	27 °C 81 °F

For elevations greater than or equal to 5500 feet in the PSCo region, ambient temperatures in the following table may be used for calculating ampacity of conductors & equipment.

Elevation (feet)	Summer Ambient Design Temperature	Winter Ambient Design Temperature
5500-6000	40°C = 104°F	24°C = 75°F
6001-6500	39°C = 101°F	24°C = 75°F
6501-7000	37°C = 99°F	24°C = 75°F
7001-7500	36°C = 97°F	24°C = 75°F
7501-8000	35°C = 95°F	23°C = 73°F
8001-8500	34°C = 93°F	22°C = 71°F
8501-9000	33°C = 91°F	21°C = 69°F
9001-9500	32°C = 89°F	20°C = 67°F
9501-10000	30°C = 87°F	19°C = 66°F
>10001	29°C = 85°F	18°C = 64°F

The Winter Operating Seasons are:

- December 1 – March 1 for NSPM and NSPW
- November 1 – March 31 for PSCo
- December 1 – March 31 for SPS

Ambient temperature assumptions are used for standards that do not state assumptions.

6.9. Ambient-Adjusted Ratings

Ambient-Adjusted Ratings may be used for real-time operations and near-term planning; however, long-term planning should not rely on Ambient-Adjusted Ratings. Typically, these ratings will rely on weather parameters for ambient temperature but may also be based on wind speed or other ambient-based parameters. In real-time operations, these ambient parameters will be obtained from local meteorological stations or from the weather service in the vicinity of the affected facility. In the case where facilities cross areas of differing weather conditions, the more conservative values will be utilized.

Once the ambient parameters are known, the Ambient-Adjusted Rating for one or more elements of the Facility may be determined by various methods. A few of the common methods are listed but other methods may be used.

- Recalculated Ambient Adjusted Rating tables
- Standalone program utilizing comparable rating calculation
- EMS dynamic rating feature
- Line monitors

If Ambient-Adjusted Ratings are applied to some but not all elements of a Facility, then the normal seasonal ratings are to be used for those elements, which do not have an Ambient-Adjusted Rating when determining the overall Facility rating.

The Ambient-Adjusted Ratings are not to exceed the maximum published facility rating unless a detailed review of relay settings is completed.

6.10. Operational Guidelines

Operating Guidelines may be utilized in cases where recent field verification has identified a potential discrepancy in the assumptions used to determine the rating of an element and the resulting facility de-rate would result in significant risk to the operation of the transmission system. These Operating Guidelines will be temporary, with the assumption that once the resulting remediation project is complete, then the Operating Guideline will be removed and the calculated rating will be implemented.

7.0 Transmission Line Rating Methodology

Xcel Energy uses the IEEE 738-2006 standard for calculating bare overhead conductor ratings. Xcel Energy will use the lesser of the Conductor Maximum Operating Temperature and the Clearance/Hardware thermal limits for conductor operating temperature in the IEEE 738-2006 calculation. The remainder of this section lists assumptions.

7.1. Conductor Maximum Operating Temperature

Xcel Energy adheres to the following table for maximum operating temperature of its conductors. The table shows normal and emergency limits.

Conductor type	Normal (Operating Temperature)	30 Minute Emergency Rating
ACSR*	100 °C	Normal Rating X 110%
ACAR	100 °C	Normal Rating X 110%
AAC	100 °C	Normal Rating X 110%
Cu	95 °C	Normal Rating X 110%
Copper Weld	95 °C	Normal Rating X 110%
ACCC	180 °C	200 °C
ACSS	200 °C	250 °C
SCACAR	100 °C	Normal Rating X 110%
ACCR	210 °C	240 °C
ZTACSR	210 °C	240 °C

*ACSR may be permitted to run at higher temperatures see “General Guidelines when considering up-rating ACSR beyond 100 degrees C” in Rating Methodology Supplement.

7.2. Permitting/Other

Conductor may be rated below the maximum operating temperature listed in section 7.1 for the following reasons:

- Permitted ROW agreements (ex. railroad or waterway crossing).
- Ampacity (ex. NESC clearance limitation).
- EMF calculations.

7.3. Clearance/Hardware Limit

The Clearance/Hardware thermal rating of a transmission line is the maximum temperature, (regardless of the current) which a conductor can attain without violating code-mandated clearances or damaging temperature limited hardware. Short-term limitations due to clearance restrictions will be considered on a case by case basis.

7.4. Remaining Assumptions

Variables	NSP – Assumption	PSCo – Assumption	SPS – Assumption
Conductor properties	Southwire Overhead Conductor Manual 2nd Edition and other various sources	Southwire Overhead Conductor Manual 2nd Edition and other various sources	Southwire Overhead Conductor Manual 2nd Edition and other various sources
Cooling Wind	Maximum of 4 ft/sec @ 90deg to conductor *	Maximum of 4 ft/sec @ 90deg to conductor	Maximum of 6 ft/sec @ 90deg to conductor
Elevation	Actual Elevation (or use default of 1100')	Actual Elevation (or use default of 5200')	Actual Elevation (or use default of 3700')
Emissivity	0.5	0.5	0.5
Absorptivity	0.5	0.5	0.5
Latitude	Actual Latitude (or use default of 43°N)	Actual Latitude (or use default of 40°N)	Actual Latitude (or us default of 35°N)
Summer Day Solar Calc	172	172	172
Winter Day Solar Calc	90	90	90
Time of Day	12:00 PM	12:00 PM	12:00 PM
Orientation of Line	Actual Orientation (or use default of East to West)	East to West	East to West
Atmosphere	Clear	Clear	Clear

***Excludes Buffalo Ridge Wind Rated Lines**

7.5. CAPX Assumptions

CapX2020 is a joint initiative of 11 transmission-owning utilities in Minnesota and the surrounding region to construct region transmission lines. These lines are to be owned jointly as a percentage share in the line. The following assumptions have been agreed upon by the utilities for rating calculations.

Variables	CAPX2020 – Assumption
Conductor properties	Southwire Overhead Conductor Manual 2nd Edition and other various sources
Cooling Wind	2 ft/sec @ 90deg to conductor
Emissivity	0.7
Absorptivity	0.9
Summer Day Solar Calc	July 8th
Winter Day Solar Calc	April 30th
Time of Day	12:00 PM
Orientation of Line	East to West
Atmosphere	Clear

7.6. Buffalo Ridge Wind Rated Lines

A few transmission lines in southwestern Minnesota that provide outlet to wind generators have a rating based on a higher wind speed than is typical throughout the rest of the NSP system. Higher output from the wind generators is only available during the time periods where the wind speed is higher than used in normal transmission line ratings. Thus a higher wind speed was used to rate these lines. The higher wind speed was approved at the time of development by the Design Review Subcommittee of the then existing NERC Reliability Region “Mid-Continent Area Power Pool (MAPP).

The transmission line circuits in the NSP Transmission System with wind ratings are the following 115kV lines: Split Rock-Pipestone and Chanarambie-Pipestone.

7.7. Underground Lines

Underground lines have been and will be rated on an individual basis using engineering analysis. The ratings are developed and based on the soil conditions, conductor type, and installation methods.

Underground cable and the associated terminators are engineered as a system and the ampacity rating is determined for the system. The ampacity rating provided for underground cable and terminator systems shall equal the most limiting element of the system.

8.0 Transmission Line Equipment Rating Methodology

8.1. Line Switches

The line switch ratings are based on the manufacturer's assigned nameplate rating and ACCC designation. The maximum ampacity to operate the switch is based on the IEEE C37.37 loading guide.

8.2. Line Jumpers

The rating methodology for line jumpers is the same as that used as for Xcel Energy's Transmission Lines, which references IEEE STD. 738. The ratings communicated for transmission lines will represent the rating of the line including all jumpers in the line. If the rating of a jumper is the limiting equipment in a line, then the rating of the line will be limited to the jumper rating.

Jumpers between transmission lines and the substation equipment should be rated per the transmission line rating methodology unless restricted by the equipment or hardware that the jumper is attached to.

8.3. Hardware

Hardware for transmission lines is temperature limited and is designed for the operating temperature of the line. The equipment manufacturer provides hardware ratings.

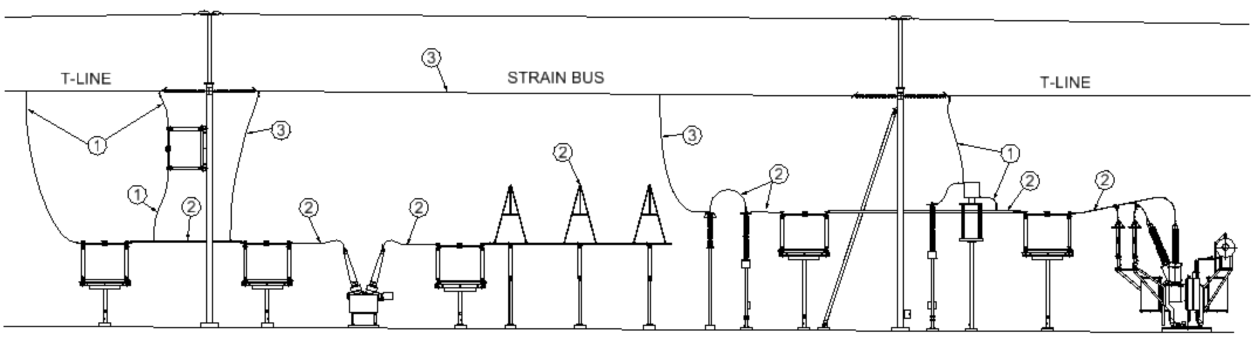
9.0 Transmission Substation Equipment Rating Methodology

Transmission Substations are comprised of several pieces of equipment. Each piece of equipment is identified below along with its ratings methodology.

The following diagrams are to be used as reference for the Substation Equipment Rating Methodology.

9.1. Substation Rating Diagrams

SUBSTATION RATING DIAGRAM



① T-LINE TO SUBSTATION EQUIPMENT - RATE ONLY FLEXIBLE CONDUCTORS PER *TRANSMISSION LINE RATING METHODOLOGY* SECTION;
DERATE CONDUCTORS WHEN CONNECTED DIRECTLY TO:

DEVICES WITH BUSHINGS	-	NORMAL 85°C	EMERGENCY 100°C,
LINE TRAPS	-	NORMAL 135°C	EMERGENCY 135°C,
SWITCHES	-	NORMAL 200°C	EMERGENCY 200°C;

ALL CONDUCTORS' RATINGS SHALL FOLLOW *CONDUCTOR MAXIMUM OPERATING TEMPERATURE* TABLE.

② SUBSTATION OR STRAIN BUS TO TUBE, BUSHING OR EQUIPMENT:

ALL CONDUCTORS	-	NORMAL 85°C	EMERGENCY 100°C

③ REFER TO THE CRITERIA UNDER *BUS CONDUCTORS AND EQUIPMENT JUMPERS* SECTION TO DETERMINE WHETHER SUBSTATION OR TRANSMISSION RATING METHODOLOGY IS APPLICABLE.

9.2. Bus Conductors and Equipment Jumpers

The rating methodology is as outlined in IEEE Standard 605 for tubular bus and IEEE Standard 738 for wire bus and jumpers. Assumptions made for conductors are as follows:

Variables used for Bus Conductor (Tube, Wire & Jumpers) Ampacity Calculations			
Variables	**NSP**	**PSCO**	**SPS**
Summer Ambient Temperature (Deg. C)	See Default Ambient Temperature under General section		
Winter Ambient Temperature (Deg. C)			
Emissivity Outdoors(e)	0.5	0.5	0.5
Emissivity Indoors(e)	0.35	N/A	N/A
Absorptivity (a)	0.5	0.5	0.5
Degrees North Latitude	Actual (or 43)	Actual (or 40)	Actual (or 35)
Time	12	12	12
Atmosphere	Clear	Clear	Clear
Elevation (ft.)	Actual (or 1100)	Actual (or 5900)	Actual (or 3700)
Wind Speed (ft./S) – indoor	0	0	0
Wind Speed (ft./sec.) - enclosed substation	2	2	2
Wind Speed (ft./sec.) - open substation	4	4	6
Wind Direction Factor (deg.)	90	90	90
Azimuth of Conductor (deg.)	90	90	90
Day of the year - Summer (Variable N from IEEE 738)*	172	172	172
Day of the year - Winter (Variable N from IEEE 738)*	90	90	90

*No solar heat gain for indoor conductors

All tube and bare overhead conductors inside the substation will have a normal rating of 85^{o} C and an emergency four hour rating of 100^{o} C. Jumpers between transmission lines and the substation equipment should be rated per the transmission line rating methodology unless restricted by the equipment or hardware that the jumper is attached to. Strain bus consisting of bare overhead conductor may be rated per the Transmission Line Rating Methodology if all of the following are true:

1. The strain bus is considered an extension of the transmission line due to the fact that one end of the strain bus terminates on the transmission line dead-end structure.

2. The strain bus terminations inside the substation are at the same height as or higher than the transmission line termination into the substation or minimum conductor ground clearance greater than 25 feet above surface grade.
3. The strain bus is in an open substation and is expected to be exposed to the same wind speed as the transmission line.
4. Structures and hardware used to install the strain bus are rated for the maximum conductor temperature and tension as outlined by the Transmission Line Rating Methodology.
5. Clearances to ground and other substation equipment can be maintained at maximum sag based on company standards when designed.

Connectors and terminations used on substation conductors will be given a rating equal to that of the conductor to which they are attached. Therefore, the ratings communicated for substation conductors will include the rating of the conductor itself as well as the connectors and terminations connected to it.

9.3. Proximity Effect of Conductors

Conductors spaced less than six inches apart are subject to reductions of capacity due to proximity effect. Xcel Energy has used Engineering Analysis to develop proper ratings for these conductors. Xcel Energy has developed ratings on these conductors based on three sources. “Skin Effect and Proximity Effect in Tubular Conductors”, “Skin Effect in Tubular and Flat Conductors,” and “Bessel Functions for A-C Problems” were used in formulating the calculation.

9.4. Circuit Breakers, Circuit Switchers, and Line-Switchers

The rating methodology is as outlined in ANSI/IEEE C37.010**.** Breakers pre 1964 utilize a 55 degree C Hot Spot temperature rise and 1964 – present utilize a 65 degree C Hot Spot temperature rise.

9.5. Disconnect Switches

The rating methodology is as outlined in ANSI/IEEE C37.30 and ANSI/IEEE C37.37**.** Xcel Energy has contacted switch manufacturers about connecting conductors, which will operate at 200^{o}C to switch pads. The manufacturers have provided test data and have stated that this will not adversely affect the operation of the switches.

9.6. Transformers

The rating methodology is as outlined in ANSI/IEEE C57.12.00. Loading/rating for loading above transformer nameplate is in accordance with ANSI/IEEE C57.91. The ratings for transformers are determined by the Criteria for Power Transformer Loading.

9.7. Current Transformers (CT's)

The overload capacity of a Current Transformer (CT) is determined by its continuous thermal rating factor (RF). The continuous thermal rating factor is defined in IEEE C37.110. The maximum secondary current of a CT is the rated value of the CT secondary*RF or as limited by other elements in the circuit.

$Itap = Itap_r * RF$

Itap = adjusted rated continuous current of specific CT tap under consideration

$Itap_r$ = rated continuous current of tap

RF = Continuous thermal rating factor (Manufacturer should be consulted for value of continuous current rating factor. Assume 1 if not available.)

9.7.1. Autotransformer neutral winding CTs

CTs on the neutral winding of an autotransformer do not experience the same current flows as the H or X windings. The method of calculating the flow in the common winding uses the following formula:

$$CommonWindingAmps = \frac{TopRating(KVA)}{\sqrt{3} * V_{lowside}(kV)} - \frac{TopRating(KVA)}{\sqrt{3} * V_{highside}(kV)}$$

This formula is applied to find the amperage flowing through the common winding when the transformer is operating at its top rating.

9.8. Power Apparatus Bushings

This section applies to power apparatus bushings as defined by IEEE C57.19.00 that have basic impulse insulation levels of 110 kV and above for use as components of oil-filled transformers and oil-filled reactors. Bushings supplied with other equipment will be rated using the same methods as the equipment they are attached to.

Bushings can be loaded up to their specified ampere rating. The overload rating of the equipment on which the bushing is installed could be limited by the bushing ampere rating. If the bushing rating cannot be confirmed by name plate or contacting manufacturer, the equipment will be rated at its nameplate rating or calculated rating with no overload. However, if the equipment was specified to have an overload rating, or if the equipment manufacture has documented an overload rating, this overload rating may be used.

9.9. Line Traps

The terms Line Traps and Wave Traps are used interchangeably throughout this document.

The ratings methodology for the wave trap is according to IEEE Std C93.3-2017 The wave trap allows for loadability to change due to ambient temperature and emergency operating conditions. The maximum terminal temperature for a wave trap is 135 degrees C. Altitude derating factors in C93.3-2017 include an elevation adjustment with a lower mean (24 hour) maximum temperature. Line traps should therefore not be ambient adjusted per the elevation table in section 6.8 above.

9.10. Shunt Reactors

The ratings methodology for shunt reactors (oil filled) is according to ANSI/IEEE C57.21. There is no emergency or overload rating for shunt reactors. Shunt reactors may be operated up to 105% of the rated voltage.

9.11. Shunt Capacitors

IEEE standard 18 specifies the technical requirement of individual capacitor units and IEEE 1036 provides the application guidelines for shunt capacitor banks.

9.12. Series Capacitors

All series Capacitors will be rated per manufacture specifications for normal and emergency conditions.

9.13. SVC (Static Var Compensators)

SVC's will be rated per the manufacturers recommended ratings for normal and emergency conditions.

9.14. DC Tie Equipment

DC Tie equipment will be rated per the manufacturers recommended ratings for normal and emergency conditions.

9.15. GIS Equipment

All Gas Insulated Substation (GIS) equipment will be rated per manufacture specifications for normal and emergency conditions.

9.16. Protective Relay & CT Secondary Devices

All secondary devices will be operated within their specified manufacturer limits. If the rating for a secondary device cannot be determined then assume the rating is 5 amps.

Protective relay settings on all equipment in the bulk electric transmission system should be designed and set to permit the emergency loading of equipment per NERC standard PRC-023 where applicable. PRC-023 shall be followed with respect to any settings that may affect facility ratings.

The over-current relays on the transmission lines used for "switch-onto-fault" should be designed and set above the maximum loading of the line.

Over-current relays on transformers should be designed and set above the maximum emergency loading.

Xcel Energy		EPR 5.200
Energy Supply Performance Optimization Policy System		**Revision: 4.3**
TITLE:	Facility Rating and Reporting NERC FAC-008 Compliance Requirements	Page 1 of **4**

1.0 Purpose:

1.1 This policy defines the responsibilities of Performance Optimization to meet certain requirements established by NERC Standard FAC-008. The policy ensures Energy Supply develops and applies a facility rating methodology.

2.0 Applicability:

2.1 This policy applies to all Xcel Energy generating facilities and Energy Supply-owned synchronous condensers connected to the Bulk Electric System. Facility ratings for jointly owned units will be determined by the generating unit operator.

3.0 Responsibilities:

3.1 Performance Optimization, Fleet Engineering management is responsible to:

3.1.1 Compile Normal and Emergency electrical ratings for the generators, transformers, relay protective devices, and terminal equipment, as applicable, for each unit in all regions.

If Emergency ratings have not been provided by the Original Equipment Manufacturer, the only ratings used will be Normal ratings. Peak and Reserve ratings and Winter/Summer ratings may be used for combustion turbine units that have been assigned such ratings by the original equipment manufacturer.

3.1.2 Determine the most limiting and next most limiting applicable equipment rating of each unit. Identify and document the most limiting and next most limiting component.

3.1.3 Maintain the records required by 5.1, 5.2 for the generating plants.

3.1.4 Review and update ratings data annually. Upon receipt of request to supply facility ratings, Performance Optimization, Fleet Engineering will review and update ratings prior to submittal in accordance with EPR 5.220P01 NERC Facility Rating Methodolgy. Reviews shall include all new facilities, modified facilities, or any changes in operational limitations of in scope equipment.

4.0 Requirements:

4.1 Performance Optimization, Fleet Engineering shall maintain, in an approved document repository, a spreadsheet, by region, of electrical component and unit ratings.

4.1.1 The equipment and unit ratings will include Normal and Emergency ratings, as well as the most limiting component rating.

If Emergency ratings have not been provided by the Original Equipment Manufacturer, the only ratings used will be Normal ratings. Peak and Reserve ratings and Winter/Summer ratings may be used for combustion turbine units that have been assigned such ratings by the original equipment manufacturer.

4.2 Performance Optimization, Fleet Engineering shall maintain, in an approved document repository, the methodology used to develop the facility ratings. Any superseded portions of the methodology that had been replaced, changed, or revised must be retained for 12 months.

4.3 Performance Optimization, Fleet Engineering shall provide, on request, each facility rating methodology, and rating, to those Reliability Coordinators, Transmission Operators, Transmission Planners, and Planning Coordinators that have responsibility for the area in which the associated facilities are located, within 21 calendar days of receipt of a request.

4.4 Performance Optimization, Fleet Engineering shall respond, within 45 calendar days, in writing, to written comments from those Reliability Coordinators, Transmission Operators, Transmission Planners, and Planning Coordinators that have responsibility for the area in which the associated facilities are located. The response shall indicate whether a change will be made to the facility rating methodology and, if no change the reason why.

4.5 Performance Optimization, Fleet Engineering shall provide its Facility Ratings and the identity of the most limiting equipment to the Reliability Coordinators, Planning Coordinators, Transmission Planners, Transmission Owners, and Transmission Operators as scheduled by these entities.

4.6 Performance Optimization, Fleet Engineering shall provide the identity of the second most limiting equipment and its thermal rating within 30 calendar days of a request from its Reliability Coordinators, Planning Coordinators, Transmission Planners, Transmission Owners, and Transmission Operators.

5.0 Required Records:

5.1 Performance Optimization, Fleet Engineering shall have evidence it provided the Reliability Coordinator, Transmission Operator, Transmission Planner, and Planning Authority the facility rating methodology and facility ratings requested within 21 calendar days.

5.2 Performance Optimization, Fleet Engineering shall have evidence it responded to comments from the Reliability Coordinator, Transmission Operator, Transmission Planner, and Planning Authority within 45 calendar days.

5.3 Performance Optimization, Fleet Engineering shall retain the spreadsheet required by section 4.1, and methodology required by section 4.2 in an approved document repository in accordance with the corporate non-nuclear records retention schedule, record class code AUD1040.

6.0 References & Definitions:

6.1 References

6.1.1 EPR 5.220P01 – NERC Facility Rating Methodology procedure found on XpressNet.

6.1.2 Corporate non-nuclear records retention schedule found on XpressNet.

6.2 Definitions

6.2.1 **North American Electric Reliability Corporation (NERC) -**The organization charged with establishing standards for the reliable operation of the North American electric power grids.

6.2.2 **NERC Reliability Standard FAC 008 –** NERC Standard applicable to Facility Ratings

6.2.3 **Bulk Electric System** – As defined by the Regional Reliability Organization, the electrical generation resources, transmission lines, interconnections with neighboring systems, and associated equipment, generally operated at voltages of 100kv or higher. Radial transmission facilities serving only load with one transmission source are generally not included in this definition.

7.0 Revision History

Date	Revision	Change
04/02/2007	Draft	Draft for FERC Reliability Standard – FAC 008, 009
04/10/2007	0	
06/07/2007	1	Added requirement to review and update ratings every 12 months or as facilities are added, modified or re-rated. Added reference to EPR-5.220. Added requirement to retain superseded portions of the methodology fro 12 months.
06/21/2007	2	Revised applicability “Facility ratings for jointly owned units will be determined by the generating unit operator.”
11/09/2007	3.0	If Emergency ratings have not been provided by the Original Equipment Manufacturer, the only ratings used will be Normal ratings. Peak and Reserve ratings and Winter/Summer ratings may be used for combustion turbine units that have been assigned such ratings by the original equipment manufacturer.
09/20/2012	4.0	Revised the policy to align with NERC Standard FAC-008-3 which replaces FAC-008-1 and FAC-009-1. Changed Maintenance Resources to Technical Resources and Compliance. Changed Production Resources to Technical Services in the header. Removed reference to Performance Monitoring.
01/01/13	4.1	Added language to specify that operational limitations be included in the review and reporting.
08/19/2013	4.2	Modified header and footer to reflect current standardized format. Updated author to current responsible employee. Corrected effective and approval dates to reflect the most recent major revision.
10/04/2016	4.2	Completed triennial review. No content change required.
10/07/2019	4.3	Updated department names to reflect current organization. Combined sections 3.1, 3.1 and 3.3 (region-specific) into a single section encompassing all regions. Updated references.

Xcel Energy	EPR 5.201S
Energy Supply Technical Services Policy System	**Revision: 3.0**
TITLE: Stability Modeling Data Maintenance and Reporting Requirements	Page 1 of **10**

1.0 PURPOSE

1.1 This standard defines responsibilities and requirements to meet certain requirements established by NERC Standards, MOD-025, “Verification and Data Reporting of Generator Real and Reactive Power Capability and Synchronous Condenser Reactive Power Capability”, MOD-026, “Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions”, MOD-027, “ Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions”, and MOD-032 “Data for Power System Modeling and Analysis”. This standard ensures Energy Supply provides generator steady state and dynamic modeling design data to the Transmission Planners as required.

2.0 APPLICABILITY

2.1 This standard is applicable to all Energy Supply generating facilities including hydro units and synchronous condensers included in the definition of Bulk Electric System.

The following additional qualifiers are applicable to MOD-026 and MOD-027:

2.1.1 In the WECC region, MOD-026 and MOD-027 are applicable to generating or synchronous condenser units >75 MVA and facilities with aggregate rating >75 MVA.

2.1.2 In the MRO and SPP regions, MOD-026 and MOD-027 are applicable to generating or synchronous condenser units >100 MVA and facilities with aggregate ratings >100 MVA.

3.0 RESPONSIBILITIES

3.1 The cognizant Plant Engineering and Technical Support (PETS) Engineer and/or Engineering & Construction (E&C) Project Manager/Engineer are responsible to:

3.1.1 Notify Technical Resources and Compliance (TR&C) of any proposed modifications to, or new installations of, excitation control system or plant volt/var control function equipment for applicable units. With TR&C’s guidance, provide TR&C with the verified model, documentation and data for the new or modified excitation control system or plant volt/var control function equipment installed. Data shall be provided within 335 days of the facility being released for Commercial Operation.

3.1.2 Notify TR&C of any proposed modifications to, or new installations of, turbine/governor and load control or active power/frequency control equipment for applicable units. With TR&C's guidance, provide TR&C with the verified model, documentation and data for the new or modified turbine/governor and load control or active power/frequency control equipment installed. Data shall be provided within 335 days of the facility being released for Commercial Operation.

3.1.3 Notify TR&C of any changes in generator steady state net real or reactive power design ratings, or any changes in design dynamic characteristics resulting from alterations of generator excitation or turbine governor equipment. This notification should be made at least 3 months prior to project installation.

3.2 PETS is responsible to provide support to Performance Testing and Analysis and TR&C in coordinating and performance of testing required to verify modeling of applicable units or facilities.

3.3 Plant Directors or designee are responsible to notify TR&C when they become aware of any changes in generator steady state net real or reactive power design ratings. Furthermore, any changes in design dynamic characteristics resulting from alterations of generator excitation or turbine governor equipment or control functions that alter the equipment response characteristic.

3.4 Performance Testing and Analysis is responsible to:

3.4.1 Verify and provide TR&C with Real Power capability of applicable units or facilities within 30 days of verification, as requested

3.5 Regional TR&C personnel are responsible to:

3.5.1 Provide overall compliance guidance and support as needed to execute activities and verify timely completion.

3.5.2 Maintain information, provide information upon request, and communicate changes of that Operating Company's power plant steady state modeling data to the regional Transmission Planning organization. This information will be maintained and promulgated per the region specific processes described in Section 4.0 below.

3.5.2.1 Evidence of correspondence with Transmission Planning concerning steady state modeling data shall be stored in the appropriate MOD-032 Documentum folder.

3.5.3 Maintain information, provide information upon request, and communicate changes of that Operating Company's power plant dynamic modeling data to the regional Transmission Planning organization. This information will be maintained and promulgated per the region specific processes described in Section 4.0 below.

3.5.3.1 Evidence of correspondence with Transmission Planning concerning dynamic modeling data shall be stored in the appropriate MOD-032 Documentum folder.

3.5.4 Verify and provide the Transmission Planner with Real and Reactive Power capability of applicable units or facilities.

3.5.4.1 Evidence of correspondence with Transmission Planning concerning Real and Reactive Power capability shall be stored in the appropriate MOD-025 Documentum folder.

3.5.5 Verify and provide the Transmission Planner with the generator excitation control system or plant volt/var control function model, including documentation and data for each applicable unit or facility.

3.5.5.1 Evidence of correspondence with Transmission Planning concerning generator excitation control system or plant volt/var control function modeling shall be stored in the appropriate MOD-026 Documentum folder.

3.5.6 Verify and provide the Transmission Planner with the turbine/governor and load control or active power/frequency control model, including documentation and data for each applicable unit or facility.

3.5.6.1 Evidence of correspondence with Transmission Planning concerning the turbine/governor and load control or active power/frequency control modeling shall be stored in the appropriate MOD-027 Documentum folder.

4.0 REQUIREMENTS:

4.1 Regional Technical Services personnel shall fulfill their MOD-032 responsibilities as follows:

4.1.1 Northern States Power (NSP), Southwestern Public Service (SPS), Public Service Company of Colorado (PsCO)

4.1.1.1 TR&C shall maintain a database of generator steady state modeling design data including minimum and maximum net real and reactive power ratings. This database shall be maintained in Documentum and provided to Transmission Planning upon request or when changes are made

4.1.1.2 TR&C shall maintain a database of generator design modeling design data. This database shall be maintained in Documentum and provided to Transmission Planning upon request or when changes are made.

4.1.1.3 TR&C personnel shall provide steady-state, dynamic, and short circuit modeling data to its Transmission Planner and Planning Coordinator according to their modeling data requirements and reporting procedures. For data that has not changed, an email notification confirming the data has not changed is sufficient. Email notifications will be maintained in Documentum.

4.1.1.4 Upon written notification from the Planning Coordinator or Transmission planner regarding technical concerns with data submitted above, TR&C will:

4.1.1.4.1 Provided either updated data or an explanation with a technical basis for maintaining the current data;

4.1.1.4.2 Provide the response within 90 calendar days of receipt, unless a longer time period is agreed upon by the notifying Planning Coordinator or Transmission Planner.

4.1.1.4.3 Evidence or correspondence will be maintained in Documentum. If no written notification(s) received, a statement that it has not received written notification regarding technical concerns with the data submitted may be posted to Documentum as evidence.

4.2 Technical Services personnel shall fulfill their MOD-025 responsibilities as follows:

4.2.1 Performance Testing and Analysis Department shall, when requested, verify the Real Power capability of each applicable units or facility in accordance with Attachment 1 of MOD-025. Performance Monitoring Department shall provide TR&C a completed Attachment 2 of MOD-025 or a form containing the same information as identified in Attachment 2, within 30 calendar days of either (i) the date the data is recorded for a staged test; or (ii) the date the data is selected for verification using historical operational data.

4.2.2 TR&C shall verify the Real and Reactive Power capability of each applicable units or facility in accordance with Attachment 1 of MOD-025. Technical Resources and Compliance shall provide the Transmission Planner a completed Attachment 2 of MOD-025 or a form containing the same information as identified in Attachment 2, within 90 calendar days of either (i) the date the data is recorded for a staged test; or (ii) the date the data is selected for verification using historical operational data.

4.3 Technical Services, TR&C personnel shall fulfill their MOD-026 responsibilities as follows:

4.3.1 Shall provide for each applicable unit, a verified generator excitation control system or plant volt/var control function model, including documentation and data as specified in 4.5.1.1 to the Transmission Planner in accordance with the periodicity specified in MOD-026 Attachment 1.

4.3.1.1 Each applicable unit's model shall be verified using one or more models acceptable to the Transmission Planner. Each verification shall include the following:

4.3.1.1.1 Documentation demonstrating the applicable unit's model response matches the recorded response for a voltage excursion from either a staged test or a measured system disturbance,

4.3.1.1.2 Manufacturer, model number (if available), and type of the excitation control system including, but not limited to static, AC brushless, DC rotating, and/or the plant volt/var control function (if installed), 4.3.1.1.3 Model structure and data including, but not limited to reactance, time constants, saturation factors, total rotational inertia, or equivalent data for the generator,

4.3.1.1.4 Model structure and data for the excitation control system, including the closed loop voltage regulator if a closed loop voltage regulator is installed or the model structure and data for the plant volt/var control function system,

4.3.1.1.5 Compensation settings (such as droop, line drop, differential compensation), if used, and

4.3.1.1.6 Model structure and data for power system stabilizer, if so equipped.

4.3.2 Shall provide a written response to the Transmission Planner within 90 calendar days of receiving one of the following items for an applicable unit:

4.3.2.1 Written notification from the Transmission Planner (in accordance with MOD-026, R6) that the excitation control system or plant volt/var control function model is not usable,

4.3.2.2 Written comments from the Transmission Planner identifying technical concerns with the verification documentation related to the excitation control system or plant volt/var control function model, or

4.3.2.3 Written comments and supporting evidence from the Transmission Planner indicating that the simulated excitation control system or plant volt/var control function model response did not match the recorded response to a transmission system event.

The written response shall contain either the technical basis for maintaining the current model, the model changes, or a plan to perform model verification.

4.3.3 Shall provide revised model data or plans to perform model verification (in accordance with MOD-026, R2) for an applicable unit to the Transmission Planner within 180 calendar days of making changes to the excitation control system or plant volt/var control function that alter the equipment response characteristic.

4.3.4 Shall provide a written response to the Transmission Planner, within 90 calendar days following receipt of a technically justified unit request from the Transmission Planner to perform a model review of a unit or plant that includes one of the following:

4.3.4.1 Details of plans to verify the model (in accordance with MOD-026, R2) or

4.3.4.2 Corrected model data including the source of revised model data such as discovery of manufacturer test values to replace generic model data or updating of data parameters based on an on-site review of the equipment.

4.4 E&C personnel shall fulfill their MOD-026 responsibilities as identified in XES 7.400 and XES 7.405.

4.5 Technical Services, TR&C personnel shall fulfill their MOD-027 responsibilities as follows:

4.5.1 Shall provide for each applicable unit, a verified turbine/governor and load control or active power/frequency control model, including documentation and data as specified in section 4.6.1.1 to the Transmission Planner in accordance with the periodicity specified in MOD-027 Attachment 1.

4.5.1.1 Each applicable unit's model shall be verified using one or more models acceptable to the Transmission Planner. Each verification shall include the following:

4.5.1.2 Documentation comparing the applicable unit's MW model response to the recorded MW response for either:

4.5.1.2.1 A frequency excursion from a system disturbance that meets MOD-027 Attachment 1 Note 1 with the applicable unit on-line,

4.5.1.2.2 A speed governor reference change with the applicable unit on-line, or

4.5.1.2.3 A partial load rejection test.

4.5.1.3 Type of governor and load control or active power control/frequency control equipment, 4.5.1.4 A description of the turbine,

4.5.1.5 Model structure and data for turbine/governor and load control or active power/frequency control, and

4.5.1.6 Representation of the real power response effects of outer loop controls that would override the governor response if applicable.

4.5.2 Shall provide a written response to the Transmission Planner within 90 calendar days of receiving one of the following items for an applicable unit.

4.5.2.1 Written notification from the Transmission Planner (in accordance with MOD-027, R5) that the turbine/governor and load control or active power/frequency control model is not usable,

4.5.2.2 Written comments from the Transmission Planner identifying technical concerns with the verification documentation related to the turbine/governor and load control or active power/frequency control model, or

4.5.2.3 Written comments and supporting evidence from it Transmission Planner indicating that the simulated turbine/governor and load control or active power/frequency control response did not approximate the recorded response for three or more transmission system events.

The written response shall contain either the technical basis for maintaining the current model, the model changes, or a plan to perform model verification (in accordance with MOD-027, R2).

4.5.3 Shall provide revised model data or plans to perform model verification (in accordance with MOD-027, R2) for an applicable unit to the Transmission Planner within 180 calendar days of making changes to the turbine/governor and load control or active power/frequency control system that alter the equipment response characteristic.

4.6 E&C personnel shall fulfill their MOD-027 responsibilities as identified in XES 7.400 and XES 7.405.

5.0 REQUIRED RECORDS

5.1 TR&C shall maintain evidence of correspondence with Transmission Planning documenting:

5.1.1 Modeling data was provided in response to requests and that Transmission Planning was notified of changes in any steady state or dynamic modeling data.

5.1.2 Real and reactive power verification was provided.

5.1.3 A verified generator excitation control system or plant volt/var control function model, including documentation and data was provided.

5.1.4 A verified turbine/governor and load control or active power/frequency control model, including documentation and data was provided.

6.0 REFERENCES AND DEFINITIONS

6.1 References

6.1.1 Glossary of Terms Used in NERC Reliability Standards

6.1.2 XES 7.405, Screening of Projects for Impact on NERC Compliance Program (found on the Energy Supply Policies web page)

6.1.3 XES 7.400, NERC FAC-002 Coordination of Plans for New Facilities (found on the Energy Supply Policies web page)

6.2 Definitions

6.2.1 North American Electric Reliability Corporation (NERC) – The organization charged with establishing standards for the reliable operation of the North American electric power grids.

6.2.2 Bulk Electric System (BES) – See definition in Glossary of Terms Used in NERC Reliability Standards.

6.2.3 NERC Reliability Standard MOD-025 – NERC Standard applicable to the verification and data reporting of generator real and reactive power capability and synchronous condenser reactive power capability.

6.2.4 NERC Reliability Standard MOD-026 – NERC Standard applicable to the verification of models and data for generator excitation control system or plant volt/var control functions.

6.2.5 NERC Reliability Standard MOD-027 – NERC Standard applicable to the verification of models and data for turbine/governor and load control or active power/frequency control functions.

6.2.6 NERC Reliability Standard MOD-032 – NERC Standard applicable to establishing consistent modeling data requirements and reporting.

6.2.7 Transmission Planner - The Transmission Planning role is performed by Xcel Energy for all fleet generation facilities in the MRO, WECC, and SPP service regions with the exception of : the PSCo Hayden Station in northwest Colorado. The Transmission Planner for this facility is not Xcel Energy, but is designated as the Western Area Power Administration, (WAPA) headquartered in Lakewood, Colorado. The Transmission planner for Pleasant Valley and Grand Meadow wind farms is Great River Energy. The transmission planner for Courtenay wind farm is Otter Tail Power.

7.0 REVISION HISTORY

Date	Revision	Change
02/03/2014	1.0	Original Issue, supersedes XES 1.110 Rev 2.2 Stability Modeling Data Maintenance and Reporting Requirements
07/21/2014	2.0	Modified to include MOD-025, MOD-026 and MOD-027
11/22/2016	3.0	Modified to include MOD-032-1 and delete MOD-010 and MOD-012.

Xcel Energy	EPR 5.202S
Energy Supply Performance Optimization Policy System	**Revision: 3.0**
TITLE: NERC Protection System Coordination, Relay Setting, and Reporting Requirements *Supersedes XES 7.410, "FERC PRC-001 System Protection Coordination"*	Page 1 of **13**

1.0 PURPOSE

1.1 This standard defines responsibilities and requirements to meet certain requirements established by the following NERC Standards:

- PRC-001, "System Protection Coordination"[1]
- PRC-019, "Coordination of Generating Unit or Plant Capabilities, Voltage Regulator Controls, and Protection"
- PRC-024, "Generator Frequency and Voltage Protective Relay Settings"
- PRC-025, "Generator Relay Loadability"
- PRC-026, “Relay Performance During Stable Power Swings”
- PRC-027, “Coordination of Protection Systems for Performance During Faults”[1]

2.0 APPLICABILITY

2.1 This standard is applicable to the all Energy Supply Bulk Electric System (BES) generating facilities. Requirements of the various NERC Standards referenced above may have applicability to Protections Systems at these facilities for:

2.1.1 Generators

2.1.2 Synchronous condensers

2.1.3 Generator step up (GSU) transformers

2.1.4 Energy Supply owned Generator interconnection facilities that connect the GSU transformer to the transmission system.

2.1.5 Main or unit connected auxiliary transformers capable of feeding plant load when the unit is at power

2.1.6 Reserve or startup auxiliary transformers capable of feeding plant load when the unit is at power.

[1] PRC-001 is effective through 9-30-2020. On 10-01-2020, PRC-027 becomes effective. This policy revision contains requirements necessary to meet both existing PRC-001 and future PRC-027 relay coordination requirements.

2.1.7 Aggregating systems and individual generating resources at dispersed generation facilities such as wind farms.

3.0 RESPONSIBILITIES

3.1 Performance Optimization Fleet Engineering personnel are responsible for the overall administration of the regional NERC Protection System Coordination and Relay Setting program. These responsibilities include maintaining coordination and settings studies for NERC related protection systems at BES generating facilities as well as performing and documenting all required communications with the other NERC Functional Entities concerning protection system coordination issues as required per Section 4.0 Requirements below.

3.2 The cognizant Performance Optimization Reliability Engineering personnel and/or ES Projects group Project Manager/Engineer are responsible:

3.2.1 To provide written notification to the Performance Optimization Fleet Engineering personnel of the installation of any new or planned installation of any NERC related protection systems; or any changes or planned changes to the existing NERC related protection systems as soon as the information becomes available.

3.2.2 To provide written notification to the Performance Optimization Fleet Engineering personnel of the installation of any new or planned installation of equipment, modification of the existing voltage regulating settings or planned modifications of existing voltage regulating settings at BES generating facilities as soon as the information becomes available.

3.2.3 To provide written notification to the Performance Optimization Fleet Engineering personnel of any change or planned changes in BES generator or synchronous condenser equipment capability as soon as the information becomes available.

3.2.4 To provide written notification to the Performance Optimization Fleet Engineering personnel of generator or synchronous condenser step up transformer, main or unit connected auxiliary transformer, or reserve or startup auxiliary transformer changes or replacements.

3.2.5 To provide an updated notification to Performance Optimization Fleet Engineering when previous notification is no longer valid for the changes described in paragraphs 3.2.1-3.2.4 above

3.2.6 As a result of any of the changes described in paragraphs 3.2.1-3.2.5 above, to work with Performance Optimization Fleet Engineering department to assure that any required coordination studies are performed, and relay settings are established and communicated to other entities as required per Section 4.0 Requirements below.

4.0 REQUIREMENTS:

4.1 General

4.1.1 A Protection System Coordination and Relay Setting Study shall be developed for any new NERC related Protection System to be installed at a BES generating facility.

4.1.2 A Protection System Coordination and Relay Setting Study shall be developed or revised to address changes in a NERC related Protection System at a BES generating facility. Examples of changes which may necessitate development or revision of a study include, (but are not limited to), relay replacements, relay setpoint changes, excitation limiter and protection settings, or changes in current or voltage sensing devices.

4.1.3 A Protection System Coordination and Relay Setting Study shall be developed or revised to address replacement of generators or synchronous condensers, generator or synchronous condenser step-up transformers, main or unit connected auxiliary transformers, or reserve or startup auxiliary transformers when the replacement device ratings and/or impedance characteristics deviate from those utilized in the existing coordination study of the protection system for the component to be replaced.

4.1.4 For conventional synchronous machines, there should be only one Protection Coordination and Relay Setting study per NERC related Protection System that addresses PRC-001/027, PRC-019, PRC-024, PRC-025, and PRC-026 requirements applicable to that scheme or unit. This integrated approach will provide for greater clarity and consistency in documentation.

4.1.5 For dispersed generating facilities such as wind farms, the complex topography often requires use of dynamic simulations by vendors to prove compliance with some of the NERC standards. Coordination studies are often performed by architect/engineer firms during construction. As such, a collection of standard specific studies are often performed to address PRC-001/027, PRC-019, PRC-024, PRC-025, and PRC-026 as required.

4.1.6 Prior to performing a Protection System Coordination and Relay Setting Study, data to be used for generator and/or transformer ratings and impedances shall be verified against equipment test reports or design values for new equipment. The following engineering data should be included in the study for reference of report reviewers:

Generator Parameters	**GSU Parameters**	**System Parameters**
Generator MVA Rating	GSU HV KV rating	Assumed system available fault current
Generator kV Rating	GSU High Volt Tap	
Generator pf Rating	GSU LV KV Rating	
Generator X_d	GSU Impedance	
Generator X'_d	GSU BASE MVA Rating	
Generator X''_d (sat)	GSU Neutral Reactance	
Generator X_2 (sat)	GSU Core Type	
Gen Neut Gr Tr Ratio		
Gen Neut Gr Resistance		

4.1.7 Prior to performing a Protection System Coordination and Relay Setting Study, updated transmission system fault current and impedance data shall be obtained. Updated transmission system fault current and impedance data shall be obtained at least annually or more frequently if significant changes are being implemented or have occurred which are anticipated to have a significant effect (>15% change) on system parameters for the substation associated with the generating unit to be analyzed.

4.1.8 All Protection System Coordination and Relay Setting Studies shall have a second engineering review to ensure adequacy of the developed protection system settings.

4.1.9 All Protection System Coordination and Relay Setting Studies shall be re-validated using updated data on a five-calendar year interval to ensure developed and applied settings remain valid for system and generating plant changes. This five-calendar year interval meets the periodic update requirements of both PRC-019 and PRC-027.

4.1.10 Protection system setting changes that do not affect fault coordination with separate interconnected entities can be processed as minor revisions and do not require review and approval by that separate entity prior to implementation. Nonetheless, a courtesy copy of the minor revision of the coordination study should be forwarded to the interconnected entity for documentation purposes.

Note that this does not eliminate the need for follow-up notifications such as those listed in Section 4.4.3 or 4.4.4 below.

4.2 PRC-001/027 Requirements

4.2.1 New or revised Protection System Coordination and Relay Setting studies SHALL be provided to Transmission Operations - Protection System Engineering and the Host Balancing Authority for review. (PRC-001)

4.2.2 General requirements 4.1.6, 4.1.7, 4.1.8, and 4.1.9 above must be met to fulfill NERC PRC-027 program requirements for having an established relay setting process to assure accuracy of input data and output results.

4.2.3 For protection system settings applied on BES elements that electrically join the generating plant to equipment owned by a separate NERC functional entity (i.e. - Transmission Owner, Generator Owner, or Distribution Provider), the following PRC-027 requirements apply:

4.2.3.1 The proposed protections settings developed by the Protection System Coordination and Relay Setting study and applied on the BES Element that electrically joins the generating facility to that owned by a separate functional entity shall be provided to that entity for review. Performance Optimization Fleet Engineering should request that the Interconnecting Entity review the relay settings and associated coordination study within 30 days, or a mutually agreed upon timeframe.

4.2.3.2 That separate functional entity will either notify us of any identified coordination issues or will affirm that no coordination issues were identified.

4.2.3.3 When provided with protection system settings from a separate functional entity and applied on the BES element joining our generating facility to their system, the provided settings shall be reviewed within a mutually agreed to timeframe. Any identified coordination issues shall be communicated to that entity or the entity shall be notified that our review did not identify any coordination issues with the proposed settings.

4.2.3.4 Any identified coordination issues identified by the reviews described in 4.2.2.1 or 4.2.2.2 shall be addressed prior to the implementation of the proposed settings.

4.2.3.5 Any protection system settings revisions for protection applied on equipment that electrically joins the generating facility to that owned by a separate functional entity and which result from unforeseen circumstances that arise during implementation or commissioning, misoperation investigations, maintenance activities, or emergency replacements as a result of a protection system failure shall be communicated to the other owner of the electrically joined facility.

4.3 PRC-019 Requirements

4.3.1 Coordination studies for generators and synchronous condensers shall show coordination for the voltage regulating system controls, including in-service limiters and protection functions, with the applicable equipment capabilities and settings of the applicable Protection System devices and functions. Assuming normal automatic voltage regulator control loop and steady-state system operating conditions, the studies should show that:

4.3.1.1 In-service limiters are set to operate before the Protection System of the applicable Facility in order to avoid disconnecting the generator unnecessarily, and

4.3.1.2 The applicable in-service Protection System devices are set to operate to isolate or de-energize equipment in order to limit the extent of damage when operating conditions exceed equipment capabilities or stability limits.

4.3.2 The study described in Section 4.3.1 shall be reviewed and updated at a maximum of every 5 calendar years or within 90 days following the identification or implementation of systems, equipment, or settings changes that will affect the coordination of devices as described in Section 4.3.1. Possible systems, settings, or equipment changes which could affect this coordination include but are not limited to:

4.3.2.1 Voltage regulating settings or equipment changes;

4.3.2.2 Protection System settings or component changes;

4.3.2.3 Generator or synchronous condenser equipment capability changes;

4.3.2.4 Generator or synchronous condenser step up transformer changes.

4.3.3 Section G of NERC Reliability Standard PRC-019, "Coordination of Generating Unit or Plant Capabilities, Voltage Regulator Controls, and Protection" (Reference 6.1.5) provides a technical discussion of methods to show possible required coordination, but all voltage regulator settings, limiters and trips shall be reviewed for coordination with protective relays.

4.4 PRC-024 Requirements

4.4.1 Coordination and Relay Settings Studies shall document that generators that have generator frequency protective relays activated to trip applicable units have protective relaying settings such that the frequency protective relaying does not trip the applicable generating unit(s) within the "no trip zone" of PRC-024 Attachment 1, subject to the following exceptions:

4.4.1.1 Generating unit(s) may trip if the protective functions (such as out-of-step or loss-of-field functions) operate due to an impending or actual loss of synchronism or, for asynchronous generators, due to instability in power conversion control equipment.

4.4.1.2 Generating unit(s) may trip if clearing a system fault necessitates disconnecting (a) generating unit(s).

4.4.1.3 Generating unit(s) may trip within a portion of the "no trip zone" of PRC-024 Attachment 1 for documented and communicated regulatory or equipment limitations. See Section 4.4.3 below for additional requirement pertaining to the application of this exception.

4.4.2 Coordination and Relay Settings Studies shall document that generators that have generator voltage protective relays activated to trip applicable units have protective relaying settings such that the voltage protective relaying does not trip the applicable generating unit(s) as a result of a voltage excursion at the transmission voltage side of the generator step up or collector system transformer for which the voltage excursion was caused by an event on the transmission system external to the generating plant that remains within the "no trip zone" of PRC-024 Attachment 2. If the Transmission Planner allows less stringent voltage settings, the protective relays shall be set within the voltage recovery characteristics of a location-specific Transmission Planner's study. The following exceptions apply to this requirement:

4.4.2.1 Generating unit(s) may trip in accordance with a Special Protection System, (SPS) or Remedial Action Scheme, (RAS).

4.4.2.2 Generating unit(s) may trip if clearing a system fault necessitates disconnecting (a) generating unit(s).

4.4.2.3 Generating unit(s) may trip if the protective functions (such as out-of-step or loss-of-field functions) operate due to an impending or actual loss of synchronism or, for asynchronous generators, due to instability in power conversion control equipment.

4.4.2.4 Generating unit(s) may trip within a portion of the "no trip zone" of PRC-024 Attachment 2 for documented and communicated regulatory or equipment limitations. See Section 4.4.3 below for additional requirement pertaining to the application of this exception.

4.4.3 If exceptions are applied in frequency relay settings per Section 4.4.1.3 or in voltage relays per Section 4.4.2.4 above because of known regulatory or equipment limitations, or when a previously documented regulatory or equipment limitation is removed, the change shall be communicated to the Planning Coordinator and Transmission Planner within 30 calendar days of any of the following:

4.4.3.1 Identification of a regulatory or equipment limitation.

4.4.3.2 Repair of the equipment causing the limitation that removes the limitation.

4.4.3.3 Replacement of the equipment causing the limitation that removes the limitation.

4.4.3.4 Creation or adjustment of an equipment limitation caused by the consumption of the cumulative turbine life-time frequency excursion allowance.

4.4.4 Frequency and voltage protective relay trip settings established per Sections 4.4.1 and 4.4.2 shall be provided to the Planning Coordinator or Transmission Planner responsible for modeling the unit within 60 calendar days of receipt of a written request for the data or within 60 calendar days of any change of previously requested trip settings unless directed by the Planning Coordinator or Transmission Planner that the reporting of relay setting changes is not required.

4.5 PRC-025 Requirements

4.5.1 Coordination and Relay Settings Studies for BES facilities identified in Section 2.1 above shall document that all settings applied to load-responsive relays are made in accordance with PRC-025-2 Attachment 1 while maintaining reliable fault protection.

4.6 PRC-026 Requirements

4.6.1 For load-responsive protective relay functions as identified in PRC-026, Coordination and Relay Setting Studies for BES generators, transformers and transmission lines shall document applicability of PRC-026 requirements. In general, these requirements only apply to phase distance (21), phase overcurrent (51), out of step tripping (78), and loss of field (40) settings with time delays of less than 15 cycles. See PRC-026 Attachment A.

4.6.2 Within 12 months of notification from the Planning Coordinator of an ES owned BES element pursuant to Requirement R1 of PRC-026, the associated Protection Coordination and Relay Setting study should be revised to determine and document whether the load responsive relay functions are applied per the criteria of PRC-026 Attachment B. This is only required if such an evaluation has not been performed in the last five years for the load responsive relay in question.

4.6.3 Within 12 months of becoming aware of an ES owned generator, transformer, or transmission line BES element that tripped in response to a stable or unstable power swing due to operation of its protective relays, the associated Protection Coordination and Relay Setting study should be revised to determine and document whether the load responsive relay functions are applied per the criteria of PRC-026 Attachment B.

4.6.4 If the evaluation performed per paragraph 4.6.2 or 4.6.3 above determines that the load responsive relay settings do not meet PRC-026 Appendix B criteria, a formal NERC Corrective Action Plan, CAP, shall be developed within six full calendar months to either:

4.6.4.1 Change settings to meet PRC-026 Attachment B criteria while maintaining dependable fault detection and, if applied, dependable out of step tripping.

Or

4.6.4.2 Modify the Protection System such that it is excluded from applicability to PRC-026 Attachment A criteria while maintaining dependable fault detection and, if applied, dependable out of step tripping.

4.6.5 Any CAP developed per paragraph 4.6.4 shall be implemented as planned. If CAP actions or timetables change, the CAP should be formally updated until all associated actions are complete.

4.7 Implementation Timelines – General Information

4.7.1 A Protection System Coordination and Relay Setting Study shall be developed to address all NERC related Protection Systems at a BES generating facility. All BES units shall have a Protection Coordination and Relay Setting study. Existing studies shall be reviewed and updated as needed per the requirements outlined in this document.

4.7.2 For PRC-026, studies performed in response to Planning Coordinator notifications per paragraph 4.6.2 or upon becoming aware that a BES element tripped because of a protective relay operation in response to a stable or unstable power swing per paragraph 4.6.3 must be completed by the later of 12 months after the notification from the Planning Coordinator, 12 months after awareness of a trip in response to a power swing or January 1, 2020.

4.7.3 For PRC-027, all initial studies for PRC-027 R2 compliance must be completed no later than 6 calendar years after the effective date of PRC-027-1. Based on PRC-027-1 effective date of 10/1/2020, the deadline for initial R2 compliance is 12/31/26.

5.0 REQUIRED RECORDS

5.1 Protection System Coordination and Relay Setting Studies written to address the requirements of this standard SHALL be stored in the regional Protection System Coordination and Relay Setting Study folder in Documentum or other approved regional data repository.

5.2 Copies of correspondence with Transmission Operators, Transmission Planners, Distribution Providers and/or Planning Coordinators concerning these Protection System Coordination and Relay Settings Studies SHALL be stored Documentum or in the regional specific data repository flagged for the applicable PRC-001, PRC-019, PRC-024, PRC-025, PRC-026, or PRC-027 standard. Note that dated sign-off blocks on Protection System Coordination and Relay Setting Study documents may be used as evidence of this communication.

5.3 Any Corrective Action Plan developed per paragraph 4.6.4 or revised Corrective Action Plant per paragraph 4.6.5 SHALL be stored in Documentum or in the regional specific data repository for PRC-026 documentation. The CAP SHALL be retained and available for review for a minimum of 12 months following completion of the implementation of the CAP.

6.0 REFERENCES AND DEFINITIONS

6.1 References

6.1.1 NERC System Protection and Control Subcommittee Technical Reference Document, "Power Plant and Transmission System Protection Coordination," Revision 2 - July 2010. It should be noted that this document does not contain the most up to date information concerning PRC-019, PRC-024, and PRC-025 requirements. The technical bases and guidelines for these specific standards supersede the information contained in the "Power Plant and Transmission System Protection Coordination," Revision 1 - July 2010 document for the affected settings.

6.1.2 IEEE Std C37.102, "IEEE Guide for AC Generator Protection"

6.1.3 IEEE Power System Relay Committee paper, "Coordination of Generator Protection with Generator Excitation Control and Generator Capability"

6.1.4 NERC Reliability Standard PRC-001, "System Protection Coordination"

6.1.5 NERC Reliability Standard PRC-019, "Coordination of Generating Unit or Plant Capabilities, Voltage Regulator Controls, and Protection"

6.1.6 NERC Reliability Standard PRC-024, "Generator Frequency and Voltage Protective Relay Settings"

6.1.7 NERC Reliability Standard PRC-025, "Generator Relay Loadability."

6.1.8 NERC Reliability Standard PRC-025 "Guideline and Technical Basis"

6.1.9 NERC Reliability Standard PRC-026 “Relay Performance During Stable Power Swings”

6.1.10 NERC Reliability Standard PRC-027, “Coordination of Protection Systems for Performance During Faults”

6.2 Definitions

6.2.1 **BES** – Bulk Electric System

6.2.2 **BES Generating Facility** – in general, an individual generator of greater than 75 MVA and that connects to the system at a voltage level > 100 KV or a generating facility that aggregates to greater than 75MVA and that connects to the system at a voltage level >100 KV. See the NERC Glossary of Terms definition of Bulk Electric System for more details

6.2.3 **GSU** – Generator Step Up

6.2.4 **NERC - North American Electric Reliability Corporation** – The organization charged with establishing standards for the reliable operation of the North American electric power grids.

6.2.5 NERC related Protection System – are located at BES generating facilities and consist of the relays, voltage and current sensing devices, DC control circuitry, DC power supply and communication systems used to protect generators, generator step up or main power transformers, synchronous condensers, reactive power sources such as capacitor banks or reactors, Unit Auxiliary or Main Station Auxiliary transformers, Startup or Reserve Station Auxiliary transformers and those portions of dispersed power facility aggregating systems where the power flow aggregates to >75 MVA.

7.0 REVISION HISTORY

Date	Revision	Change
07/21/2014	1.0	Original Issue, supersedes *XES 7.410, "FERC PRC-001 System Protection Coordination"*
05/23/2017	2.0	Revised paragraph 3.2.6 and added paragraph 4.2.3 to clarify that a revised coordination study may be required for changes of the generator and/or GSU, MSA or UST, or RSA or SST transformers. Added section 4.6 to document PRC-026 requirements. Revised section 4.7 to document PRC-026 implementation requirements.

		Revised section 5.0 to document PRC-026 record retention requirements.
06/05/2018	2.1	Corrected section references for PRC-024.
01/02/2019	2.2	Corrected section 4.5 references to current version of applicable standard, PRC-025-2.
06/09/2020	3.0	Updated department names. Added requirements for PRC-027 including requirements for obtaining up to date input data for the performance of coordination studies and specific requirements for coordination of protection applied on equipment that joins the generating facility to that owned by other NERC functional entities.

Xcel Energy	EPR 5.220P01
Energy Supply Technical Services Policy System	Revision: 7.4
TITLE: NERC Facility Rating Methodology	Page 1 of 6

1.0 Purpose:

1.1 This procedure establishes facility ratings to meet certain requirements established by NERC Standard FAC-008. This procedure ensures that Energy Supply develops and applies a facility rating methodology that complies with the NERC Reliability Standards. Energy Supply Technical Services policy EPR 5.200, Facility Rating and Reporting, establishes responsibilities and requirements for utilizing this procedure.

2.0 Applicability:

2.1 This procedure is applicable to all generating facilities including hydro units and Energy Supply-owned synchronous condensers connected to the Bulk Electric System.

2.2 The facility ratings determined from this procedure shall equal the most limiting applicable equipment rating of the individual equipment that comprises the facility.

If Emergency ratings have not been provided by the original equipment manufacturer, the only ratings used will be Normal ratings. Peak and Reserve ratings and Winter/Summer ratings may be used for combustion turbine units that have been assigned such ratings by the original equipment manufacturer.

Facility ratings for jointly owned units will be determined by the generating unit operator.

3.0 Responsibilities:

3.1 Technical Resources and Compliance management is responsible to compile the Normal and Emergency electrical ratings for the generators, transformers, relay protective devices, and terminal equipment, as applicable, for each Bulk Electric System unit.

3.1.1 The point of interconnect between Energy Supply and Xcel Energy Transmission Owners is agreed upon with the Transmission Owner per the XEL-PRO-Facility Rating Coord bet TO and GO.docx.

3.1.2 The point of interconnection between Energy Supply and other Transmission Owners is determined by agreement between the two parties.

4.0 Requirements:

4.1 NERC Facility Rating Methodology

4.1.1 The following methodology is to be used to determine the Facility Rating used for compliance with NERC Standard FAC-008-3.

4.1.2 The facility ratings determined from this procedure shall equal the most limiting applicable equipment rating of the individual equipment that comprises the facility.

4.1.3 To determine the limiting piece of equipment for a facility it is necessary to determine the electrical current (ampere) rating of the following pieces of equipment for conventional generating stations:

- Generator
- Generator Current Transformers
- Generator Disconnect
- Bus or cable conductors that connect the Generator, Generator Breaker (if applicable) and the GSU Transformer.
- Generator Circuit Breaker
- Generator Breaker Current Transformers
- Generator Circuit Breaker Disconnects
- Generator Step-Up (GSU) Transformer – use primary (low voltage) winding current rating for comparison purposes.
- Generator Step-Up Transformer Current Transformers
- Generator Step-Up Transformer Disconnect
- Bus or cable conductors that connect the GSU Transformer or GSU Transformer Disconnect (if applicable) to the Transmission Substation.
- Overcurrent relay minimum pick-up setpoint

4.1.4 The following scope of equipment shall be used for wind farms:

- The combined kVA rating of individual turbines connected to a collector feeder.
- Collector Feeder cable or conductor rating.
- Collector Feeder circuit breaker.
- Collector Feeder circuit breaker disconnects.
- Collector Feeder circuit breaker current transformers.
- Step-Up Transformer
- Step-Up Transformer Disconnects
- Step-Up Transformer Current Transformers

- Conductors that connect the Step-Up Transformer to the Transmission Substation.
- Overcurrent Relay minimum pick-up setpoint.
- Series and Shunt compensation devices

4.1.5 For equipment operating at a voltage other than the generator voltage (or collector feeder voltage for wind farms), for comparison purposes, its current rating shall be adjusted to the equivalent of its rating at the generator (or collector feeder) for the same MVA power level. For example, for a generator rated 10 kV, connected to a generator breaker installed on the high side of the GSU Transformer operating at 100 kV, if the nameplate current rating of the breaker is 1,000 amperes, for the facility rating evaluation, use 100 kV/10 kV times 1,000 amperes = 10,000 amperes.

4.1.6 The rating normally is the manufacturer's nameplate rating. The rating for the nominal generator voltage, normal operating coolant pressure and ambient temperature during summer peak should be used.

4.1.7 For units where the bus or cable does not have a nameplate rating, the current rating of the generator may be substituted.

4.1.8 For bus or conductors in air, use ratings developed based on IEEE 738 for overhead conductors and IEEE 605 for bus. The assumptions used in calculating the ratings are contained in the 'Transmission Line Rating Methodology' and 'Bus Conductors and Equipment Jumpers' sections of Transmission System Policy **XEL-POL-Facility Rating Methodology.** For units with a separate summer and winter rating, the appropriate summer or winter "Normal" current rating should be used. For units with only one seasonal rating, use the appropriate summer "Normal" current rating.

4.1.9 Operating limitations (such as temporary deratings) will be captured in the ratings determination and will be used in finding the most limiting and next most limiting equipment. Temporary operating limitations will be noted as such in the rating documentation.

4.1.10 The identity of the most limiting equipment and the next most limiting equipment shall be identified.

5.0 Required Records:

5.1 Technical Resources and Compliance shall have evidence it provided the Reliability Coordinator, Transmission Operator, Transmission Planner, and

Planning Coordinator the facility rating methodology requested within 21 calendar days of receipt of a request.

5.2 Technical Resources and Compliance shall have evidence it responded, in writing, to comments from the Reliability Coordinator, Transmission Operator, Transmission Planner, and Planning Coordinator within 45 calendar days of receipt of those comments The response shall indicate whether a change will be made to the facility ratings methodology and, if no change will be made to the facility ratings methodology, the reason why.

5.3 Technical Resources and Compliance shall have evidence it provided the Reliability Coordinator, Transmission Operator, Transmission Planner, and Planning Coordinator the facility ratings as scheduled by such requesting entities.

5.4 Technical Resources and Compliance shall have evidence it provided the Reliability Coordinator, Planning Coordinator, Transmission Planner, Transmission Owner, and Transmission Operator with the identity and thermal rating of the next most limiting equipment within 30 calendar days of a request.

6.0 References & Definitions:

6.1 References

6.1.1 **EPR 5.200** Facility Ratings and Reporting Policy
6.1.2 **IEEE 738** IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors
6.1.3 **IEEE 605** IEEE Guide for Design of Substation Rigid-Bus Structures
6.1.4 **XEL-POL-Facility Rating Methodology**
6.1.5 **XEL-PRO-Facility Rating Coord bet TO and GO.docx**

6.2 Definitions

6.2.1 **North American Electric Reliability Corporation (NERC) -**The organization charged with establishing standards for the reliable operation of the North American electric power grids.

6.2.2 **NERC Reliability Standard FAC 008 –** NERC Standard applicable to Facility Ratings

6.2.3 **Bulk Electric System** – As defined by the Regional Entity, the electrical generation resources, transmission lines, interconnections with neighboring systems, and associated equipment, generally operated at voltages of 100kv or higher. Radial transmission facilities serving only load with one transmission source are generally not included in this definition.

7.0 Revision History

Date	Revision	Change
05/31/2007	Draft	Draft for FERC Reliability Standard – FAC 008, 009
06/07/07	Rev 0	Added reference to EPR – 5.200P
06/21/07	Rev 1	Revised Applicability "Facility ratings for jointly owned units will be determined by the generating unit operator."
9/13/07	Rev 2	Revised Section 3 "producing for an eight (8) hour period for three (3) consecutive days during the summer or winter months at reference ambient conditions as defined in PPT – MC – 01."
11/09/07	Rev 3	If Emergency ratings have not been provided by the Original Equipment Manufacturer, the only ratings used will be Normal ratings. Peak and Reserve ratings and Winter/Summer ratings may be used for combustion turbine units that have been assigned such ratings by the original equipment manufacturer.
8/15/08	4.0	Administrative change only. Modified numbering to match Documentum version.
10/2/08	5.0	Clarification of capacity terms
6/17/10	6.0	Added generator disconnects, generator breakers (and associated disconnects and CT's), and GSU CT's to the scope of Facility Rating equipment to be evaluated. Added a procedure to evaluate wind farms.
10/01/12	7.0	Revised the procedure to align with NERC Standard FAC-008-3 which replaces FAC-008-1 and FAC-009-1. Changed Maintenance Resources to Technical Resources and Compliance. Changed Production Resources to Technical Services in the header. Removed references to Performance Monitoring.
01/01/13	7.1	Removed Energy Supply specification from section 2.1 and clarified that only Energy Supply-owned synchronous condensers are covered by this policy. Added section to explicitly call out for consideration of operating limitations in section 4 of the methodology.
08/05/2013	7.2	Changed title wording from "determination" to "methodology". Modified header and footer to reflect current standardized format. Updated author to current responsible employee.

Date	Revision	Change
		Corrected effective date to reflect the most recent major revision.
09/15/2014	7.3	Updated section 4.1.8 to included a statement about the assumptions used in calculating the ratings of bus and conductors in air. Added reference to Transmission's facility rating methodology.
10/10/2016	7.4	Added section 6.1.5 and added sections 3.1.1 and 3.1.2 to the Responsibility section to include policy reference XEL-PRO-Facility Rating Coord bet TO and GO.docx. Added "Series and shunt compensation devices" to wind farm scope section 4.1.4.

Xcel Energy	EPR 5.704S
Energy Supply Technical Services Policy System	Revision: 2.3
TITLE: Battery Maintenance Standard	Page 1 of 8

1.0 PURPOSE:

This maintenance standard establishes general practices for routine preventative maintenance of batteries and battery chargers utilized at the Company's electric generating plants.

2.0 APPLICABILITY:

2.1 This standard addresses all aspects of routine maintenance and recommended maintenance intervals.

2.2 Xcel Energy Generating Plants have a large variety of battery types and battery applications. This standard is primarily directed toward the maintenance of large strings of flooded cells of either the vented lead acid, lead calcium, lead antimony, or lead selenium type. As such, IEEE Standard 450 – "IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead Acid Batteries for Stationary Applications" provides, in general, the basis for both the content and the frequency of performance of the battery maintenance and testing procedures set forth in this Energy Supply Maintenance Standard. Any deviations between the requirements contained in this standard and the specific IEEE Standard 450 recommendations are within the allowable program considerations discussed in Section 1.2 of IEEE Standard 450. Maintenance activities specific to other types of batteries such as valve regulated lead acid batteries that are used in these applications in power plants have also been included in the program. Proper functioning of battery chargers is validated by observing that the battery charger maintains connected batteries in a fully charged condition by its ability to maintain a proper float voltage on the battery.

For batteries and battery chargers serving as part of a NERC PRC-005 related Protection System, the maintenance activities and maximum allowable intervals of this standard meet or are more restrictive than the NERC Standard PRC-005 for minimum maintenance activities and maximum maintenance intervals for batteries and battery chargers. NERC PRC-005 related batteries and chargers SHALL be maintained per this standard and are on a time-based maintenance program with intervals not to exceed the PRC-005specified maintenance intervals for unmonitored components.

2.3 In particular, this standard applies to batteries and battery chargers used in the following applications:

2.3.1 24 V, 48 V, 125 V or 250 VDC Station Service Batteries

2.3.2 UPS batteries

2.4 Some provisions of this document may be applicable to other battery types and applications. Compliance with this standard for these additional battery types and applications is at the discretion of the power plant for non-NERC PRC-005 related batteries.

3.0 RESPONSIBILITIES:

3.1 The facility director is responsible for ensuring a battery maintenance program is in place for plant batteries. The facility director should designate an individual to serve as a Site Electrical Maintenance Coordinator whose responsibilities will, in part, include administration of the requirements identified in Section 4.0 below.

3.2 Technical Resources and Compliance is responsible to aid the Site Electrical Maintenance Coordinator in initially establishing the program and for providing technical support.

4.0 REQUIREMENTS:

The following maintenance and testing activities are identified for implementation of the battery maintenance program and shall be used by plant management, engineering, operations, and maintenance personnel to assure reliable operations of station DC systems:

4.1 Monthly Inspections:

4.1.1 Plant electrical staff or other knowledgeable battery technician shall perform a monthly inspection of applicable batteries.

4.1.2 The above work should be performed per Technical Resources and Compliance Maintenance Procedure, “Battery – Monthly Testing”. This procedure should be set up in the work and asset management program to be performed on each applicable station battery on a monthly basis. A copy of the procedure is available on the Technical Services Maintenance Procedures web page.

4.2 Quarterly Inspections

4.2.1 In addition to the monthly inspections, plant personnel or other knowledgeable battery technician shall also perform a quarterly inspection of applicable batteries.

4.2.2 The above work should be performed per Technical Resources and Compliance Maintenance Procedure, "Battery – Quarterly Testing". This procedure should be set up in the work and asset management program to be performed on each applicable station battery on a quarterly basis. A copy of the procedure is available on the Technical Services Maintenance Procedures web page.

4.3 Annual Inspections:

4.3.1 In addition to the monthly and quarterly battery inspection requirements, plant electrical staff or other knowledgeable battery technicians shall perform a detailed annual inspection of applicable batteries.

4.3.2 The above work should be performed per Technical Resources and Compliance Maintenance Procedure, "Battery – Annual Testing". This procedure should be set up in the work and asset management program to be performed on each applicable station battery on an annual basis. A copy of the procedure is available on the Technical Services Maintenance Procedures web page.

4.4 Battery Capacity Tests

4.4.1 Plant electrical staff or knowledgeable battery technicians shall perform a battery capacity test at no longer than a 6 calendar year interval for Vented Lead Acid batteries or a 3 calendar year interval for Valve Regulated Lead Acid batteries.

4.4.2 The above work should be performed per Technical Resources and Compliance Maintenance Procedure, "Battery – Capacity Testing." This procedure should be set up in the work and asset management program to be performed on each applicable station battery on an interval not to exceed that identified in Section 4.4.1 for that type of battery. A copy of the procedure is available on the Technical Services Maintenance Procedures web page. As battery capacity tests frequently require a plant outage, plants should consider their typical maintenance outage interval when establishing the interval for the performance of battery capacity tests associated with a given unit.

4.5 For newly acquired plants, the following grace period is established to bring the facility's battery maintenance program into alignment with this Standard:

4.5.1 The newly acquired plant's NERC related battery system(s) SHALL have a Monthly and Quarterly Inspection performed per the procedures referenced in Sections 4.1 and 4.2 above within three months of assuming ownership of the facility.

4.5.2 The newly acquired plant's NERC related battery systems SHALL have an Annual Inspection performed per the procedure referenced in Section 4.3 above within the first year of assuming ownership of the facility.

4.5.3 The newly acquired plant's NERC related battery system(s) SHALL have a Capacity Test performed per the procedure referenced in Section 4.4 above no later than the sooner of the end of first scheduled maintenance outage or within two years of assuming ownership of the facility unless test records are available from the previous owner's testing program to justify a later test date.

4.6 For batteries and battery chargers serving as part of a NERC PRC-005 related Protection System, the work and asset management shall call for the use of the Monthly, Quarterly, Annual, and Capacity Procedures or approved equivalent forms.

4.7 Plants shall maintain a listing of NERC PRC-005 related batteries and associated battery acceptance criteria. This Battery Acceptance Criteria document shall be kept current.

4.8 Identify any subsequent Maximo Work Orders issued to address and track any Unresolved Maintenance Issues.

5.0 REQUIRED RECORDS

5.1 The plant shall maintain copies of monthly and quarterly inspection data sheets in the plant maintenance files for at least 3 years. For NERC PRC-005 related batteries, the plant shall maintain copies of monthly and quarterly inspection data sheets for the longer of three years or since the last NERC Compliance audit.

5.2 The plant shall maintain copies of annual inspection completed procedure and data sheets in the plant maintenance files for at least 5 years. For NERC PRC-005 related batteries, the plant shall maintain completed copies of the annual inspection procedure and data sheets for the longer of five years or since the last NERC Compliance audit.

5.3 The plant shall maintain copies of battery capacity procedure and test data sheets in the plant maintenance files for the life of the battery or three years, whichever is longer. For NERC PRC-005 related batteries, the plant shall maintain completed copies of the completed capacity test procedure and data sheets for the longer of the life of the battery or since the last NERC Compliance audit.

6.0 DEFINITIONS & REFERENCES

6.1 Definitions

6.1.1 **Battery Monthly Inspection** – A documented routine inspection of a battery and its charger that should be performed once each month of the year. If scheduling or resource issues prevent completion of a monthly inspection in a given calendar month, the reason for the failure to complete the inspection on the normal monthly basis SHALL be documented on the associated Work Order or maintenance procedure and the monthly inspection SHALL be completed within the next calendar month. Technical Rationale for Monthly Inspection Time Allowance: IEEE Standard 450, Section 1.2 allows for some minor program deviations. Furthermore, the Monthly inspection delineated in the associated procedure contains all measurements required on a 4 calendar month interval by the current draft of PRC-005. As such, the one month time allowance discussed in this paragraph still results in inspections on an interval roughly half of that allowed in the NERC PRC-005 standard. Furthermore, a NERC violation only occurs if a Battery Monthly Inspection is missed for 4 consecutive months

6.1.2 **Battery Quarterly Inspection**– A documented routine inspection of a battery and its charger that should be performed once each quarter of the year. If scheduling or resource issues prevent completion of a quarterly inspection, the reason for the failure to complete the inspection SHALL be documented on the associated Work Order or maintenance procedure and the quarterly inspection SHALL be completed in conjunction with the next monthly inspection.

Technical Rationale for Quarterly Inspection Time Allowance for Vented Lead Acid Batteries: IEEE Standard 450, Section 1.2 allows for some minor program deviations. Furthermore, the Quarterly inspection delineated in the associated procedure contains measurements required for Vented Lead Acid batteries on an 18 calendar month interval by the current revision of PRC-005. As such, the additional one month time allowance discussed in the above paragraph still results in inspections on a not to exceed 4 month interval which is over 4 times as frequent at the 18 calendar month interval allowed in NERC PRC-005 standard. As such, a NERC violation only occurs if a Battery Quarterly Inspection is missed for 6 consecutive quarters for a Vented Lead Acid Battery and then only if the Annual Inspection for the associated battery was also missed.

Technical Rationale for Quarterly Inspection Time Allowance for Valve Regulated Lead Acid Batteries: The Quarterly inspection delineated in the associated procedure contains measurements required for Valve Regulated Lead Acid batteries on a 6 calendar month interval by the current version of PRC-005. As such, the additional one month time allowance discussed in the above paragraph still results in inspections on a not to exceed 4 month interval which is still more frequent than the 6 calendar month allowed in the NERC PRC-005 standard. As such, a NERC violation only occurs if a Battery Quarterly Inspection is missed for 2 consecutive quarters for a Valve Regulated Lead Acid Battery.

6.1.3 **Battery Annual Inspection** – A documented and detailed inspection of a battery and its charger that should be performed on a one-year interval. If scheduling or resource issues prevent completion of the annual inspection within 12 calendar months of its last completion, the reason for the failure to complete the inspection within the normal annual basis SHALL be documented on the associated Work Order or maintenance procedure and the annual inspection SHALL be completed within the next six calendar months. Technical Rationale for Annual Inspection Time Allowance: IEEE Standard 450, Section 1.2 allows for some minor program deviations. Furthermore, the Annual inspection delineated in the associated procedure contains measurements required on an 18 calendar month interval by the current version of PRC-005. As such, the additional six month time allowance discussed in this paragraph results in inspections on an interval equivalent to the 18 calendar month allowed in the NERC PRC-005 standard.

6.1.4 **Unresolved Maintenance Issue** – a deficiency identified during a maintenance activity that causes the component to not meet the intended performance, cannot be corrected during the maintenance interval, and requires follow-up corrective action.

6.1.5 **Additional Definitions** – see IEEE Standard 450 for definitions and further descriptions of battery terms used in this standard or associated maintenance procedures.

6.2 References

6.2.1 IEEE Standard 450 – "IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead Acid Batteries for Stationary Applications. "

6.2.2 NERC Standard PRC-005

7.0 REVISION HISTORY

Date	Revision	Change
8/1/05	0	Original Issue

Date	Revision	Change
3/12/07	0	Guideline rewritten into a standard
3/26/07	1.1	Clarified requirements for reading cell voltages only on a quarterly basis during performance of monthly inspections. See paragraph 4.1.1.
3/13/08	1.2	Expanded on definitions of monthly and annual inspections to allow for flexibility in scheduling.
4/7/08	1.3	Removed quarterly testing requirements from description of monthly inspection and added a stand alone quarterly inspection requirement.
11/6/08	1.4	Removed inspection detailed guidelines from paragraphs 4.1.1, 4.2.1, 4.3.1 and 4.4.1 of the standard as this information is provided in the respective inspection and test procedures.
9/24/09	1.5	Revised paragraph 2.0 to clarify that IEEE Standard 450 serves as the primary basis of the Energy Supply Battery Maintenance program. Clarified maximum allowable interval for performance of battery capacity tests in paragraph in paragraph 4.4, and in Paragraph 6.0, eliminated definitions and instead referred to IEEE Standard 450 definitions and added IEEE Standard 450 as a reference.
1/26/2010	1.6	Reinstated definitions of monthly, quarterly, and annual inspections at section 6.0 to allow flexibility in scheduling.
05/24/2012	1.7	Updated hyperlinks.
08/26/2012	1.8	Updated hyperlinks, changed department names to reflect current organization.
11/21/2012	2.0	Major Revision to establish and document program alignment with pending PRC-005-2 requirements and to address change in NERC definition to include battery chargers as part of the DC Supply element of a Protection System.
03/02/2015	2.1	Reformatted to comply with XES 1.100P01 'Configuration Management for ES Policies and Procedures'. Minor grammatical revisions and clarification that monitoring attributes are not utilized to extend maintenance intervals.
02/09/2016	2.2	Changed references from revision-specific to non-revision specific NERC standard PRC-005.

Date	Revision	Change
03/13/2017	2.3	Changed Maximo to generic "work and asset management"

1.0 PURPOSE:

1.1 This standard establishes general practices for routine preventative maintenance of Protection Systems and Sudden Pressure Relaying utilized at the Company's electric generating plants.

2.0 APPLICABILITY:

2.1 Included in the scope of this standard are Protection Systems and Sudden Pressure Relaying that protect generators, transformers, switchgear, and the individual loads fed from the circuit breakers on a medium voltage or low voltage bus. The standard addresses all aspects of routine maintenance as well as recommended testing and maintenance intervals. Note that Protection Systems and Sudden Pressure Relaying for generators, generator step-up transformers, generator interconnection facilities, main or unit connected auxiliary transformers, reserve or startup auxiliary transformers, and generator bus connected excitation transformers at Bulk Electrical System (BES) plants or Protection Systems for facilities used in aggregating dispersed BES generation from the point where those resources aggregate to greater than 75 MVA to a common point of connection at 100 kV or above, must be maintained per this standard to meet NERC Standard PRC-005, "Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance," requirements.

2.2 Energy Supply does not utilize Automatic Reclosing and as such, maintenance of Automatic Reclosing components is not addressed in this standard. Furthermore, Energy Supply has no RAS, UVLS or UFLS systems and therefore maintenance of those systems is not addressed.

2.3 The maintenance activities and associated maximum maintenance intervals established within this policy are based on those contained in the current version of NERC Standard PRC-005 and associated documents as they exist at the time of the approval of this standard.

2.4 For NERC Standard PRC-005 related schemes all Relays, Voltage and Current Sensing Devices, Associated Control Circuitry Protection System Component Types, as well as Sudden Pressure Relaying, are maintained per a time-based maintenance program with intervals not to exceed the PRC-005 specified maintenance intervals for unmonitored components.

2.5 For NERC Standard PRC-005 related schemes, Communication Protection System Components maintained per this Energy Supply program are maintained per a time-based maintenance program for continuously monitored Communication Protection Systems with intervals not to exceed the PRC-005 specified maintenance intervals for monitored communication components. All present Communication Protection System Components alarm to an operator for communication system failure.

2.6 For NERC Standard PRC-005 related schemes, Battery and Battery Charger Protection System Components are maintained per EPR 5.704S.

3.0 RESPONSIBILITIES:

3.1 The facility director is responsible for ensuring a Protection System maintenance program is in place for the plant. The facility director should designate an individual to serve as a Site Electrical Maintenance Coordinator whose responsibilities will, in part, include administration of the requirements identified in Section 4.0 below.

3.2 Technical Resources and Compliance is responsible to aid the Site Electrical Maintenance Coordinator in initially establishing the program and for providing technical support.

4.0 REQUIREMENTS:

The following maintenance and testing activities are identified for implementation of the Protection System maintenance program and shall be used by plant management, engineering, operations, and maintenance personnel to assure reliable operation and performance of the Protection Systems:

4.1 Development and Management of the Site Protection System Maintenance Program.

4.1.1 Plant and regional Technical Resources and Compliance personnel should work together to identify all protective relays, voltage and current sensing devices (PTs and CTs/DC shunts), and associated control circuitry used in Protection Systems and Sudden Pressure Relaying on a site and to group these devices into protective schemes for the purposes of scheduling and performing maintenance.

4.1.2 For NERC PRC-005 Related Protection Systems and Sudden Pressure Relaying, Plant personnel and regional Technical Resources & Compliance personnel SHALL develop scheme specific Protection System maintenance procedures. These procedures SHALL

4.1.2.1 Clearly identify all relays, voltage and current sensing devices, associated control circuitry trip paths and Sudden Pressure relaying to be tested in conjunction with the maintenance of that particular NERC PRC-005 Related Protection System.

4.1.2.2 Provide adequate guidance to assure that the maintenance activities specified in paragraph 4.2.2 below are performed and documented for each component type utilized within that particular Protection System scheme.

4.1.2.3 Identify any subsequent work and asset management system Work Orders issued to address and track any Unresolved Maintenance Issues - issues identified but not corrected during the performance of the procedure

4.1.2.4 For any Protection System modifications, Plant personnel and regional Technical Resources & Compliance personnel SHALL review the scheme specific Protection System maintenance procedures and update them as applicable.

4.1.3 The plant is responsible for maintaining documentation of the desired setpoints of all protective relays and to have this information available for technician reference during maintenance. The Technical Resources and Compliance Department can help the plant develop a method of documenting this setpoint information. Technical Resources and Compliance should strive to develop consistent setpoint documentation at all plants in a given region. Consistency in the methods of setpoint documentation will make maintenance much easier for the technicians who travel from site to site throughout the region to perform relay calibration.

4.1.4 Plant personnel shall ensure that plant protective system component maintenance and testing as described in this standard is performed within the intervals established in Table 1, “Maximum Allowed Protection System Maintenance Intervals.”

4.1.4.1 Plant personnel and regional Technical Resources and Compliance personnel shall schedule the maintenance and testing of Protection Systems within the intervals prescribed in Table 1. Under no circumstance shall the period between tests of any particular device exceed the timeframe prescribed in Table 1, except that maintenance and testing of a device may be completed any time within a calendar year (i.e., the interval is based on calendar years and not anniversary dates).

4.1.4.2 The plant overhaul schedule should be taken into consideration when scheduling protection system maintenance and testing.

4.1.4.3 Equipment outages may be required to maintain and test certain devices; therefore, equipment outage schedules should be considered when scheduling protection system maintenance and testing.

4.1.4.4 In scheduling the maintenance and testing activities, priority should be driven by the criticality of the equipment, the cleanliness of the environment, the type of relay involved (electromechanical, solid state, or microprocessor based), and past maintenance history. While prioritization of scheduling may be appropriate, in no event shall the period between maintenance and testing of a specific device exceed the applicable interval set out in Table 1.

4.1.5 Once all of the protective relay schemes have been identified and appropriate maintenance intervals have been identified for each of the individual schemes, the plant should enter this information into the work and asset management system PM program so that protective relay maintenance of all protective relay schemes will be automatically scheduled to be performed on a recurring basis.

4.1.5.1 For NERC PRC-005 Related Protection Systems and Sudden Pressure Relaying, the work and asset management system PM shall call for the performance of the scheme specific procedures developed per Section 4.1.2 above

4.1.6 Periodically, the plant should review as found vs. as left test data recorded during performance of maintenance. Based on the findings of this review, the plant may elect to lengthen or shorten the maintenance interval assigned to a particular scheme. However, for NERC PRC-005 related protection and sudden pressure relaying systems, the interval cannot be extended beyond that specified on Table 1.

4.2 Performance of Protection System Maintenance

4.2.1 Effective Program Start Date. For compliance purposes, the relay maintenance program effective start date is the original effective date of this standard, 3/12/07.

4.2.1.1 For those protection systems for which maintenance activities meeting the requirements of paragraph 4.2.2 were performed prior to 3/12/07, initial maintenance may be scheduled based on the last completion date and the appropriate Table 1 maximum allowed interval.

4.2.1.2 For newly installed or modified Protection Systems, initial maintenance should be scheduled based on the final commission/acceptance test date and the appropriate Table 1 maximum allowed interval.

4.2.2 **Maintenance Activities.** The following maintenance activities should be performed for the various component types making up a Protection System. For PRC-005 related schemes, these maintenance activities must be performed to meet the maintenance activity requirements of PRC-005.

4.2.2.1 Maintenance Activities for Electromechanical Protective Relays

Perform the following as appropriate:

- Perform and record a single point, as found calibration check of the device prior to cleaning or adjusting the relay.
- Clean, inspect, and adjust the relay as necessary.
- Perform an as left calibration check of the device. For time overcurrent relays, this as left check should be at a minimum of three points on the time characteristic curve.
- Verify that the relay output contacts will act to trip the associated circuit breaker or actuate any associated lockout device.
- Verify the relay as left settings are as specified

4.2.2.2 Maintenance Activities for Analog Electronic Protective Relays

Perform the following as appropriate:

- Perform and record a single point as found calibration check of the device. The results of this initial test should be recorded.

- If the results of the as found test or relay self test were acceptable, the technician need not perform any as left testing. If the results of the initial test were unacceptable, the technician should adjust the relay and perform as left testing. If performed, the results of the as left testing should be recorded.
- Verify that the relay output contacts will act to trip the associated circuit breaker or actuate any associated lockout device.
- Verify the as left relay settings are as specified

4.2.2.3 Maintenance Activities for Microprocessor Based Protective Relays

Perform the following as appropriate:

- Verify that the relay output contacts will act to trip the associated circuit breaker or actuate any associated lockout device.
- Verify proper functioning of the input analog/digital converters.
- Verify proper response to relay inputs critical to Protection System performance.
- Verify the as left relay settings are as specified.

4.2.2.4 Maintenance Activities for Current Transformers (CTs) and DC shunts

A CT/Shunt Verification Test should be performed at the interval listed in Table 1. Acceptable methods of CT Verification include:

- CT Feedback (Saturation) Test
- CT/Shunt Load Check Test
- CT/Shunt Comparison Test

4.2.2.5 Maintenance Activities for Potential Transformers (PTs)

A PT Verification Test should be performed at the interval listed in Table 1. Acceptable methods of PT Verification include:

- Turns Ratio Test
- Phase Comparison Test

- PT Comparison Test

4.2.2.6 Maintenance Activities for Associated Control Circuitry

4.2.2.6.1 For NERC PRC-005 related schemes, control circuitry between the protective relay output contacts and the trip coil(s) of the interrupting device(s) actuated by the protection system must be tested. This includes actuation of lockout devices and auxiliary tripping relays and verifying that each trip coil can trip the associated circuit breaker.

4.2.2.6.2 When testing control circuits, it is not necessary to test each individual path completely from the relay all the way to the trip coils of the interrupting device. However, each segment must be functionally tested and overlap of testing will assure functionality of the entire circuit. For example, if several different protective relays can cause a lockout device to actuate and that lockout in turn actuates a circuit breaker trip coil, it is only necessary to prove that each individual relay can actuate the lockout and only once prove that the lockout can actuate the breaker trip coil.

4.2.2.6.3 For NERC PRC-005 related schemes, testing of associated control circuitry SHALL be performed and documented using the scheme specific testing procedures discussed in Sections 4.1.2 and 4.1.5.1 above.

4.2.2.7 Maintenance Activities for Batteries and Battery Chargers Associated with Protection Systems

4.2.2.7.1 Batteries have many critical functions at power plants beyond those served in Protection Systems. Furthermore, maintenance of batteries is vastly different in scope and process than that for other Protection System devices. As such, requirements for the maintenance and testing of battery and charger systems is provided for in a separate stand alone document, EPR 5.704S, “Battery Maintenance Standard”

4.2.2.7.2 Plant personnel SHALL assure that batteries and chargers associated with NERC PRC-005 Related Protection Systems are maintained per EPR 5.704S.

4.2.2.8 Maintenance Activities for Protection System Communication Systems

4.2.2.8.1 Verify that the communications system meets performance criteria pertinent to the communications technology applied (e.g. signal level, reflected power, or data error rate)

For Fiber Optic Systems perform the following:

- Perform equipment alarm function test back to station DCS
- Single end testing utilizes the local relay and looped back communication equipment to verify local scheme functionally.

4.2.2.8.2 The trips via the communications shall be maintained per the DC Control Circuitry maintenance requirements at an interval of 6 years. This includes verification of communication system inputs and outputs that are essential to proper functioning of the protection system.

4.2.2.8.3 In lieu of the above, Protection System Communication Systems, if present, at the interface between power plants and the substation may be maintained per the Substation/Transmission Protection System Maintenance Program for communication systems.

4.2.2.8.4 Synchronized and Non-synchronized end to end protective system testing shall be done in coordination of the authority on the other end of the communication line.

4.2.2.9 Maintenance Activities for Sudden Pressure Relaying

4.2.2.9.1 Sudden Pressure Relaying should be performed at the interval listed in Table 1 and verify:

- The pressure or flow sensing mechanism is operable.
- Electrical operation of associated electromechanical lockout devices.

- Functionality of all associated paths of the trip circuits inclusive of all auxiliary relays through the trip coil(s) of the circuit breakers or other interrupting devices.

4.2.2.9.2 For NERC PRC-005 related schemes, testing of Sudden Pressure Relaying SHALL be performed and documented using the scheme specific testing procedures discussed in Sections 4.1.2 and 4.1.5.1 above.

4.3 Implementation Schedule for Newly Acquired Plants

For Protection Systems acquired through acquisition or merger process there will be a transition period from the previous entity's program to Xcel Energy Supply's program. PRC-005 related protection systems reviews SHALL be completed before commercial operation begins under Xcel Energy's control. The initial performance of all the maintenance activities required by Section 4.2 must be completed no later than the sooner of the end of first scheduled maintenance outage or within two years of assuming ownership of the facility. However, if test records are available from the previous owner's testing program and the requirements of Section 4.2 are met; the first scheduled maintenance may be based on the completion date of those records.

For batteries, see Section 4.5 of EPR 5.704S 'Battery Maintenance Standard (NERC)'

5.0 REQUIRED RECORDS

5.1 Each plant SHALL have a method to identify all protective relay schemes and to document the individual relays, CTs, and PTs making up a particular scheme. Note that scheme specific procedures can be used to fulfill this requirement.

5.2 Each plant SHALL maintain documentation of the desired setpoints of all protective relays and baseline CT, DC shunt and PT verification test data.

5.3 For every protective relay, voltage and current sensing device, calibration or testing history should be maintained in the program maintenance files for the last three test intervals. For NERC PRC-005 Related Protection Systems, calibration and/or test history SHALL be maintained at least for the last 2 completed test intervals

5.4 For NERC PRC-005 Related Protection Systems and Sudden Pressure Relaying, the plant SHALL maintain the last 2 completed scheme specific maintenance procedures in the program maintenance files

6.0 DEFINITIONS & REFERENCES

6.1 Definitions

6.1.1 **As Found Setting** – a check of a relay setpoint that is taken prior to performing any cleaning, adjustment, or maintenance on a relay.

6.1.2 **As Left Setting** – a check of a relay setpoint that is taken after all cleaning, adjustment, and maintenance has been completed on a relay.

6.1.3 **Automatic Reclosing –** Includes the following Components:

- Reclosing relay
- Supervisory relay(s) or function(s) – relay(s) or function(s) that perform voltage and/or sync check functions that enable or disable operation of the reclosing relay
- Voltage sensing devices associated with the supervisory relay(s) or function(s)
- Control circuitry associated with the reclosing relay or supervisory relay(s) or function(s)

Automatic Reclosing is not installed or used in Energy Supply owned facilities.

6.1.4 **Bulk Electric System (BES) Plants –** plants which connect to the transmission system at voltages $\geq$ 100 KV at the point of interconnection and are either individual units sized at >20 MVA or aggregate site size of > 75 MVA. Additionally any units used for black start restoration, regardless of the size or the voltage at which they connect to the system are included in the BES. See NERC BES definition for BES classification of dispersed generating assets such as wind or solar farms.

6.1.5 **Communication Systems** – Communication Systems in Protection Systems are typically defined as relays at remote ends of transmission lines communicating via various mediums in order to transmit data such as current values and trip signals. Communication Systems types such as Carrier and Tone, are not used with Protection Systems maintained by Energy Supply Power Plants. Digital Equipment type Communication Systems are occasionally used. Digital Equipment is typically defined as follows:

6.1.5.1 Digital Equipment types self monitor channel integrity and will alarm back to the control center through DCS equipment notifying of channel issues or problems.

6.1.5.2 Communication Processors that act as a RTU (remote terminal unit) to communicate relay status are not applicable to this standard as long as no digital bits are passed between relays for protection functions.

6.1.6 **Current Transformer (CT)** – an instrument transformer that has its primary winding in series with the current to be measured and which produces a small signal current in its secondary winding that is proportional to the current in its primary winding. This secondary current is used to provide inputs to protective relaying and/or metering that requires a current signal to operate.

6.1.7 **CT/DC shunt Verification Test** – any type of test or observation that provides some level of assurance that a CT or DC shunt is functioning properly. The verification test should include the CT secondary wiring or shunt MV signal wiring between the relay panel and the location of the CT or DC shunt. Some possible methods of verifying proper CT/DC Shunt function include:

6.1.7.1 Performance of a CT Feedback test (Saturation Test) – an offline test in which a voltage is impressed on a CT and current is measured and compared to previous test data. This test can detect developing problems with the CT or with the wiring that interconnects the CT to the meter or relay that it feeds. The CT is considered acceptable if the excitation current is within +/- 50% of the baseline value for a given input voltage.

6.1.7.2 Performance of CT/DC shunt load checks – observation of secondary currents on in service CTs or millivolt signals from DC shunts to verify currents are as expected for a given load. A three-phase set of CT’s is considered acceptable if the current from each CT is within +/- 5% of the average of the set of CT’s. A DC shunt is considered acceptable if within 5% of the anticipated value for the given operating point for the DC circuit being monitored.

6.1.7.3 CT/Shunt Comparison Test – For CTs, a comparison of the outputs of 2 separate CTs monitoring the same current. This may be accomplished by observing current, Volt-ampere, watt, or VAR indications fed from two separate sets of CTs. The CT is considered acceptable if the current from the CT is within +/- 5% of the CT to which it is being compared. For DC shunts, comparison of the output of a DC shunt to current measured by use of a DC clamp on ammeter and is acceptable if within 5%

6.1.8 **Electromechanical Relay** – any relay that relies on interaction of electromagnetic forces and moving parts such as springs, disks, or pneumatic diaphragms to establish the relay setpoint. Electromechanical relays often have tight mechanical clearances and rely on low friction jewel bearings to allow movement of the relay disk. As such, these relays are quite sensitive to the presence of coal dust and other environmental factors. Relays located in dusty or dirty areas will require more frequent maintenance than similar relays located in cleaner environments. Electromechanical relays also make use of magnets whose magnetic properties degrade over time resulting in setpoint drift that necessitates periodic re-calibration of the relay. For the above reasons, electromechanical relays require more frequent maintenance than do electronic or microprocessor based relays.

6.1.9 **(Analog) Electronic Relay** – a relay whose setpoint is controlled by analog electronics such that there are no moving parts involved in establishing the setpoint. These relays are much less affected by dust and dirt and exhibit significantly less setpoint drift than do electromechanical relays. Electronic or solid state relays require less frequent and less extensive maintenance then do electromechanical relays.

6.1.10 **Generator Interconnection Facility -** a sole-use facility that interconnects the generator to the grid. Typically this would be a >100 KV line, owned by the Generator Owner, from the high voltage side of the GSU transformer to the point of interconnection to the Transmission System.

6.1.11 **Microprocessor Based Relay** - a relay that uses digital electronics and has a programmable microprocessor to control trip and alarm features. These devices are equipped with alarming self check features that are constantly monitoring relay performance and condition. As such, microprocessor relays are highly reliable and require much less frequent and extensive maintenance than either electromechanical or analog electronic relays.

6.1.12 **NERC PRC-005 Related Protection Systems–** protection system relays, communication systems, associated trip circuits and instrument transformers which protect and act to trip generator, generator step up transformer, generator interconnection facilities, main or unit connected auxiliary transformers, reserve or startup auxiliary transformers at BES plants, or Protection Systems for facilities used in aggregating dispersed BES generation from the point where those resources aggregate to greater than 75 MVA to a common point of connection at 100 kV or above.

6.1.13 **Potential Transformer (PT)** – an instrument transformer that is intended to have its primary winding connected in parallel with a power circuit such that the small voltage signal induced in the secondary is proportional to the voltage on the power circuit and primary winding of the transformer. The secondary winding voltage signal is then used in metering and relays.

6.1.14 **Protection System -** NERC's official definition of a Protection System is:

- Protective relays which respond to electrical quantities,
- Communications systems necessary for correct operation of protective functions
- Voltage and current sensing devices providing inputs to protective relays,
- Station dc supply associated with protective functions (including batteries, battery chargers, and non-battery-based dc supply), and
- Control circuitry associated with protective functions through the trip coil(s) of the circuit breakers or other interrupting devices

6.1.15 **PT Verification Test -** any type of test or observation that provides some level of assurance that a PT is functioning properly. The verification test should include the PT secondary wiring between the relay panel and the location of the PT. Some possible methods of verifying proper PT function include:

6.1.15.1 Turns Ratio Test. A turns ratio test is performed by injecting a voltage into one of the windings and the resultant output is measured on the other winding. The test is acceptable if resultant voltage is within +/- 2% of expected values.

6.1.15.2 Phase Comparison Test. A test where each of the phase outputs of a set of PT's is compared to the average of the set. A three-phase set of PT's is considered acceptable if the voltage from each PT is within +/- 5% of the average of the set of PT's.

6.1.15.3 Comparison Test – comparison of the outputs of 2 separate PTs monitoring the same current. This may be accomplished by observing current, Volt-ampere, watt, or VAR indications fed from two separate sets of PTs. The PT is considered acceptable if the voltage from the PT is within +/- 5% of the PT to which it is being compared.

6.1.16 **Scheme** – a grouping of protective relays applied together to protect a device such as a generator, transformer, bus, or load. Typically, all relays in a relaying scheme will require many of the same isolation points and equipment outages in order to perform maintenance or calibration of the relay. As such, maintenance of protective relaying is planned and scheduled on the basis of protective schemes rather than by individual relays.

6.1.17 **Sudden Pressure Relaying** – A system that trips an interrupting device(s) to isolate the equipment it is monitoring and includes the following components:

- Fault pressure relay – a mechanical relay or device that detects rapid changes in gas pressure, oil pressure, or oil flow that are indicative of faults within liquid filled, wire-wound equipment

- Control circuitry associated with a fault pressure relay

6.2 References

6.2.1 PRC-005-6, "Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance"

6.2.2 NERC PRC-005 Supplementary Reference and FAQ

7.0 REVISION HISTORY

Date	Revision	Change
8/1/05	0	Original Issue
3/12/07	0	Revised into a standard
3/20/07	1	Revised Table A Plant identifiers to Coal/RDF and Gas/CT/Hydro
5/21/08	1.1	Corrected policy number in heading on Appendix A and reference to Appendix A in ¶4.4
11/17/08	2.0	Reformatted numbering of section 4.2 and provided for alternative methods of current and potential transformer verification. Added paragraph 4.2.1 to clarify program start date

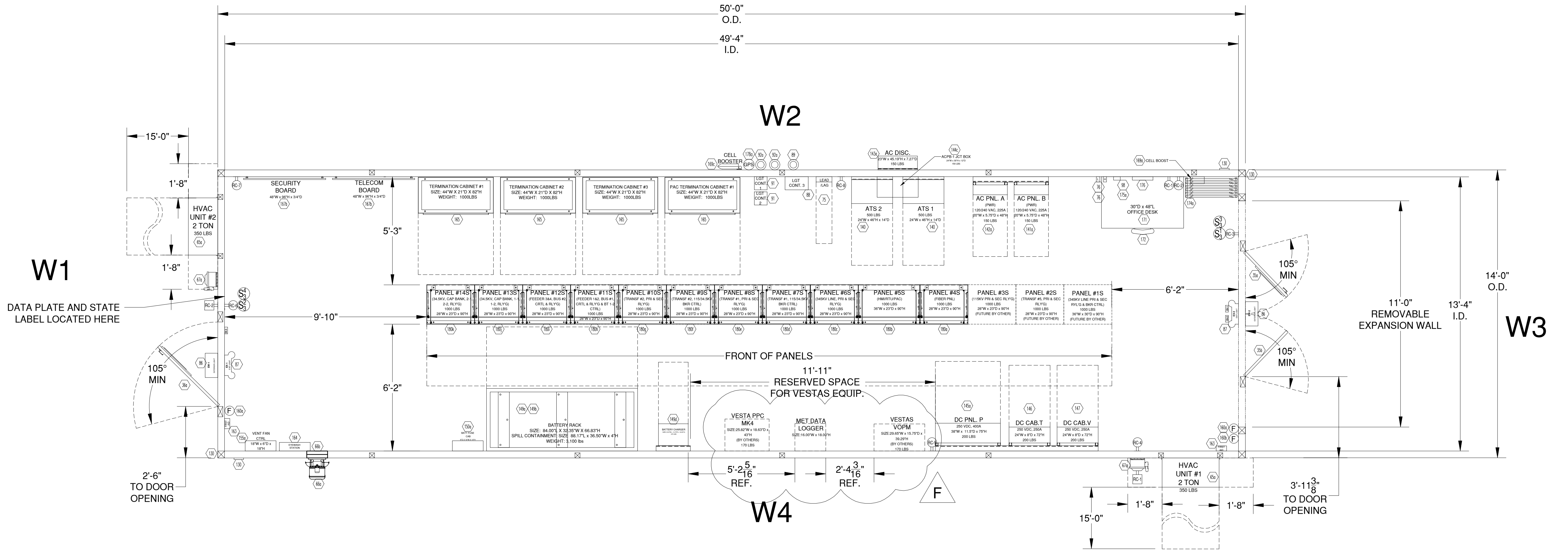
Date	Revision	Change
6/1/09	2.1	Added definition of microprocessor based relay and delineated requirements for microprocessor vs. analog electronic relays in paragraphs 4.2.3 and 4.2.4 and Table A. Added further clarification of the bases of Table A intervals in paragraph 4.1.3
7/21/10	2.2	Added sentence to paragraph 4.2.1 to clarify intent of requirements for scheduling of initial maintenance necessary to fulfill program initiation requirements
11/21/2012	3.0	Major Rewrite to meet requirements of pending NERC standard PRC-005-2. Significant changes include: -change in title to clarify scope of standard is for Protection Systems rather than just protective relays. -moved program bases description up to Section 2.0. Establish draft PRC-005-2 materials as the basis for the program. -changed departmental references from “Maintenance Resources” to “Technical Resources & Compliance” to reflect organizational changes. -added paragraphs 4.1.2, 4.1.5.1, and 5.3 to discuss new requirements for scheme specific testing procedures for NERC PRC-005 Related Protection Systems -added paragraph 4.2.2.6 and modified Table A to Table 1 and provided greater clarity for requirements for testing of associated control circuits. -added paragraph 4.2.2.7 to recognize and emphasize that batteries and battery chargers are part of a protection system but are maintained per requirements delineated in EPR 5.704S, Battery Maintenance Standard. -added paragraph 4.2.2.8 to recognize that Communication Systems are part of protection systems but to document that they are not utilized within Protection Systems maintained by Energy Supply
03/26/2013	3.1	– Removed Supersedes EPR 5.714G from title block – Removed references to PRC-005-2 and made all references to PRC-005 throughout document – Added UAT/RAT and SU transformers back in section 2.0 – Updated section 2.0 applicability for a communication device maintenance program, defining types and monitoring statuses. – 4.1.2.4 added for updating procedures for changes in relaying – 4.1.5.1 added ‘of’ for clarification in the statement ‘for the

Date	Revision	Change
		performance of' – 4.2.2 the statement 'requirements required by' was changed to 'requirements of PRC-005' – Completely rewrote 4.2.2.8 and added subsections for fiber optic communication systems in all regions – Updates to section 4.3 for acquired plants – Added 6.1.14 definition of a communication system – Updated Section 6.2 references – Updated Table 1 to include communication systems
05/07/2013	3.2	– Added wording in section 2.0 that was inadvertently deleted in previous revision.
11/04/2013	3.3	– Added wording to address generator interconnection facilities in the following sections: Section 2.0, new definition 6.1.8, modified definition 6.1.10, and Table 1
08/03/2015	3.4	– Revised section 2.0 to more accurately describe in scope protection systems at dispersed BES generation facilities per PRC-005-2(i) applicability – Deleted section 4.4 which referenced a non-existent specification for performance of relay testing by vendor personnel
02/09/2016	4.0	– Major re-write to address requirements of NERC standard PRC-005-6, including adding Automatic Reclosing and Sudden Pressure Relaying.
11/07/2016	4.1	– Minor re-write to include: ▪ use of the generic term "voltage and current sensing device" instead of "instrument transformer" or "CTs/PTs" and to include DC shunt testing for new AVR systems which have Protection System trips derived from DC shunt signals for generator field current. ▪ Re-organization of Table A to clarify applicability for dispersed generation assets. ▪ Deletion of references to Maximo and addition of generic term "work and asset management system". ▪ Clarified in applicability that ES does not have RAS, UFLS or UVLS systems.

Table 1 – Maximum Allowed Protection System Maintenance Intervals

Relay Application	Environment	Device Type	Maximum Allowed Maintenance Interval*
Generator, Generator Interconnection Facility, and Dispersed Gen Aggregating Facility Protective Relays	All	Electromechanical or Electronic (Analog)	6 years
	All	Microprocessor based	6 years
GSU, MSA RSA/Startup Transformer Relays	All	Electromechanical or Electronic (Analog)	6 years
	All	Microprocessor based	6 years
MV & LV Switchgear Protection Relays	All	Electromechanical or Electronic (Analog)	6 years
	All	Microprocessor based	12 years
Voltage and Current Sensing Devices	All	Current	12 years
	All	Potential	12 years
Communication Systems	All	Communications	12 years
Associated Control Circuits	All	Trip Paths	6 years
Sudden Pressure Relaying	All	Pressure and Flow Sensor, Associated Lockout Devices and Control Circuits	6 years

*Maximum allowed interval is based on calendar years.



GENERAL NOTES:

1. ALL CONDUIT FITTINGS TO BE SET SCREW TYPE.

SYMBOLS & LEGEND: ("#" DENOTES ORDER OF CIRCUIT)

$S_3^{\#}$	THREE-WAY SWITCH: 20A, 120 VOLT
F	FIRE EXTINGUISHER
RC-#	120 VOLT INTERIOR DUPLEX RECEPTACLE
RC-#	GFCI 120 VOLT EXTERIOR DUPLEX RECEPTACLE
EWL-#	EXTERIOR WALL PACK LIGHT
DI-#	DOOR ALARM CONTACT
EX-LT#	EMERGENCY LIGHT EXIT SIGN
	IN FRONT OF EQUIPMENT DENOTES 36" WALKWAY CLEARANCE
	DENOTES MIN. REQUIRED 20" CLEARANCE FOR HVAC

N

SCALE IN ft.

0 1 2 3 4

W2

W1 W3

W4

ELEVATION KEY

BLAZING STAR 1 WIND FARM
NSP DWG# NX-240579-4-1

This map/document is a tool to assist employees in the performance of their jobs. Your personal safety is provided for by using safety practices, procedures, and equipment as described in safety training programs and manuals.

ANCHOR CHART

DETAIL	MOUNTING LOCATION	ANCHOR SIZE	ANCHOR METHOD	QTY (MIN)
ATS	WALL MOUNT	3/8-16 x 1.50" LONG, ASTM A307, BOLT	MOUNT TO W200 STRUT ON WALL, WITH 12-24 SCREWS @ 6" O.C.	4
PANEL BOARDS	WALL MOUNT	3/8-16 x 1.50" LONG, ASTM A307, BOLT	MOUNT TO W150 & W200 STRUT ON WALL, WITH 12-24 SCREWS @ 6" O.C.	4
TERMINATION CABINETS	FLOOR MOUNT	1/2-13 x 1.50" LONG, ASTM A325, BOLT	DRILL AND TAP INTO BUILDING FLOOR PLATE	4
COMM & SECURITY BOARDS	WALL MOUNT	3/8-16 x 1.50" LONG, ASTM A307, BOLT	MOUNT TO W200 STRUT ON WALL, WITH 12-24 SCREWS @ 6" O.C.	4
JUNCTION BOXES	WALL MOUNT	#12-24 x 1.50" LONG, SELF TAPPING SCREW	MOUNT DIRECTLY TO WALL	4
BATTERY RACK	FLOOR MOUNT	1/2-13 x 1.50" LONG, ASTM A325, BOLT	DRILL AND TAP INTO BUILDING FLOOR PLATE	4
BATTERY CHARGER	WALL MOUNT	3/8-16 x 1.50" LONG, ASTM A307, BOLT	MOUNT TO W150 & W200 STRUT ON WALL, WITH 12-24 SCREWS @ 6" O.C.	4
RELAY PANELS	FLOOR MOUNT	1/2-13 x 1.50" LONG, ASTM A325, BOLT	DRILL AND TAP INTO BUILDING FLOOR PLATE	4

Mortenson

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FAX: (763) 287-5163

I certify that revisions F and G of this plan, specification or report was prepared by me or directly under my supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Signature: Kevin Lennon
Typed or Printed Name: Kevin Lennon
Date: July 14, 2020
License Number: 24655

RESERVED FOR ENGINEER SEAL

ENGINEER OF RECORD:
PLUMP ENGINEERING, INC.
RICHARD PLUMP, P.E.
(714) 385-1835 FIRM #: 15214

CROWN TECHNICAL SYSTEMS
13470 PHILADELPHIA AVE
FONTANA, CA 92337
PH:(951)332-4170

NO.	DESCRIPTION	DATE	INITIAL
G	MET TOWER DATA LOGGER - ISSUED FOR CONSTRUCTION	07/13/20	MHF
F	MET TOWER DATA LOGGER - FOR REVIEW	07/01/20	MHF
E	AS-BUILT	08/14/19	RA
D	ADDED TEMP ALARMS AND SPLIT LIGTING CIRCUIT, ADDED CELL BOOST, REVISED BATT FUSE J-BOX SIZE	07/22/19	RA
C	REMOVED LIGHT SWITCH #3 & #4	06/06/19	RA
B	UPDATED BATTERY RACK, MOVED RELAY PANELS	05/01/19	RA
A	RFC, UPDATED EQUIPMENT DESCRIPTION	12/3/18	GL
1	UPD RELAY PANEL LABEL, UPDATED AC PNL VOLTAGE RATING, ADDED LIGHTING CONTACTORS, UPD EQUIPMENT SIZES	7/30/18	GL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES:
.XXX ±.125 .XX ±.25 ANGLES ±1.0°

SCALE:
DRAWN BY: G LEAL
CHECKED BY: C BOYER
ENGINEER: G LEAL
APPROVED BY: C BOYER
DATE: 7/30/18
SHEET NUMBER:

PROJECT NAME: BLAZING STAR 1 SUBSTATION

DRAWING DESCRIPTION: PLAN VIEW

REVISION: G

DRAWING NUMBER: 218084-B01-P1

NO	REVISION	ZONE	DATE	BY	CHK	ENG	NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD							
1A	MPT UPDATES - FOR REVIEW		09-06-19	LML	PS	KJD							
2	MPT UPDATES - FOR CONSTRUCTION		09-27-19	LML	PS	KJD							
3	ISSUED FOR RECORD - BLAZING STAR 1 - 22571		02/14/2020	LML	KJD	JJW							

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

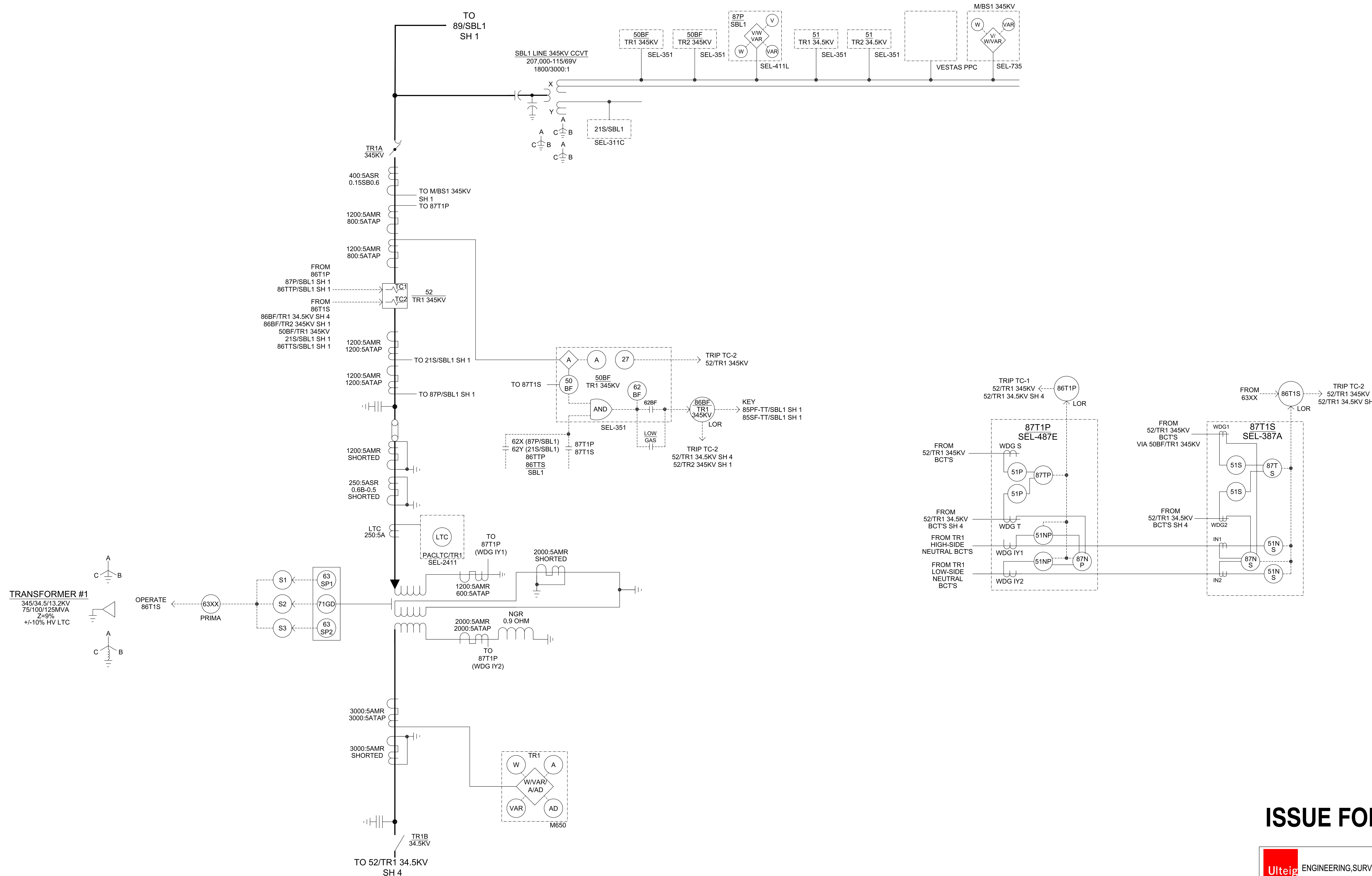
Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES, AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS AND MANUALS.

ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
345-34.5KV
METERING AND RELAYING DIAGRAM
NH-275116-1
REV 3



ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1A	MPT UPDATES - FOR REVIEW		09-06-19	LML	PS	KJD
2	MPT UPDATES - FOR CONSTRUCTION		09-27-19	LML	PS	KJD
3	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®

NORTHERN STATES POWER COMPANY

BLAZING STAR 1 COLLECTOR SUBSTATION

LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

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ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0

345-34.5KV

METERING AND RELAYING DIAGRAM

NH-275116-2

REV 3

NOTES

1. XFMR T1 ATS AND XFMR T2 ATS ARE PRE-INSTALLED ON TRANSFORMER BY VENDOR.
2. 52b CONTACT FROM 52/VAR1 TRIPS CAPSWITCHERS 52/CAP1-1 AND 52/CAP1-2. 52b CONTACT FROM 52/VAR2 TRIPS CAPSWITCHERS 52/CAP2-1 AND 52/CAP2-2.

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1A	90% SUBMITTAL-EDITS FOR STEP UP YARD		07-31-19	LML	PS	KJD
2	FOR CONSTRUCTION - MPT AND STEP UP YARD		09-25-19	LML	PS	KJD
3	ISSUE FOR RECORD - BLAZING STAR 1 - 22571(2019 WORK ONLY)		02-14-2020	LML	KJD	JJW

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

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ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
34.5KV
METERING AND RELAYING DIAGRAM
NH-275116-3
REV 3

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	FOR CONSTRUCTION - MPT AND STEP UP YARD		09-25-19	LML	PS	KJD
2	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

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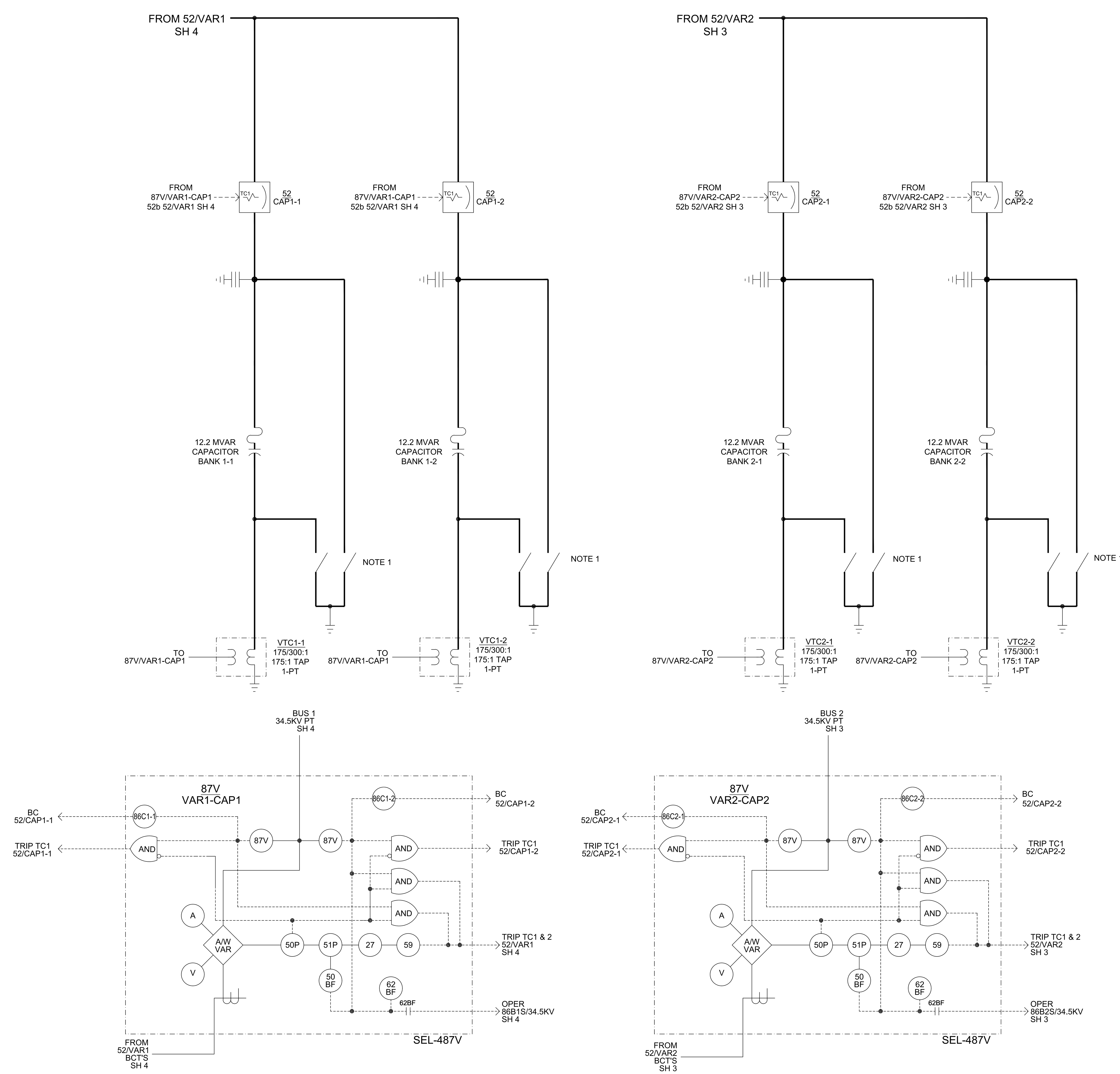
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
34.5KV
METERING AND RELAYING DIAGRAM

NH-275116-4 REV 2



NOTES

1. KIRK KEY INTERLOCK SYSTEM IMPLEMENTED. EACH CAPACITOR BANK GROUNDING SWITCH SHALL ONLY BE CLOSED WHEN ITS RESPECTIVE UPSTREAM CAPSWITCHER IS OPEN

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

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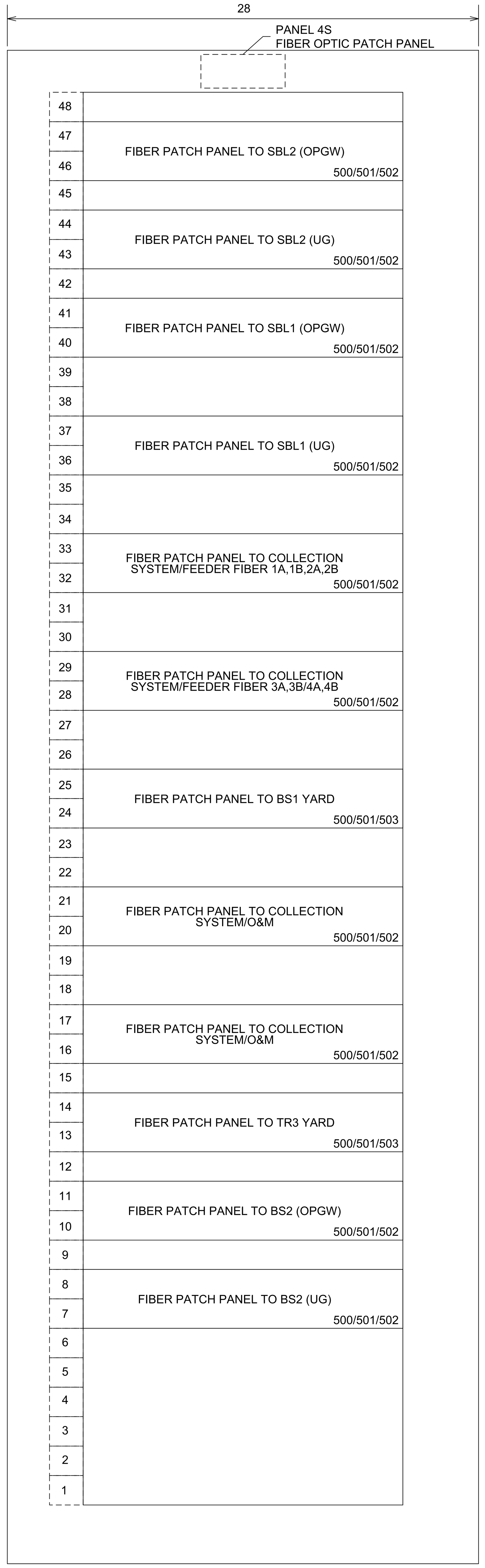
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
34.5KV
METERING AND RELAYING

NH-275116-5 REV 1



FRONT VIEW

ITEM	DEV	QUAN	DESCRIPTION	ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL COUNT DETAIL 3300.1-1)				
500	PATCH PANEL	12	72/288-F RACK-MT ENCLOSURE 19" 2U EMPTY, ADD 4 CCH PANELS OR MODULES, CCH-02U				
501	PATCH PANEL	12	FLUSH MOUNTING BRACKET FOR CCH-02U				
502	PATCH PANEL	40	CCH PIGTAIL SPLICE CASSETTE, 12F, LC UPC, DUPLEX, SINGLE-MODE, CCH-CS12-A9-P00RE				
503	PATCH PANEL	8	CCH PIGTAIL SPLICE CASSETTE, 12F, ST UPC, MULTI-MODE, CCH-CS12-G5-P00BE				

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

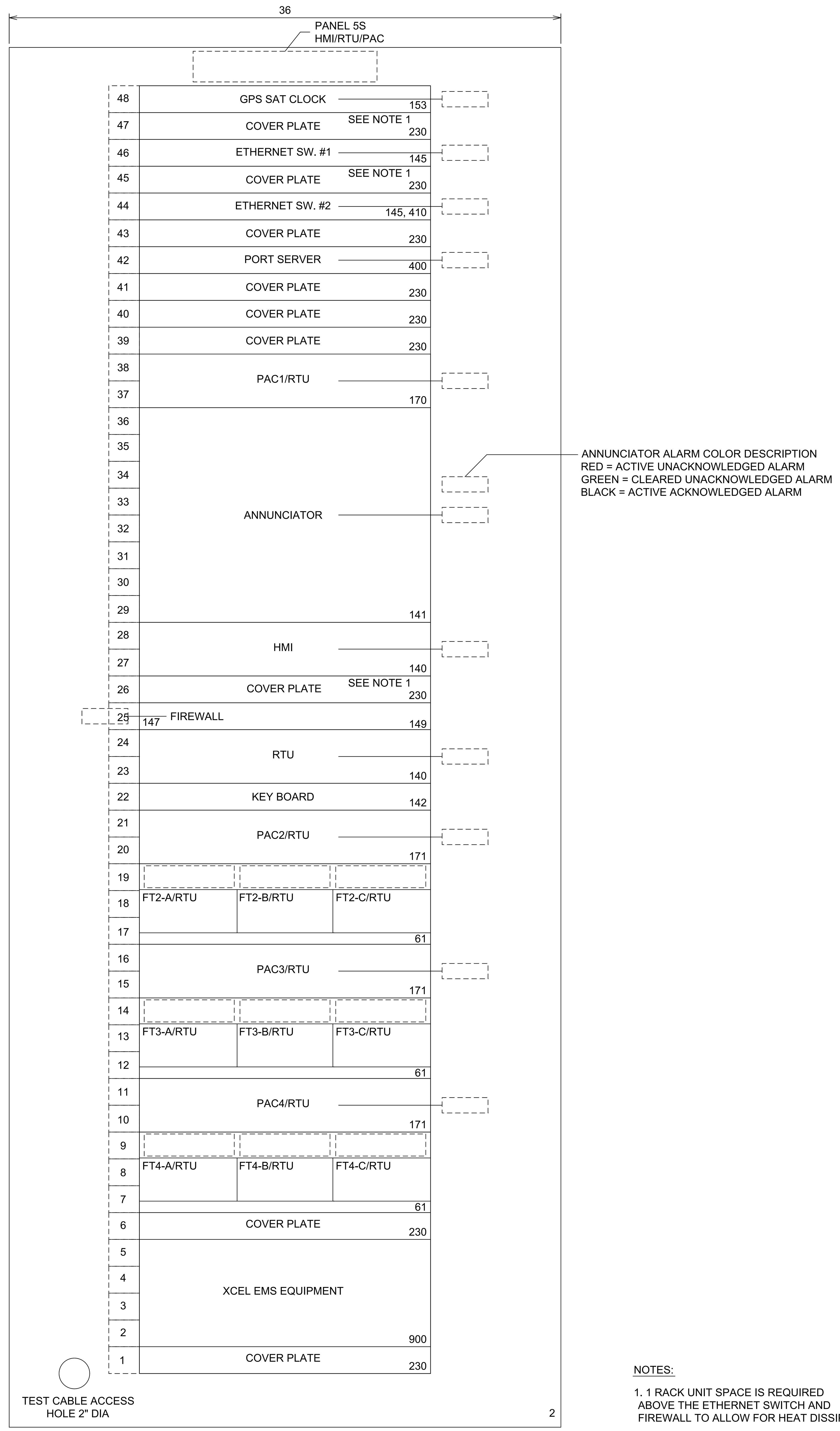
DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
345KV/34.5KV
PANEL 4S
FIBER OPTIC PATCH PANEL
PANEL ELEVATION

NH-275117-4

REV 1



FRONT VIEW

ITEM	DEV	QUAN	DESCRIPTION
2	PANEL	1	90"H X 36"W (PANEL CONST DETAIL 3300.1-1-1)
61	FT-19R	3	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493493493AX08
140	RTU HMI	1 1	ORIONLX AUTOMATION PLATFORM, NOVATECH MODEL#ORIONLX-E3-ENEN-CPX-MMB-XM4-IHV-HVXX-01-03-04-07-42-44-47-52-57-70-35-83-95-101 STANDARD HARDWARE AND SOFTWARE COMPONENTS: ONE FIXED DIAGNOSTICS/MAINTENANCE RS-232 PORT (STANDARD) ONE CONFIGURABLE RS-232 PORT (STANDARD) THREE USB MEMORY PORTS DUAL COPPER ETHERNET PORTS (ENEN) SINGLE 48-125VDC/120VAC POWER SUPPLY (HVXX) IRIG-B PORT ETHERNET CLIENT PROTOCOL NTP ETHERNET SERVER PROTOCOLS TELNET, SSH, FTP, SFTP, HTTP, HTTPS, NTP COMPLETE CYBER SECURITY PACKAGE HARDWARE INCLUDED: THREE CONFIGURABLE RS-232 EXPANSION SERIAL PORTS (E3) HIGH PERFORMANCE CPU (CPX) (INCLUDES XM4) MULTIMEDIA BOARD (MMB) EXPANDED FLASH MEMORY (XM4) (INCLUDED WITH CPX) 48VDC/125VDC DISCRETE INPUT VOLTAGE (IVH) MASTER (IED) PROTOCOLS INCLUDED: DNP3.0 SERIAL (01) DNP3.0 IP (TCP & UDP) (03) MODBUS ASCII/RTU SERIAL (04) MODBUS TCP/IP (07) SLAVE (SCADA) PROTOCOLS INCLUDED: DNP3.0 SERIAL SLAVE (42) DNP3.0 IP SLAVE (TCP & UDP) (44) MODBUS ASCII/RTU SERIAL (47) PUSHER (52) WEBSERVER XML (57) SPS (70) SOFTWARE OPTIONS: LOGIC PAK (35) ORION MATH AND LOGIC (83) ALARM/ARCHIVE/RETENTIVE (95) IEC6-1131 LOGIC (101)
141	ANN SCREEN	1	19" TOUCHSCREEN MONITOR WITH 19" RACK-MOUNT BRACKET, TRANSDUCTION INC., CAT# TR-LCD1900-RM-TOUCH-125VDC, 125VAC/VDC
142	KEYBOARD	1	RACK-MOUNT USB KEYBOARD/DRAWER WITH TOUCHPAD, ADESSO, PN# ACK-730UB-MRP
145	ENET SW	2	ETHERNET SWITCH/ROUTER, RUGGEDCOM RUGGEDBACKBONE RX1501, CAT# RX1501-L2-RM-HI-L3SECL2HW-6TX01-6TX01-6TX01-6TX01-6TX01-XX, LAYER 2 SWITCH, 19" RACK MOUNT, SOFTWARE: LAYER 3 SECURITY EDITION (WITH L2 HW), 88-300VDC OR 85-264VAC POWER SUPPLY WITH SCREW TERMINAL BLOCK, 6 X 10/100Tx RJ45 ETHERNET PORTS (LINE MODULES 1, 2, 3, 4, 5 & 6)
147	FIREWALL	1	SECURITY APPLIANCE: FIREWALL, IPS, APPLICATION CONTROL AND ANTIVIRUS, CHECK POINT SOFTWARE TYPE CIP-1200R, WITH MULTI-PROTOCOL SUPPORT, 4 X 10/100/1000BASE-T RJ45 LAN PORTS, 1 X 10/100/1000BASE-T RJ45 OR 1 X 1000BASE-F WAN PORT, 1 X 10/100/1000BASE-T RJ45 OR 1 X 1000BASE-F DMZ PORT, -40C TO +75C, 100-240VAC/12-72VDC POWER SUPPLY WITH SCREW TERMINALS, WITH STANDARD DIN RAIL MOUNT PROVISIONS (CAT #CPAP-SG1200R-NGTP), WITH ADDITIONAL 2-YEAR BLADE/LICENSE PACKAGE (CAT #CPSB-NGTP-1200R-2Y), WITH 3-YEAR 24X7 SUPPORT (CAT #CPES-SS-PREMIUM-3Y)
149	SHELF	1	CUSTOM RACK SHELF FOR FIREWALL SEE DETAIL 3300.1-1-6

ITEM	DEV	QUAN	DESCRIPTION
153	GPS CLOCK	1	GPS SATELLITE-CONTROLLED CLOCK, SCHWEITZER ENGINEERING LABORATORIES INC. MODEL# SEL-2407, CAT# 24070003B, POWER SUPPLY INPUT RANGE: 18-300 VDC AND 85-264 VAC (50-60 HZ), CLOCK WITH 19 INCH RACK MOUNT BRACKET,
★ 154	ANT	1	SCHWEITZER ENGINEERING LAB. CAT #9524A, GPS ANTENNA
★ 155	CABLE	1	SCHWEITZER ENGINEERING LAB. CAT #C961-075, 75FT GPS ANTENNA CABLE
170	PAC	1	SCHWEITZER ENGINEERING LAB. TYPE SEL-2440, CAT #24402H12A1A11630.
171	PAC	3	SCHWEITZER ENGINEERING LAB. TYPE SEL-2440, CAT #24402H11A6X11630.
230	COVER PLATE	9	COVER PLATE 19"W X 1 3/4"H
★ 250	FB	26	FUSE BLOCK, 1 POLE, 250V, 30A, BUSSMAN, #BMM603-1SQ
★ 252	FUSE	16	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 5 AMP, CAT# KLM-5
★ 253	FUSE	10	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10
★ 255	TB	32	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
★ 285	DC-DC	1	DC-DC CONVERTER PHOENIX CONTACT, 90-350VDC INPUT, 24VDC OUTPUT, 5A, TYPE QUINT-PS-100-240AC/24DC/S CAT #2938581
★ 300	XCVR	2	SEL 2812 MR FIBER OPTIC TRANSCEIVER MULTIMODE CAT #2812MRX0.
400	PORT SERVER	1	SCHWEITZER ENGINEERING LAB. TYPE SEL-3610, CAT #3610XHA0XXX0
410	SFP	1	RUGGEDCOM 4 MULTIMODE 1300NM LC FIBER OPTIC PORTS TO BE INSTALLED IN ETHERNET SWITCH 2, CAT # 6GK6015-0AL20-0BC0
900	EMS	1	XCEL EMS EQUIPMENT

NOTES:

1. 1 RACK UNIT SPACE IS REQUIRED ABOVE THE ETHERNET SWITCH AND FIREWALL TO ALLOW FOR HEAT DISSIPATION.

SYMBOLS

* REAR MOUNTED EQUIPMENT.

NAMEPLATES PRODUCED AND MOUNTED PER PANEL NAMEPLATE DETAIL 3300.1-1-11

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®

NORTHERN STATES POWER COMPANY

BLAZING STAR 1 COLLECTOR SUBSTATION

LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
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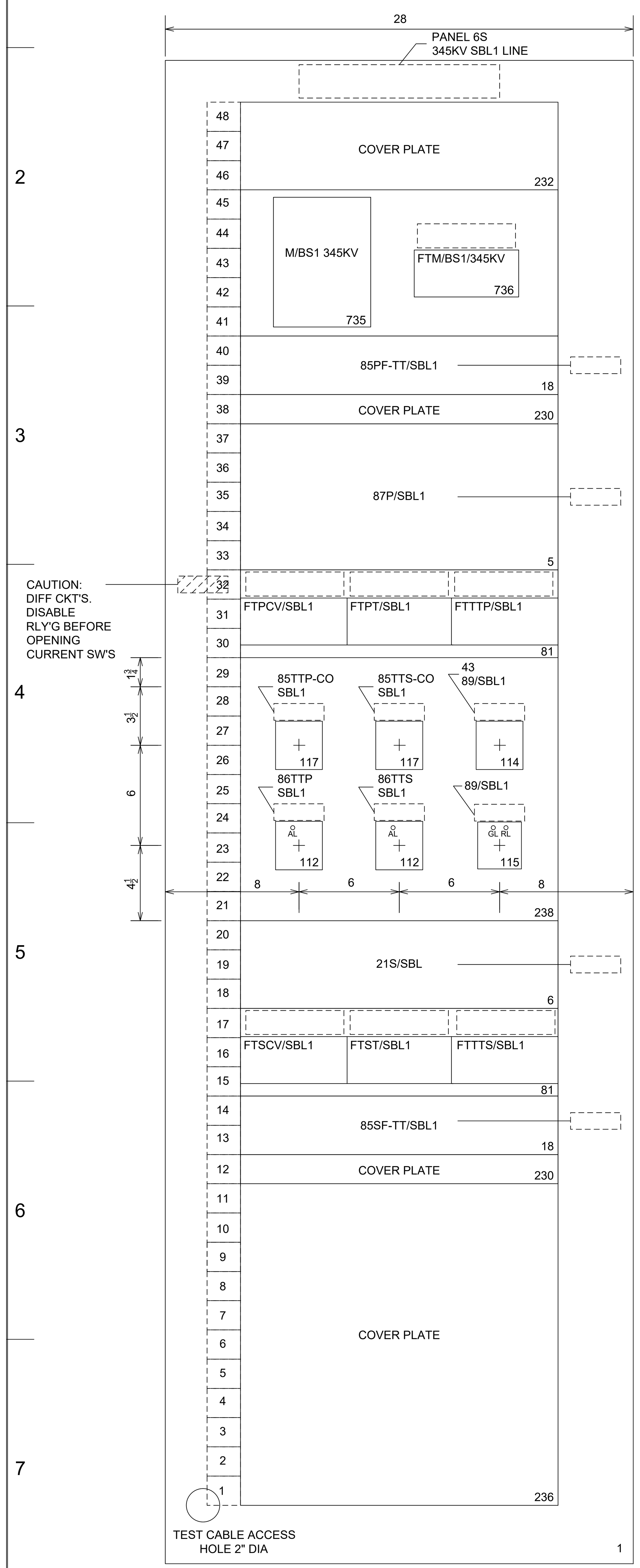
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0

345KV
PANEL 5S
HMI/RTU/PAC
PANEL ELEVATION

NH-275117-5

REV 1



FRONT VIEW

ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)
5	87P	1	SCHWEITZER ENG. LAB. TYPE SEL-411L; CAT. #0411L1X4X5B8ECXH57424XX
6	21S	1	SCHWEITZER ENG. LAB. TYPE SEL-311C; CAT# 0311C31HP3J5421
18	85F	2	SCHWEITZER ENG LAB TYPE SEL-2506; CAT #250603514X
81	FT-19R	2	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 10" EXTENDED DEPTH. STYLE #FRXG137493493AX10
112	86TT	2	LOCKOUT RELAY, ELECTROSWITCH, SERIES 24 LOR-ER, CAT# 78PA35LE, ELECTRIC RESET, HIGH SPEED TRIP, MANUAL TARGET RESET, 125VDC "D" COIL TRIP, 125VDC RESET, 5 DECK 10 N.O. & 10 N.C. CONTACTS, TITLE "TRANSFER TRIP", ENGRAVING CODE: 00N-0L13, OVAL-SHANK HANDLE LIGHTED NAMEPLATE LED: AMBER(LEFT)
114	43	1	AUTO-MANUAL TRANSFER SWITCH, ELECTROSWITCH SERIES 24, CAT# 24902D DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, "AUTO" AT 12:00, "MAN" AT 1:30, TITLE "AUTO-MANUAL", ENGRAVING CODE: 010D-2A21K, PISTOL GRIP HANDLE
115	1	1	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PB202QS, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPERATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: RED(RIGHT) GREEN(LEFT)
117	85TT-CO	2	OFF-ON SWITCH, ELECTROSWITCH SERIES 24 LSR, CAT# 9202DD DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, 125VDC LOW LEVEL CONTROL, PANEL MOUNT, "NORMAL" AT 12:00, "OFF" AT 1:30, TITLE "TT CUT-OFF", ENGRAVING CODE: 010D-2T18CX, PISTOL GRIP HANDLE
230	COVER PLATE	2	COVER PLATE 19"W X 1 3/4"H
232	COVER PLATE	1	COVER PLATE 19"W X 5 1/4"H
236	COVER PLATE	1	COVER PLATE 19"W X 19 1/4"H
238	COVER PLATE	1	COVER PLATE 19"W X 15 3/4"H
* 251	FB	12	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ
* 253	FUSE	9	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10
* 255	TB	14	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
* 256	TB	7	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504 SC
* 313	XCVR	1	SCHWEITZER ENG LAB TYPE SEL-2831; CAT #2831M

ITEM	DEV	QUAN	DESCRIPTION
735	M	1	SCHWEITZER ENG LAB. TYPE SEL-735; CAT 0735VX00944CXXXXXX16101XX
736	FT	1	SWITCH BOX, ABB CORP., FT-1, SCREW TERMINALS, 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, BLACK COVER, STYLE #714B325G32

SYMBOLS

* REAR MOUNTED EQUIPMENT.

NAMEPLATES PRODUCED AND MOUNTED PER PANEL NAMEPLATE DETAIL 3300.1-1-11

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®

NORTHERN STATES POWER COMPANY

BLAZING STAR 1 COLLECTOR SUBSTATION

LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
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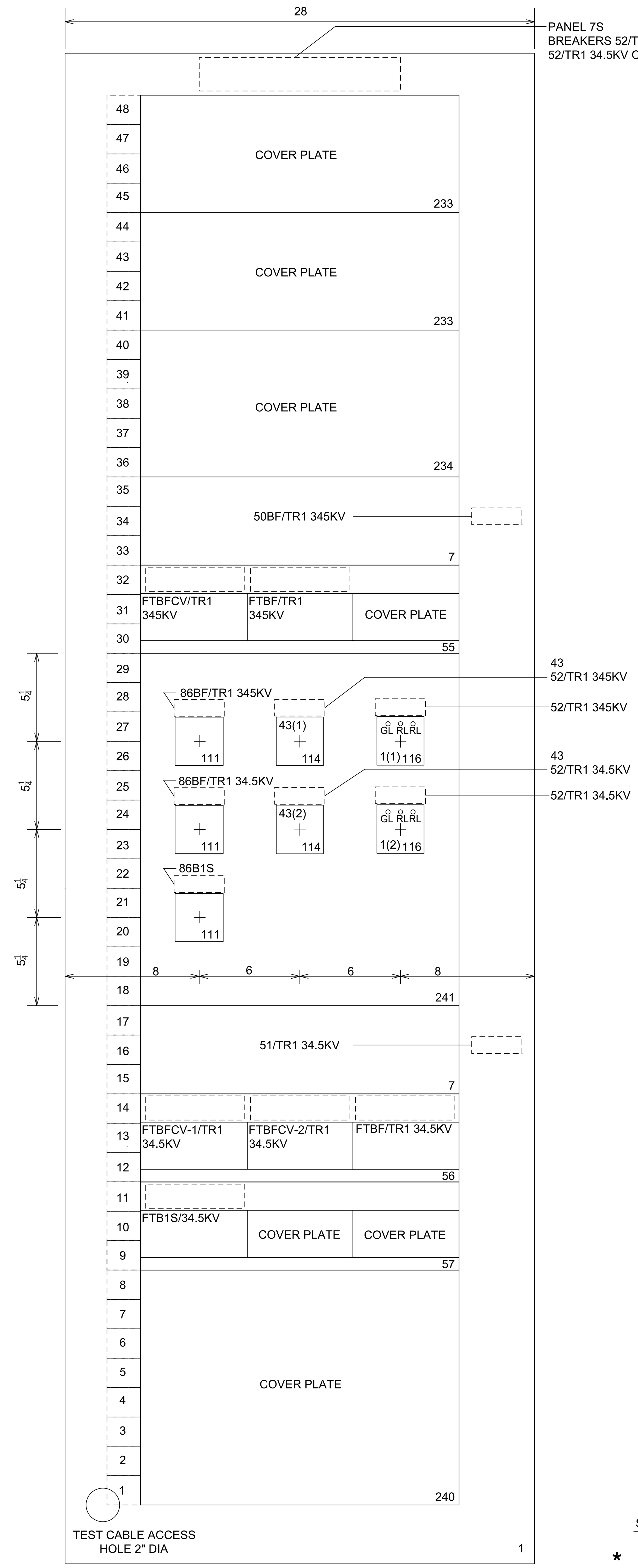
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0

345KV
PANEL 6S
SBL1 LINE RLYG
PANEL ELEVATION

NH-275117-6

REV 1



FRONT VIEW

SYMBOLS

★ REAR MOUNTED EQUIPMENT.
NAMEPLATES FOR DEVICE
NAMEPLATE DENOTING CIRCUIT CAUTION

ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)
7	50BF 51	1 1	SCHWEITZER ENG. LAB. TYPE SEL-351; CAT. #035163C3J542X1
55	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493000AX08
56	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137137493AX08
57	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - COVER PLATE OVER FT-1 CUTOUT, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493000000AX08
111	86BF 86B1S	2 1	LOCKOUT RELAY, ELECTROSWITCH, SERIES 24 LOR, CAT# 7810D, 125VDC "D" COIL, 10 DECK 10 N.O. & 10 N.C. CONTACTS, TITLE "LOCK-OUT RELAY", ENGRAVING CODE: 17C-2L22 OVAL-SHANK HANDLE
114	43	2	AUTO-MANUAL TRANSFER SWITCH, ELECTROSWITCH SERIES 24, CAT# 24902D DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, "AUTO" AT 12:00, "MAN" AT 1:30, TITLE "AUTO-MANUAL", ENGRAVING CODE: 010D-2A21K, PISTOL GRIP HANDLE
116	1	2	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PDGRRX202LB, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPERATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: 2 RED(RIGHT, MIDDLE) GREEN(LEFT)

ITEM	DEV	QUAN	DESCRIPTION
233	COVER PLATE	2	COVER PLATE 19"W X 7"H
234	COVER PLATE	1	COVER PLATE 19"W X 8 3/4"H
240	COVER PLATE	1	COVER PLATE 19"W X 14"
241	COVER PLATE	1	COVER PLATE 19"W X 21"H
★251	FB	10	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ
★253	FUSE	6	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10
★254	TB	15	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
★256	TB	2	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC

CONSTRUCTION

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECOR - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

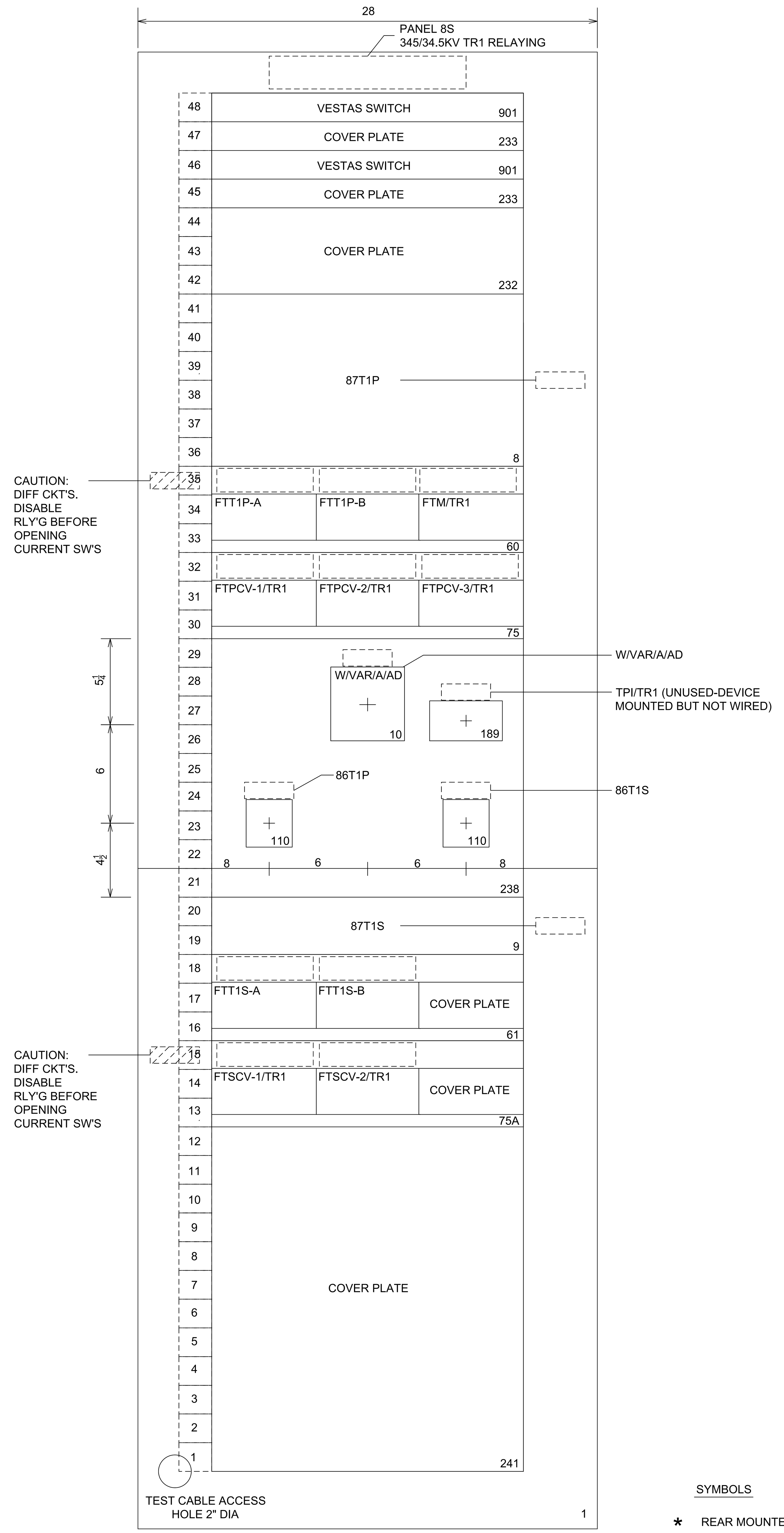
THIS MAP/DOCUMENT IS A TOOL TO ASSIST EMPLOYEES IN THE PERFORMANCE OF THEIR JOBS. YOUR PERSONAL SAFETY IS PROVIDED FOR BY USING SAFETY PRACTICES, PROCEDURES, AND EQUIPMENT AS DESCRIBED IN THE SAFETY TRAINING PROGRAMS AND MANUALS.

ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
345/34.5KV
PANEL 7S
BKR 52/TR1 345KV & 52/TR1 34.5KV CONTROL
PANEL ELEVATION

NH-275117-7

REV 1



FRONT VIEW

SYMBOLS

* REAR MOUNTED EQUIPMENT.
NAMEPLATES FOR DEVICE
NAMEPLATE DENOTING CIRCUIT CAUTION

ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)
8	87T1P	1	SCHWEITZER ENG. LAB. TYPE SEL-487E; CAT. #0487E3X411XXB0X4H624XXX
9	87T1S	1	SCHWEITZER ENG. LAB. TYPE SEL-387A; CAT. #0387A010HX4X341
10	W/VAR/A/AD	1	MULTIFUNCTION AMP/DEMAND AMP/VOLT/WATT/VAR METER, BITRONICS TYPE M650, CAT# M650B3U511, 2, 2 1/2 OR 3-ELEMENT 0-5A AND 0-120VAC NOM, INPUT, UNIVERSAL PWR SUPPLY 55-240VAC/48-250VDC, THREE 5-DIGIT RED LED DISPLAYS, 4.5" SQUARE FACEPLATE, 6.5" DEEP BY 4" ROUND CASE, PORT 1: CONFIGURABLE RS-232/485 SERIAL, PORT 2: 10/100BASE-TX ETHERNET WITH MODBUS OR DNP3 OVER TCP/IP PROTOCOLS, VOLTAGE TO BE DISPLAYED IN PHASE TO PHASE PRIMARY UNITS.
60	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493493137AX08
61	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493493000AX08
75	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION C - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, FULL BLACK COVER, 10" EXTENDED DEPTH. STYLE #FRXG084084137AX10
75A	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT FULL BLACK COVER, 10" EXTENDED DEPTH. STYLE #FRXG084084000AX10
110	86T	2	LOCKOUT RELAY, ELECTROSWITCH, SERIES 24 LOR, CAT# 7810D, 125VDC "D" COIL, 10 DECK 20 N.O. & 20 N.C. CONTACTS, TITLE "LOCK-OUT RELAY", ENGRAVING CODE: 17C-2L22, OVAL-SHANK HANDLE
189	TPI/TR1	1	INTELLIGENT CONTROL INC., PROGRAMMABLE TAP POSITION MONITOR, M#1250B-1-I 110VAC UNIT, -1 TO +1 MA ANALOG OUTPUT, LED DISPLAY, ISOLATED INPUT CARD, SEMI-FLUSH MOUNT, COMPATIBLE TO RECIEVE INPUT FROM SELSYN TRANSMITTER.

ITEM	DEV	QUAN	DESCRIPTION
232	COVER PLATE	1	COVER PLATE 19"W X 5 1/4"H
233	COVER PLATE	2	COVER PLATE 19"W X 1 3/4"H
238	COVER PLATE	1	COVER PLATE 19"W X 15 3/4"H
241	COVER PLATE	1	COVER PLATE 19"W X 21"H
* 251	FB	11	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ
* 252	FUSE	2	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 3 AMP, CAT# KLM-3
* 253	FUSE	6	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10
* 254	TB	15	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
* 256	TB	6	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC
901	VESTAS	2	VESTAS ETHERNET SWITCH

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1A	MPT UPDATES - FOR REVIEW		09-06-19	LML	PS	KJD
2	MPT UPDATES - FOR CONSTRUCTION		09-27-19	LML	PS	KJD
3	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

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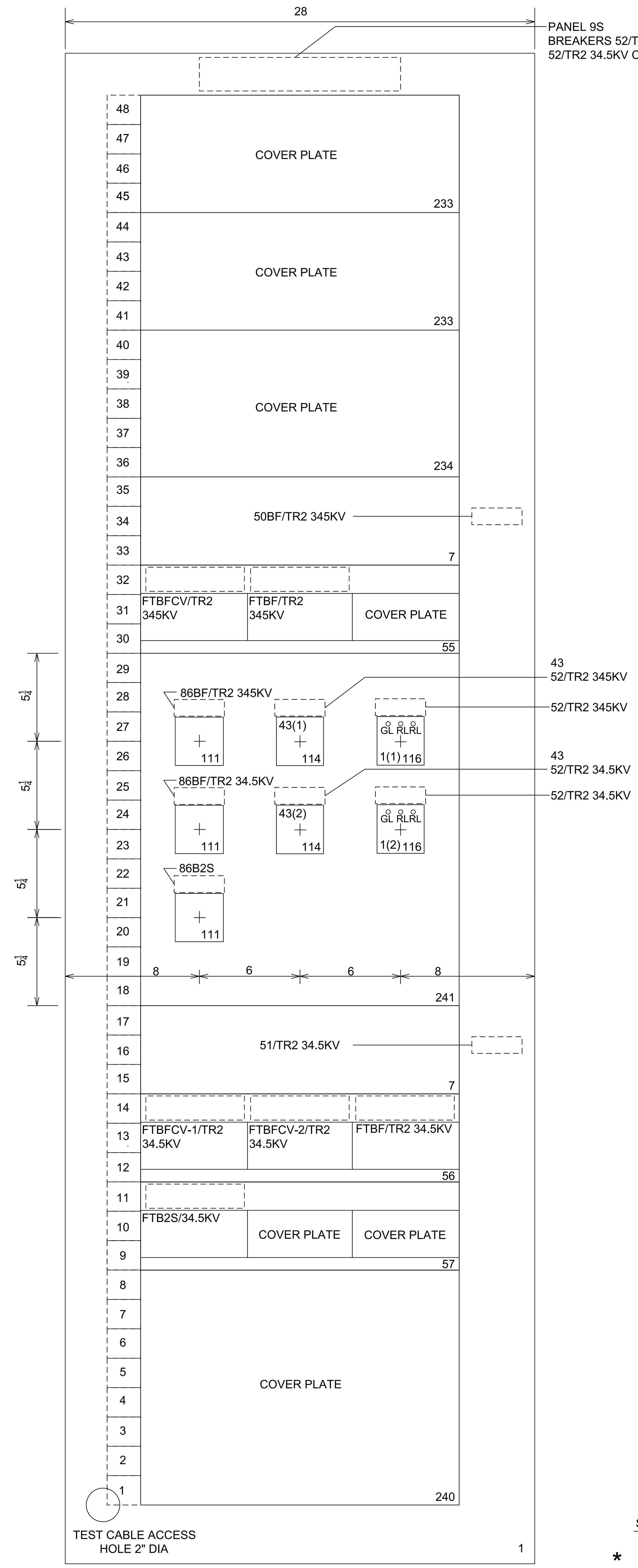
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
345/34.5KV
PANEL 8S
TR1 PRI AND SEC PROTECTION
PANEL ELEVATION

NH-275117-8

REV 3



FRONT VIEW

ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)
7	50BF 51	1 1	SCHWEITZER ENG. LAB. TYPE SEL-351; CAT. #035163C3J542X1
55	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493000AX08
56	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137137493AX08
57	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - COVER PLATE OVER FT-1 CUTOUT, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493000000AX08
111	86BF 86B2S	2 1	LOCKOUT RELAY, ELECTROSWITCH, SERIES 24 LOR, CAT# 7810D, 125VDC "D" COIL, 10 DECK 10 N.O. & 10 N.C. CONTACTS, TITLE "LOCK-OUT RELAY", ENGRAVING CODE: 17C-2L22 OVAL-SHANK HANDLE
114	43	2	AUTO-MANUAL TRANSFER SWITCH, ELECTROSWITCH SERIES 24, CAT# 24902D DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, "AUTO" AT 12:00, "MAN" AT 1:30, TITLE "AUTO-MANUAL", ENGRAVING CODE: 010D-2A21K, PISTOL GRIP HANDLE
116	1	2	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PDGRRX202LB, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPERATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: 2 RED(RIGHT, MIDDLE) GREEN(LEFT)

ITEM	DEV	QUAN	DESCRIPTION
233	COVER PLATE	2	COVER PLATE 19"W X 7"H
234	COVER PLATE	1	COVER PLATE 19"W X 8 3/4"H
240	COVER PLATE	1	COVER PLATE 19"W X 14"
241	COVER PLATE	1	COVER PLATE 19"W X 21"H
*251	FB	10	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ
*253	FUSE	6	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10
*254	TB	15	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
*256	TB	2	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC

SYMBOLS

* REAR MOUNTED EQUIPMENT.
NAMEPLATES FOR DEVICE
NAMEPLATE DENOTING CIRCUIT CAUTION

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

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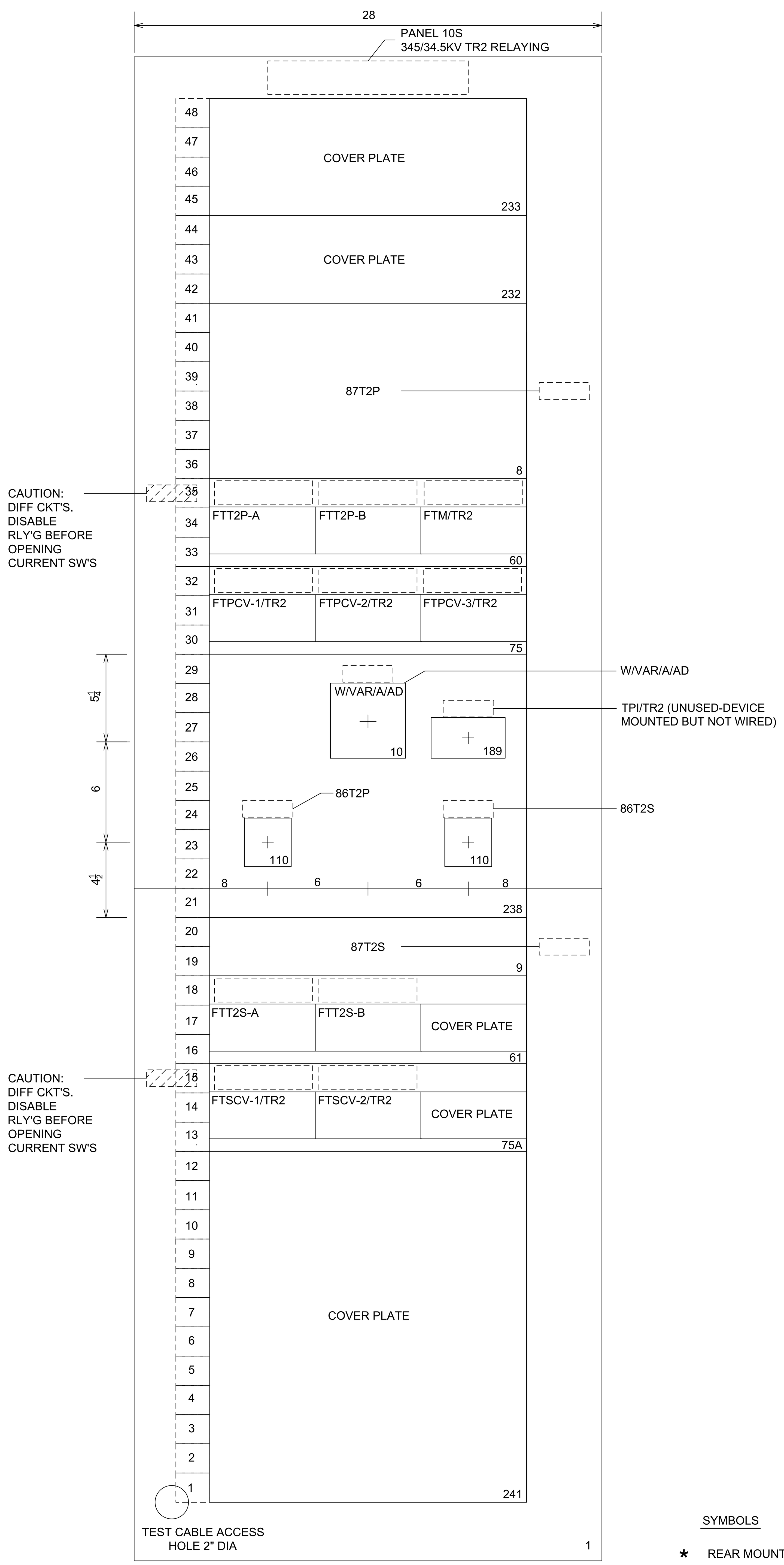
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
345/34.5KV
PANEL 9S
BKR 52/TR2 345KV & 52/TR2 34.5KV CONTROL
PANEL ELEVATION

NH-275117-9

REV 1



FRONT VIEW

SYMBOLS

* REAR MOUNTED EQUIPMENT.
NAMEPLATES FOR DEVICE
NAMEPLATE DENOTING CIRCUIT CAUTION

ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)
8	87T2P	1	SCHWEITZER ENG. LAB. TYPE SEL-487E; CAT. #0487E3X411XXB0X4H624XXX
9	87T2S	1	SCHWEITZER ENG. LAB. TYPE SEL-387A; CAT. #0387A010HX4X341
10	W/VAR/A/AD	1	MULTIFUNCTION AMP/DEMAND AMP/VOLT/WATT/VAR METER, BITRONICS TYPE M650, CAT# M650B3U511, 2, 2 1/2 OR 3-ELEMENT 0-5A AND 0-120VAC NOM. INPUT, UNIVERSAL PWR SUPPLY 55-240VAC/48-250VDC, THREE 5-DIGIT RED LED DISPLAYS, 4.5" SQUARE FACEPLATE, 6.5" DEEP BY 4" ROUND CASE, PORT 1: CONFIGURABLE RS-232/485 SERIAL, PORT 2: 10/100BASE-TX ETHERNET WITH MODBUS OR DNP3 OVER TCP/IP PROTOCOLS, VOLTAGE TO BE DISPLAYED IN PHASE TO PHASE PRIMARY UNITS.
60	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493493137AX08
61	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493493000AX08
75	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION C - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES FULL BLACK COVER, 10" EXTENDED DEPTH. STYLE #FRXG084084137AX10
75A	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 8 CURRENT (BLACK) AND 2 POTENTIAL (RED) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT FULL BLACK COVER, 10" EXTENDED DEPTH. STYLE #FRXG084084000AX10
110	86T	2	LOCKOUT RELAY, ELECTROSWITCH, SERIES 24 LOR, CAT# 7810D, 125VDC "D" COIL, 10 DECK 20 N.O. & 20 N.C. CONTACTS, TITLE "LOCK-OUT RELAY", ENGRAVING CODE: 17C-2L22, OVAL-SHANK HANDLE
189	TPI/TR2	1	INTELLIGENT CONTROL INC., PROGRAMMABLE TAP POSITION MONITOR, M#1250B-1-I 110VAC UNIT, -1 TO +1 MA ANALOG OUTPUT, LED DISPLAY, ISOLATED INPUT CARD, SEMI-FLUSH MOUNT, COMPATIBLE TO RECIEVE INPUT FROM SELSYN TRANSMITTER.

ITEM	DEV	QUAN	DESCRIPTION
232	COVER PLATE	1	COVER PLATE 19"W X 5 1/4"H
233	COVER PLATE	1	COVER PLATE 19"W X 7"H
238	COVER PLATE	1	COVER PLATE 19"W X 15 3/4"H
241	COVER PLATE	1	COVER PLATE 19"W X 21"H
*249	FB	1	FUSE BLOCK, 3 POLE, 250V, 30A, BUSSMAN, CAT#HM25030-3SR
*250	FB	1	FUSE BLOCK, 2 POLE, 250V, 30A, BUSSMAN, #H25030-2SR
*251	FB	11	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ
* 252	FUSE	2	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 3 AMP, CAT# KLM-3
* 253	FUSE	6	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10
*254	TB	15	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
*256	TB	6	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1A	MPT UPDATES - FOR REVIEW		09-06-19	LML	PS	KJD
2	MPT UPDATES - FOR CONSTRUCTION		09-27-19	LML	PS	KJD
3	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
APVD: KJD	DATE: 06-25-19	SCALE: NONE	

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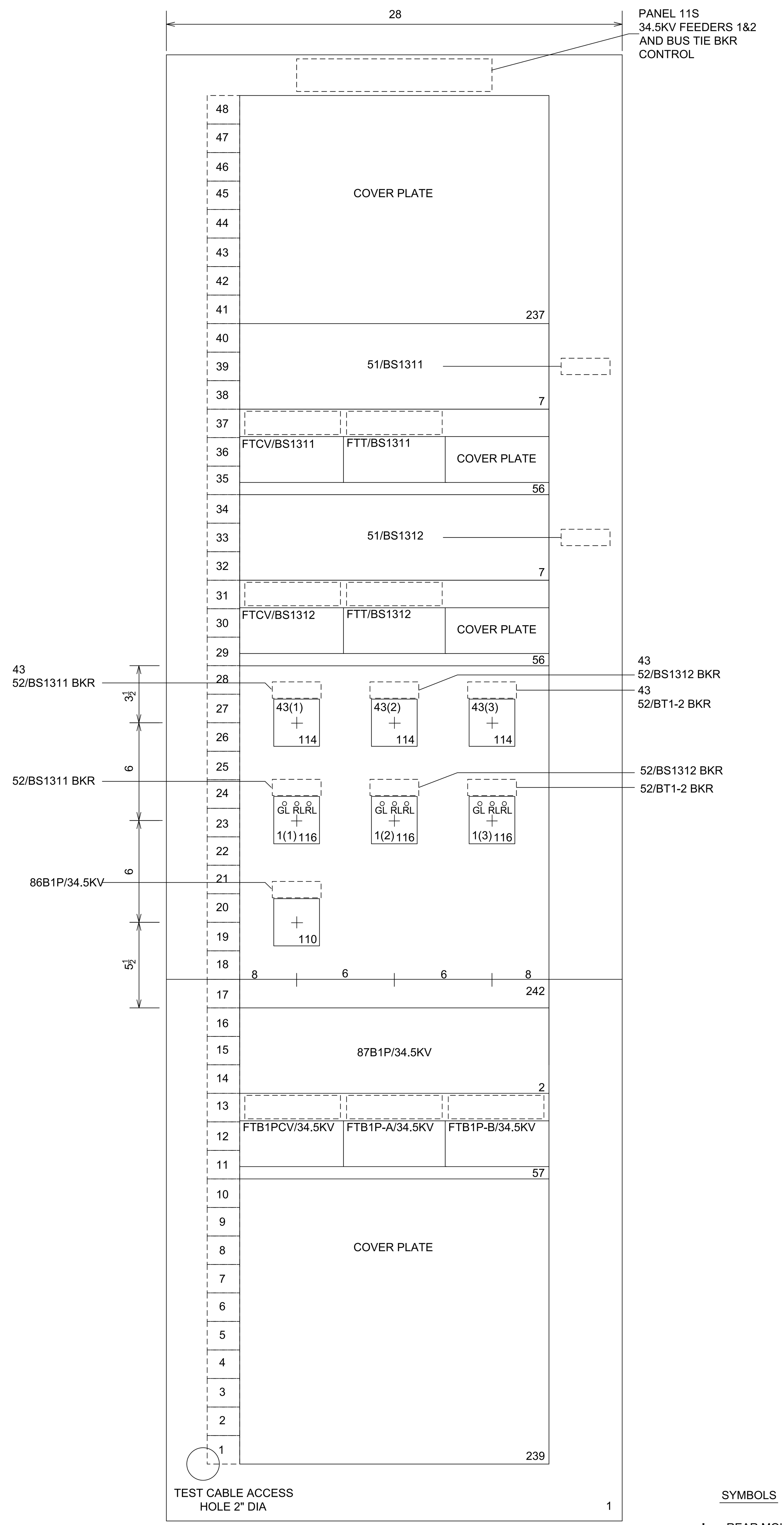
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
345/34.5KV
PANEL 10S
TR2 PRI AND SEC PROTECTION
PANEL ELEVATION

NH-275117-10

REV 3



FRONT VIEW

SYMBOLS

★ REAR MOUNTED EQUIPMENT.
NAMEPLATES FOR DEVICE
NAMEPLATE DENOTING CIRCUIT CAUTION

ITEM	DEV	QUAN	DESCRIPTION	ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)				
2	87B1P	1	SCHWEITZER ENG. LAB. TYPE SEL-587Z; CAT. #0587Z0X325H12XX				
7	51	2	SCHWEITZER ENG. LAB. TYPE SEL-351; CAT. #035163C3J542X1				
56	FT-19R	2	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493000AX08				
57	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493493AX08				
110	86B	1	LOCKOUT RELAY, ELECTROSWITCH, SERIES 24 LOR, CAT# 7810D, 125VDC "D" COIL, 10 DECK 20 N.O. & 20 N.C. CONTACTS, TITLE "LOCK-OUT RELAY", ENGRAVING CODE: 17C-2L22, OVAL-SHANK HANDLE				
114	43	3	AUTO-MANUAL TRANSFER SWITCH, ELECTROSWITCH SERIES 24, CAT# 24902D DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, "AUTO" AT 12:00, "MAN" AT 1:30, TITLE "AUTO-MANUAL", ENGRAVING CODE: 010D-2A21K, PISTOL GRIP HANDLE				
116	1	3	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PDGRRX202LB, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPERATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: 2 RED(RIGHT, MIDDLE) GREEN(LEFT)				
237	COVER PLATE	1	COVER PLATE 19"W X 14"H				
239	COVER PLATE	1	COVER PLATE 19"W X 17 ½"H				
242	COVER PLATE	1	COVER PLATE 19"W X 21"H				
★ 251	FB	8	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ				
★ 253	FUSE	6	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10				
★ 254	TB	16	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD				
★ 256	TB	4	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC				

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECORD - BLAZEING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

DWG NO.	MANUFACTURER	DESCRIPTION

Xcel Energy®

NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

DWN: LML	DATE: 06-25-19	CHK:	DATE:
ENG: KJD	DATE: 06-25-19	CHK:	DATE:
PM: ML	DATE: 06-25-19	PROJ. NO: 22571	
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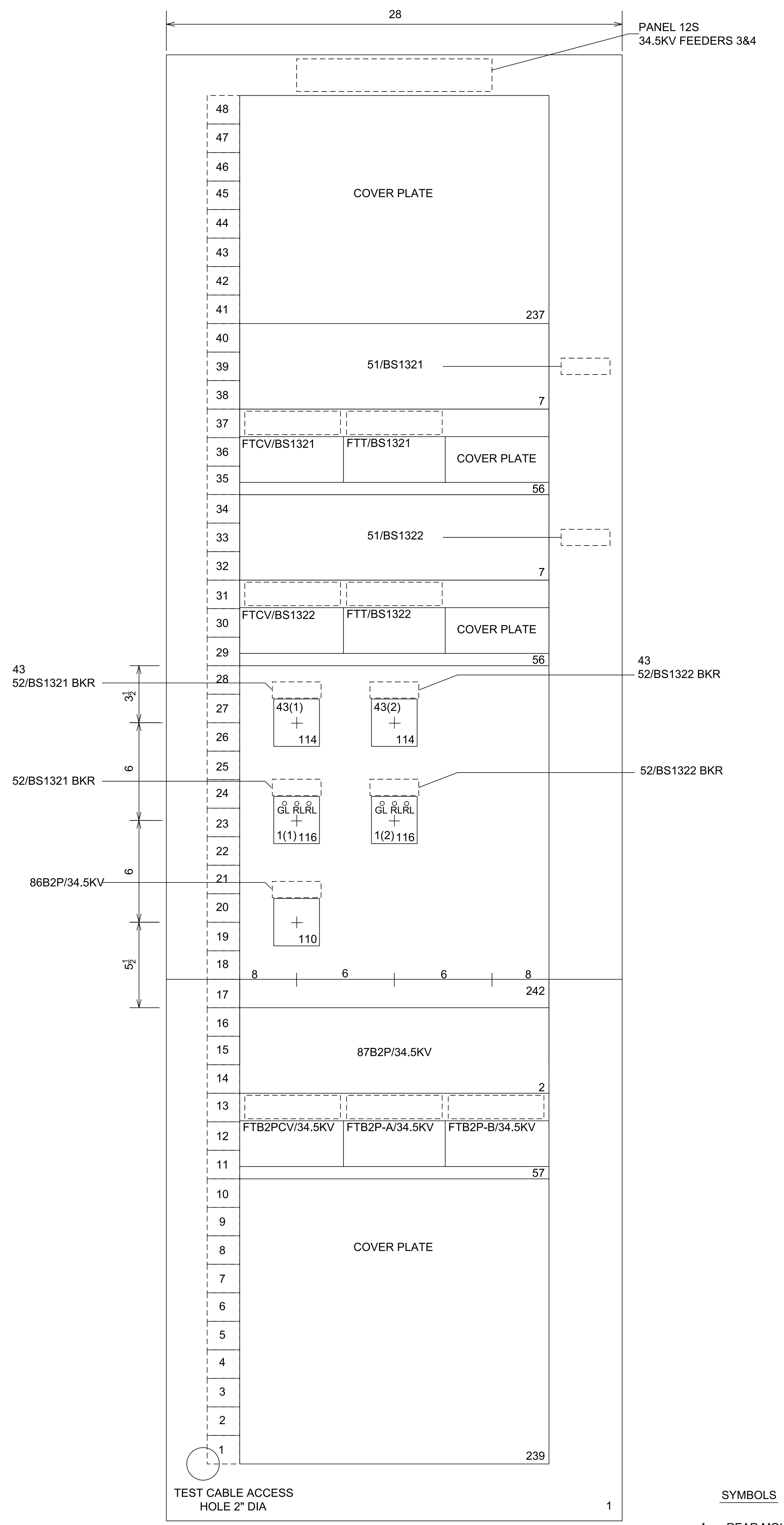
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
34.5KV
PANEL 11S
FEEDERS 1&2, BUS TIE CTRL AND RLY'G
PANEL ELEVATION

NH-275117-11

REV 2



FRONT VIEW

ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)
2	87B2P	1	SCHWEITZER ENG. LAB. TYPE SEL-587Z; CAT. #0587Z0X325H12XX
7	51	2	SCHWEITZER ENG. LAB. TYPE SEL-351; CAT. #035163C3J542X1
56	FT-19R	2	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - COVER PLATE OVER FT-1 CUTOUT, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493000AX08
57	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493493AX08
110	86B	1	LOCKOUT RELAY, ELECTROSWITCH, SERIES 24 LOR, CAT# 7810D, 125VDC "D" COIL, 10 DECK 20 N.O. & 20 N.C. CONTACTS, TITLE "LOCK-OUT RELAY", ENGRAVING CODE: 17C-2L22, OVAL-SHANK HANDLE
114	43	2	AUTO-MANUAL TRANSFER SWITCH, ELECTROSWITCH SERIES 24, CAT# 24902D DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, "AUTO" AT 12:00, "MAN" AT 1:30, TITLE "AUTO-MANUAL", ENGRAVING CODE: 010D-2A21K, PISTOL GRIP HANDLE
116	1	2	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PDGRRX202LB, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPERATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: 2 RED(RIGHT, MIDDLE) GREEN(LEFT)
237	COVER PLATE	1	COVER PLATE 19"W X 14"H
242	COVER PLATE	1	COVER PLATE 19"W X 21"H
239	COVER PLATE	1	COVER PLATE 19"W X 17 $\frac{1}{2}$"H
* 251	FB	8	FUSE BLOCK, 1 POLE, 250V, 30A, BUSSMAN, #BMM603-1SQ
* 253	FUSE	6	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10
* 254	TB	16	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
* 256	TB	4	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC

ITEM	DEV	QUAN	DESCRIPTION

SYMBOLS

* REAR MOUNTED EQUIPMENT.
NAMEPLATES FOR DEVICE
NAMEPLATE DENOTING CIRCUIT CAUTION

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

NO	REVISION	ZONE	DATE	BY	CHK	ENG
0	FOR CONSTRUCTION		06-25-19	LML	JAS	KJD
1	ISSUE FOR RECORD - BLAZING STAR 1 - 22571		02-14-2020	LML	KJD	JJW

NO	REVISION	ZONE	DATE	BY	CHK	ENG

REFERENCE DRAWINGS

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Xcel Energy®
NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

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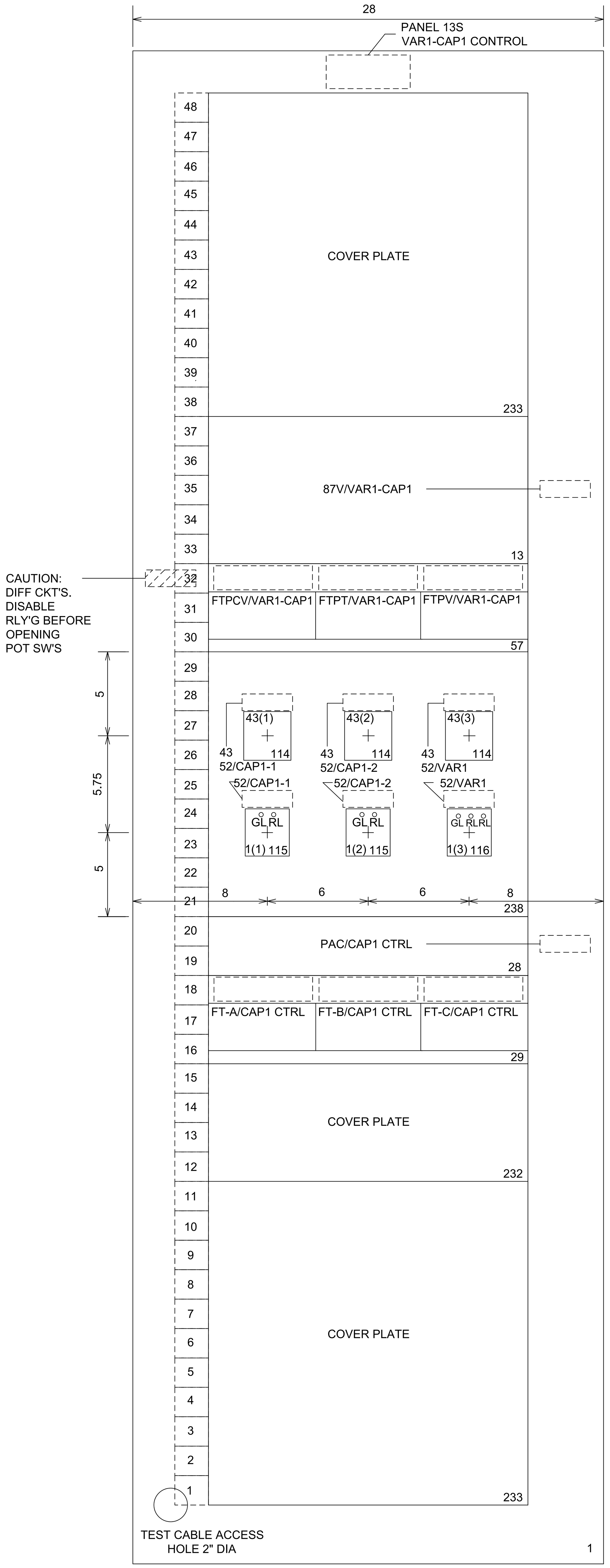
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
34.5KV
PANEL 12S
FEEDERS 3&4 CTRL AND RLY'G
PANEL ELEVATION

NH-275117-12
REV 1



FRONT VIEW

ITEM	DEV	QUAN	DESCRIPTION	ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)				
13	87V	1	SCHWEITZER ENG. LAB. TYPE SEL-487V; CAT. #0487V1X4151XB0X4H54424X				
28	PAC	1	SCHWEITZER ENGINEERING LAB. TYPE SEL-2440, CAT #24402H11A6X11630.				
29	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493493493AX08				
57	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (RED) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493036AX08				
114	43	3	AUTO-MANUAL TRANSFER SWITCH, ELECTROSWITCH SERIES 24, CAT# 24902D DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, "AUTO" AT 12:00, "MAN" AT 1:30, TITLE "AUTO-MANUAL", ENGRAVING CODE: 010D-2A21K, PISTOL GRIP HANDLE				
115	1	2	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PB202QS, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPERATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: RED(RIGHT) GREEN(LEFT)				
116	1	1	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PDGRRX202LB, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPARATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: 2 RED(RIGHT, MIDDLE) GREEN(LEFT)				
232	COVER PLATE	1	COVER PLATE 19"W X 7"H				
233	COVER PLATE	2	COVER PLATE 19"W X 19 $\frac{1}{4}$"H				
238	COVER PLATE	1	COVER PLATE 19"W X 15 $\frac{3}{4}$"H				
★251	FB	10	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ				
★253	FUSE	7	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10				
★254	TB	12	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD				
★256	TB	1	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC				

SYMBOLS

- ⬡ INSTRUCTION LEAFLETS TO BE FURNISHED BY PANEL FABRICATOR.
- ★ REAR MOUNTED EQUIPMENT.
- NAMEPLATES FOR DEVICE
- NAMEPLATE DENOTING CIRCUIT CAUTION

ISSUE FOR RECORD

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LINCOLN COUNTY, MINNESOTA

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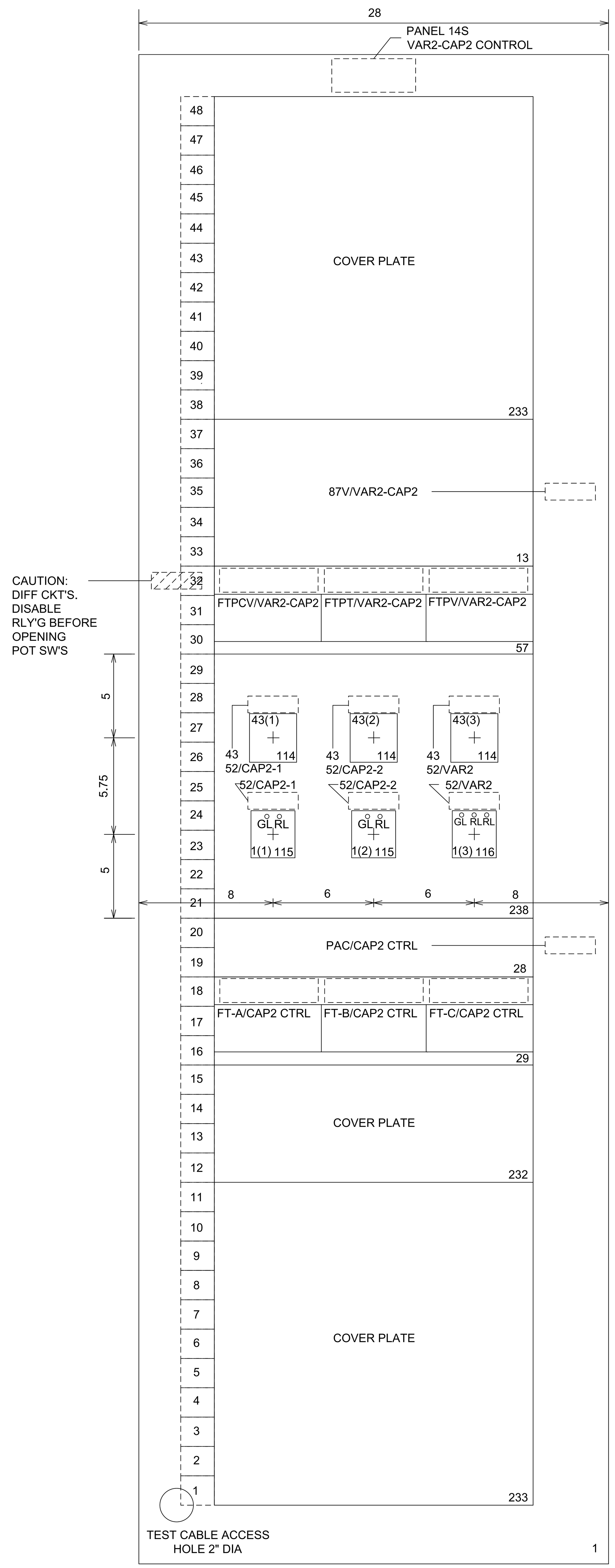
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
34.5KV
PANEL 13S
VAR1-CAP1 CONTROL & RLY'G
PANEL ELEVATION

NH-275117-13

REV 1



FRONT VIEW

ITEM	DEV	QUAN	DESCRIPTION	ITEM	DEV	QUAN	DESCRIPTION
1	PANEL	1	90"H X 28"W (PANEL CONST DETAIL 3300.1-1)				
13	87V	1	SCHWEITZER ENG. LAB. TYPE SEL-487V; CAT. #0487V1X4151XB0X4H54424X				
28	PAC	1	SCHWEITZER ENGINEERING LAB. TYPE SEL-2440, CAT #24402H11A6X11630.				
29	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG493493493AX08				
57	FT-19R	1	SWITCH BOX, ABB CORP., TYPE FT-19R, 3RU(LO) HEIGHT, SCREW TERMINALS, INCLUDES: POSITION A - 6 CURRENT (BLACK) AND 4 POTENTIAL (RED) HANDLE SWITCHES, POSITION B - 0 CURRENT (BLACK) AND 10 POTENTIAL (BLUE) HANDLE SWITCHES, POSITION C - 0 CURRENT (BLACK) AND 10 POTENTIAL (RED) HANDLE SWITCHES, FULL BLACK COVER, 8" EXTENDED DEPTH. STYLE #FRXG137493036AX08				
114	43	3	AUTO-MANUAL TRANSFER SWITCH, ELECTROSWITCH SERIES 24, CAT# 24902D DETENT ACTION ROTARY SWITCH, 2 POSITION, 2 DECK, 4 DOUBLE CONTACTS PER DECK, "AUTO" AT 12:00, "MAN" AT 1:30, TITLE "AUTO-MANUAL", ENGRAVING CODE: 010D-2A21K, PISTOL GRIP HANDLE				
115	1	2	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PB202QS, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPERATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: RED(RIGHT) GREEN(LEFT)				
116	1	1	CONTROL SWITCH, ELECTROSWITCH SERIES 24, CAT# 74PDGRRX202LB, BREAKER CONTROL SWITCH, 2 POSITION, 2 DECK, ELECTRICALLY SEPARATED CONTACTS, "TRIP" AT 11:00, "CLOSE" AT 1:00, TITLE "CONTROL", OVAL-SHANK HANDLE, LIGHTED NAMEPLATE LEDS: 2 RED(RIGHT, MIDDLE) GREEN(LEFT)				
232	COVER PLATE	1	COVER PLATE 19"W X 7"H				
233	COVER PLATE	2	COVER PLATE 19"W X 19 $\frac{1}{4}$"H				
238	COVER PLATE	1	COVER PLATE 19"W X 15 $\frac{3}{4}$"H				
*251	FB	7	FUSE BLOCK, 1 POLE, 600V, 30A, BUSSMAN, #BMM603-1SQ				
* 253	FUSE	5	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 10 AMP, CAT# KLM-10				
* 254	TB	12	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD				
* 256	TB	1	TERMINAL BLOCK, 4 POINT, MARATHON CO., CAT #1504SC				

SYMBOLS

INSTRUCTION LEAFLETS TO BE FURNISHED BY PANEL FABRICATOR.
* REAR MOUNTED EQUIPMENT.
NAMEPLATES FOR DEVICE
NAMEPLATE DENOTING CIRCUIT CAUTION

ISSUE FOR RECORD

Ulteig ENGINEERING,SURVEYING, & CONSULTING SERVICES

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NORTHERN STATES POWER COMPANY
BLAZING STAR 1 COLLECTOR SUBSTATION
LINCOLN COUNTY, MINNESOTA

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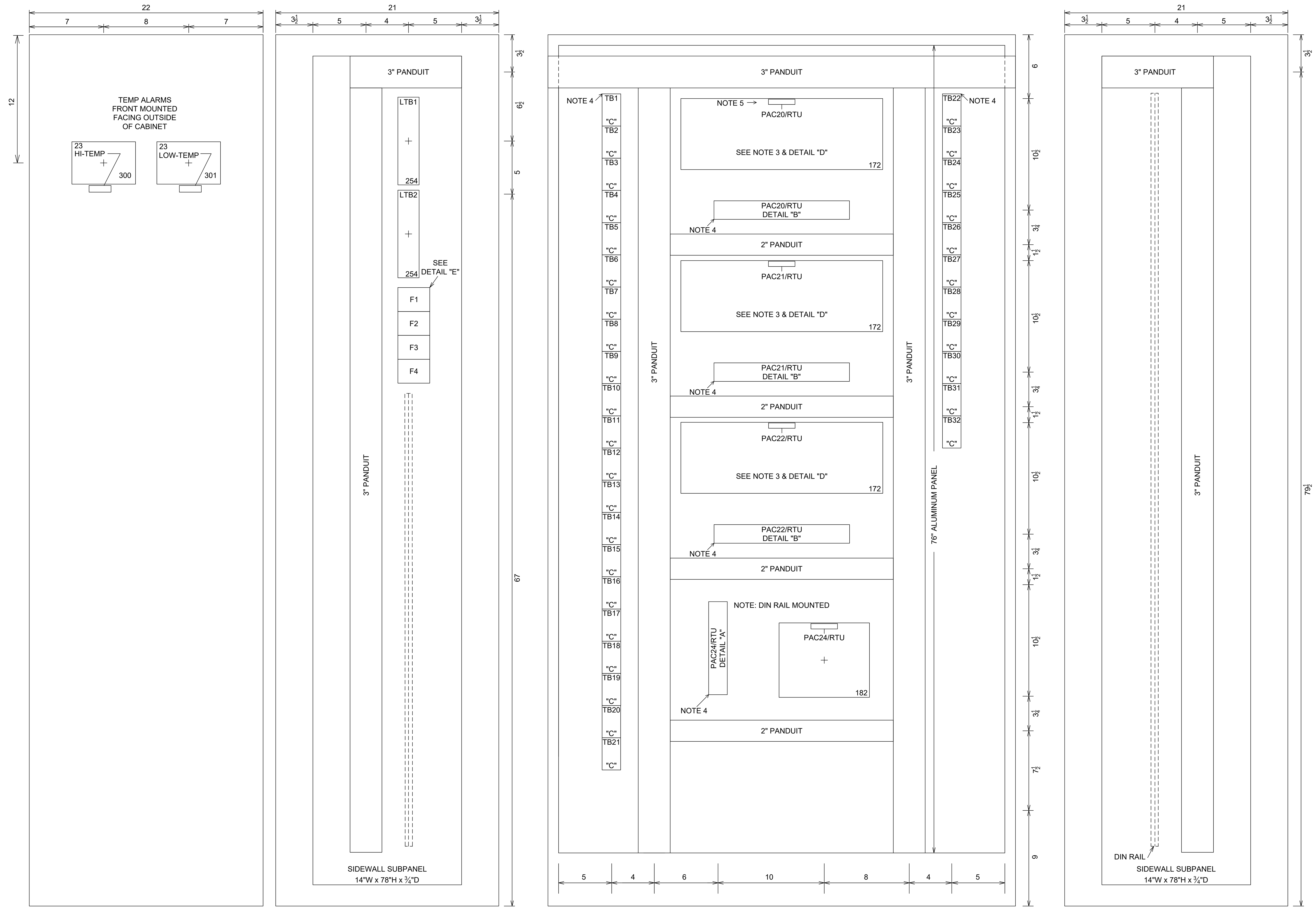
ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
34.5KV
PANEL 14S
VAR2-CAP2 CONTROL & RLY'G
PANEL ELEVATION

NH-275117-14

REV
1

ITEM	DEV	QUAN	DESCRIPTION
4	TERM CAB	1	TERMINAL CABINET, INDOOR, GALVANIZED STEEL, 6'-10 H X 3'-8 W X 1'-9 D, PER DRAWING 3300.1-1-2
172	PAC	3	SCHWEITZER ENGINEERING LAB. TYPE SEL-2440, CAT #24402W12A1A11630.
182	PAC	1	SCHWEITZER ENG. LAB. TYPE SEL-2411, CAT. # 241111A3A3A3A520130.
251	FB	4	FUSE BLOCK, 2 POLE, 250V, 30A, BUSSMANN, CAT#HM25030-2SR
251A	FUSE	8	FUSE, COOPER BUSSMANN, 600V FAST-ACTING SUPPLEMENTAL, 5 AMP, CAT# KLM-5
254	TB	2	TERMINAL BLOCK, 12 POINT, MARATHON CO., CAT #1512 STD
270	END STOP	72	ENTRELEC END STOP (GREY), TYPE BAM, PART #206351.16
271	TB	36	ENTRELEC TERMINAL BLOCK, TYPE M 10/10.RTS, PART #115572.10
272	GRD TB	64	ENTRELEC TERMINAL BLOCK, TYPE M 4/6.P, PART #165113.16, TERM BLOCK FOR GROUND WIRES, MARKING GREEN + YELLOW BODY WITH RAIL CONTACT
272A	END SECT	32	ENTRELEC END SECTION (YELLOW), TYPE FEM6, PART #103062.21 (USE WITH ITEM 272)
273	SW	160	ENTRELEC SWITCH TERMINAL BLOCK, TYPE M 4/6. SNT, PART #115438.12
274	TB	48	ENTRELEC TERMINAL BLOCK, TYPE M 4/6.T, PART #115224.13
274A	END SECT	32	ENTRELEC END SECTION (GREY), TYPE FEM6, PART #118368.16 (USE WITH ITEM 274)
275	TEST PLUG	1	ENTRELEC TEST PLUG, TYPE FC2, PART #0007865.26
276	TB	172	ENTRELEC TERMINAL BLOCK, TYPE D 1,5/6.ADO, PART #199055.22
277	NAME-PLATES	1 LOT	ENTRELEC TERMINAL BLOCK NAMEPLATES
280	PANDUIT	1 LOT	PANDUIT 2"
281	PANDUIT	1 LOT	PANDUIT 3"
282	DIN RAIL	1 LOT	DIN RAIL, SQUARE D CLASS 9080, TYPE NSYSDR200
300	23/HI	1	HIGH-TEMPERATURE ALARM, HONEYWELL, FARM-O-STAT, M#T631A, TEMPERATURE RANGE 70-140 DEGREES FAHRENHEIT, S#T631A1022 (FIELD TO SET AT 110°F)
301	23/LO	1	LOW-TEMPERATURE ALARM, HONEYWELL, FARM-O-STAT, M#T631A, TEMPERATURE RANGE 35-100 DEGREES FAHRENHEIT, S#T631A1006 (FIELD TO SET AT 55°F)
302	RESISTORS	4	5 KOHM SCALING RESISTORS



FRONT VIEW OF LEFT CABINET DOOR

LEFT SIDEWALL OF CABINET

FRONT VIEW OF CABINET WITH DOORS OPEN

RIGHT SIDEWALL OF CABINET

ITEM #	NAMEPLATE
270	(END STOP)
271	PAC*/RTU
273	+AI401
274	-AI401
273	+AI402
274	-AI402
273	+AI403
274	-AI403
273	+AI404
274	-AI404
273	+AI405
274	-AI405
273	+AI406
274	-AI406
273	+AI407
274	-AI407
273	+AI408
274	-AI408
273	+AI501
274	-AI501
273	+AI502
274	-AI502
273	+AI503
274	-AI503
273	+AI504
274	-AI504
273	+AI505
274	-AI505
273	+AI506
274	-AI506
273	+AI507
274	-AI507
273	+AI508
274	-AI508
270	(END STOP)

TYPICAL TERMINAL BLOCK ARRANGEMENT FOR SEL-2411

DETAIL "A"

ITEM #	NAMEPLATE
270	(END STOP)
271	PAC*/RTU
273	I101
273	I102
273	I103
273	I104
273	I105
273	I106
273	I107
273	I108
273	I109
273	I110
273	I111
273	I112
273	I113
273	I114
273	I115
273	I116
273	I201
273	I202
273	I203
273	I204
273	I205
273	I206
273	I207
273	I208
273	I209
273	I210
273	I211
273	I212
273	I213
273	I214
273	I215
273	I216
273	I301
273	I302
273	I303
273	I304
273	I305
273	I306
273	I307
273	I308
273	I309
273	I310
273	I311
273	I312
273	I313
273	I314
273	I315
273	I316
270	(END STOP)

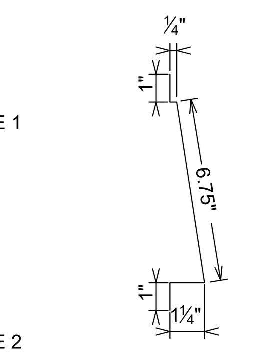
TYPICAL TERMINAL BLOCK ARRANGEMENT FOR SEL-2440

DETAIL "B"

ITEM #	NAMEPLATE	
270	(END STOP)	
271	TB*	
274	PAC INPUT POS	SEE NOTE 1
274A	(END SECT)	
276	3 TB FOR 2PR/SH CABLE 7 TB FOR 4PR/SH CABLE 15 TB FOR 8PR/SH CABLE	
272	PAIR SH	SEE NOTE 2
272	CABLE SH	
272A	(END SECT)	
270	(END STOP)	

TYPICAL TERMINAL BLOCK ARRANGEMENT FOR TWISTED PAIR CABLE

DETAIL "C"



SEL-2440 SHIM PANEL

DETAIL "D"

NAMEPLATE	251
FUSE	251
FUSE	251

2 POLE FUSE BLOCK ASSEMBLY

DETAIL "E"

NOTES

NOTE 1 : THIS TERMINAL BLOCK IS TO BE USED FOR THE PAC INPUT POSITIVE AND JUMPERED TO OTHER PAC INPUT POSITIVE BLOCKS AS NECESSARY ON THE INTERNAL SIDE OF THE BLOCK. (SEE CSUC-E21018-1)

NOTE 2 : CABLE MAY NOT HAVE INDIVIDUAL PAIRS. IF THIS IS THE CASE THE PAIR SHIELD BLOCKS WILL BE SPARE.

NOTE 3 : CREATE PANEL TO SHIM THE BOTTOM OF THE SEL-2440 PAC'S OUT TO ALLOW EASIER CONNECTIONS OF WIRES TO TERMINAL STRIPS. PANEL TO BE 19" WIDE, SEE DETAIL "D" FOR OTHER DIMENSIONS.

NOTE 4 : PANEL SHOP TO SHIM OUT ENTRELEC BLOCKS SO OUTER EDGE IS FLUSH WITH OUTER EDGE OF PANDUIT. EQUIPMENT TO BE DIN RAIL MOUNTED.

NOTE 5 : RELAY NAMES TO BE LABELED WITH SELF ADHESIVE LABEL. 1/2" HIGH BY 2 1/2"" WIDE TAG WITH 1/4" LETTERING. WHITE LABEL WITH BLACK TEXT.

ENTRELEC QUANTITY BY DETAIL								
ITEM #	270	271	272	272A	273	274	274A	276
DETAIL "A"	2	1			16	16		
DETAIL "B"	2	1			48			
DETAIL "C"	2	1	2	1		1	1	3, 7 OR 15

PAC NUMBER
PAC INPUT 201
RTU 20 I201

WIRE NUMBER DETAIL

ISSUE FOR RECORD

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ENERGY SUPPLY
ENGINEERING & CONSTRUCTION

UNIT 0
345/34.5KV
PAC TERMINAL
CABINET #1
PANEL ELEVATION

NH-275117-15

REV 1

1. Operations and Maintenance Building

1.1. Design

1.1.1. Contractor shall procure and deliver and provide, in accordance with the Project Schedule and Design Documents, all services, labor, equipment, land rights, Permits, Approvals, and materials necessary to construct, assemble, erect and install a fully finished O&M building and sand shed in accordance with the Outline Specifications in this Section, but not limited to: heated & air conditioned office/SCADA space, heated shop & warehouse space, security system, paved driveway, potable water, septic system, single phase electrical service with a 400 amp minimum rating, communication wiring, exterior water faucets, outlets, and security lighting, 5 acre minimum building site, fenced gravel storage area suitable for large parts such as blades, and landscaping and wind screen. Not all items may apply to sites < 200 MW.

1.1.2. Building type shall be standardized metal panel and steel support and framing by Butler, Morton, or Owner approved alternate.

1.1.3. The minimum building size shall be based on the Project size and may be adjusted slightly to match standard materials:

Plant Rating (MW-AC)	Building Type/Size
< 200	40 ft converted shipping container
200 – 399	1,020 sq ft
400 - 799	4,140 sq ft
800+	5,758 sq ft

1.1.1. Floor plan layouts are shown in Figure 1, Figure 2, and Figure 3.

1.1.2. The site layout is shown in Figure 4 and Figure 14. The building orientation shall be fixed and the entrance road shall enter from the south. Parking lot area will need to be adjusted based on the building used.

1.1.3. The final floor and site plans shall be agreed to within 30 days following execution of the Project agreement. Issued for construction plans and specifications shall be submitted to Owner for review and approval prior to construction. Building design and construction shall be in accordance with all current state and local codes.

1.1.4. Office finished ceiling height to be 9’.

1.1.5. SCADA room ceiling minimum height is 10’.

1.1.6. Mechanical room ceiling to be building height and walls shall extend to the ceiling.

1.1.7. Shop area garage door height to be 12’.

1.1.8. Shop area ceiling height to be high enough to allow room for garage door track and lighting above garage door. Shop walls shall be finished with metal to the ceiling, including around the office area. Ceiling shall be finished in metal.

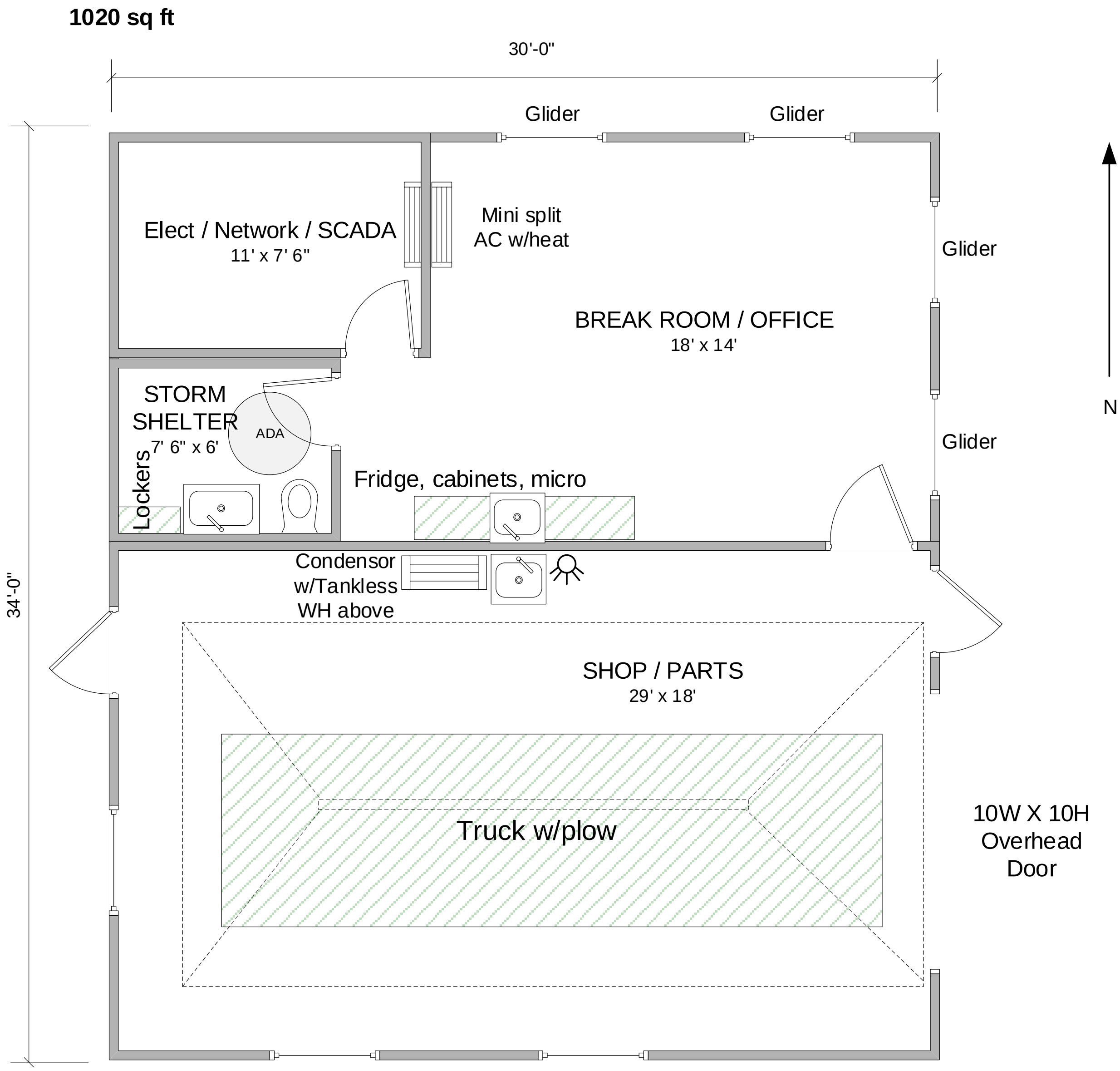


Figure 1: O&M building interior layout - 1,020 sq. ft.

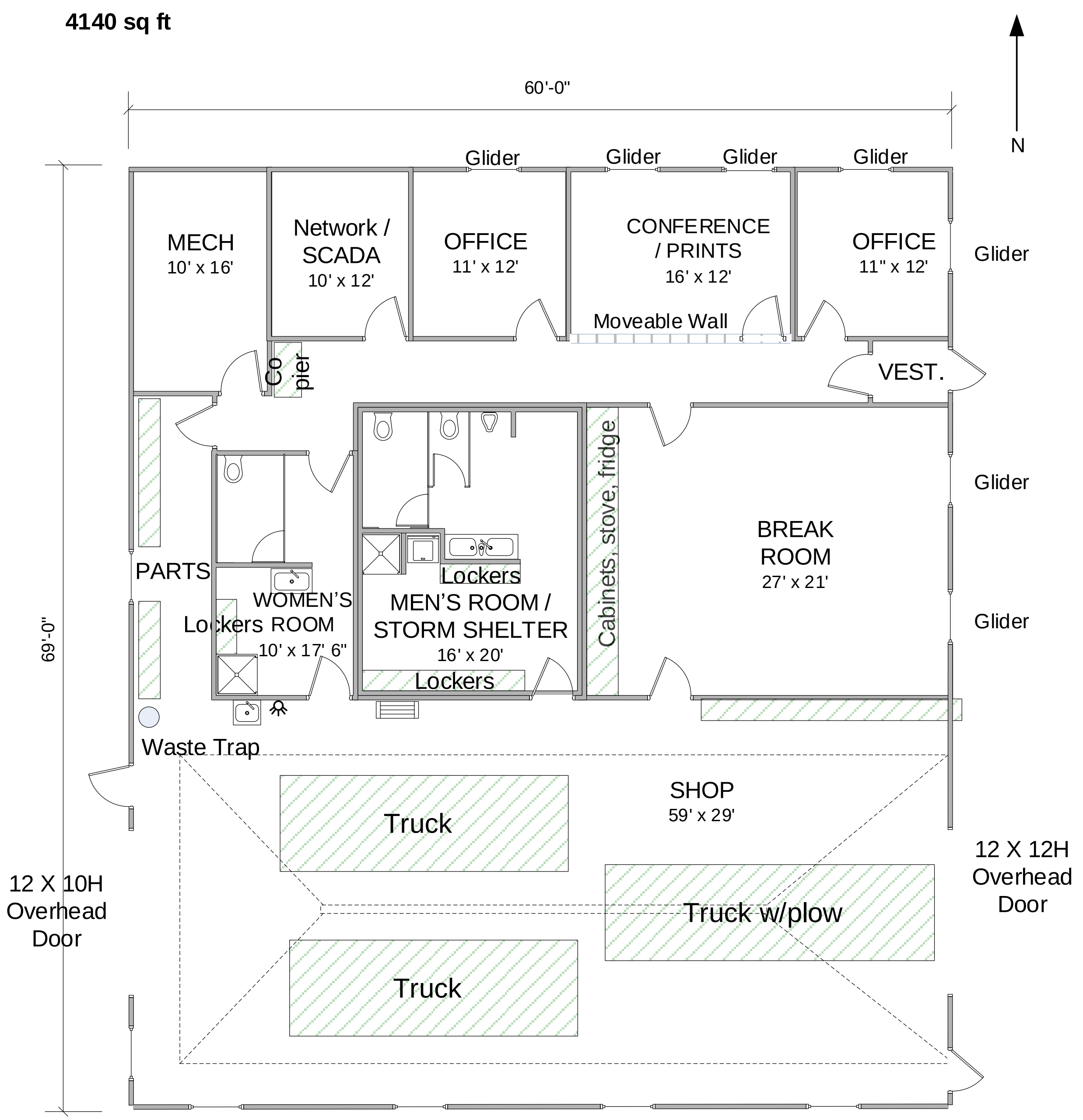


Figure 2: O&M building interior layout - 4,140 sq. ft.

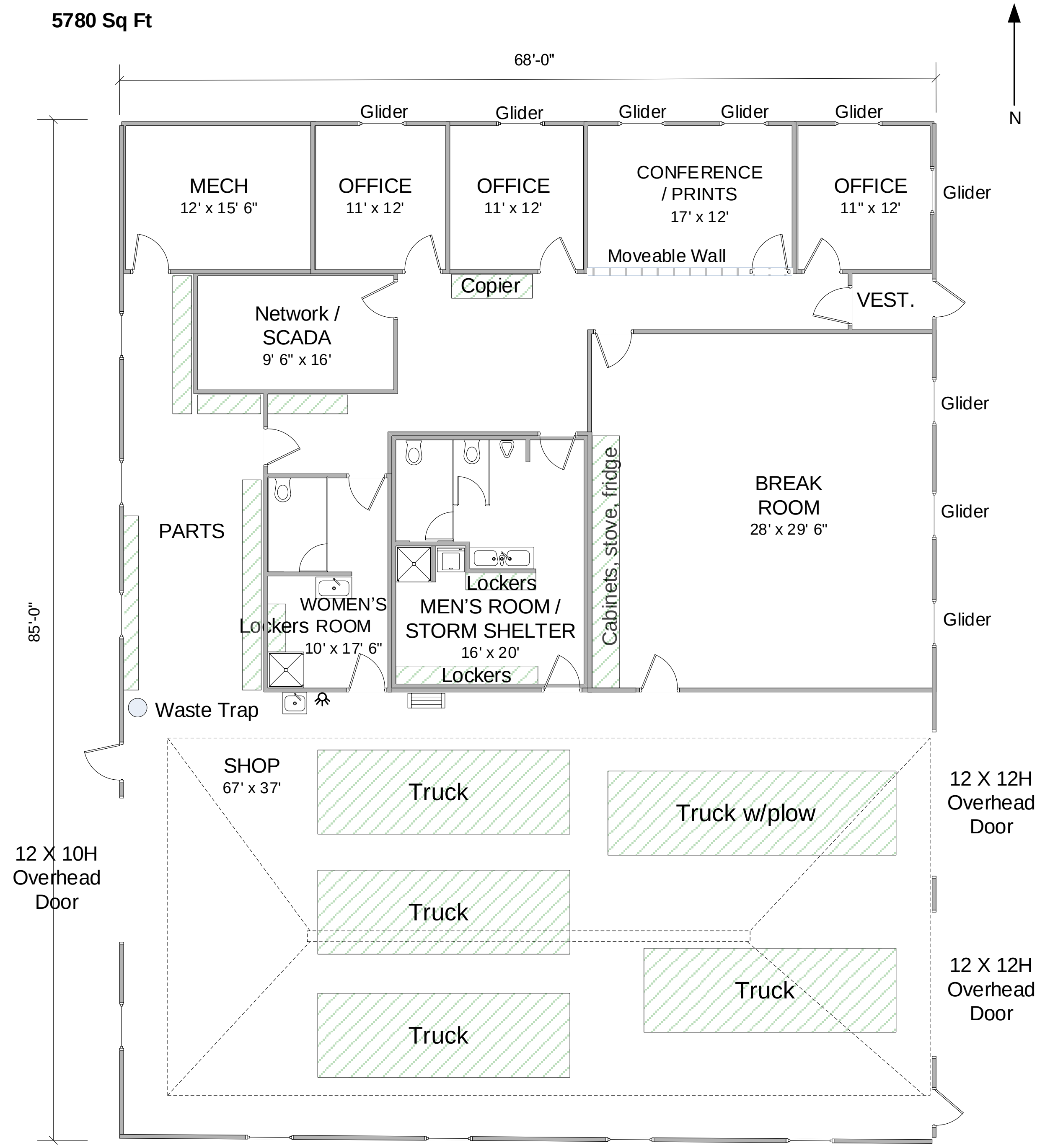


Figure 3: O&M building interior layout - 5,758 sq. ft.

Site Layout

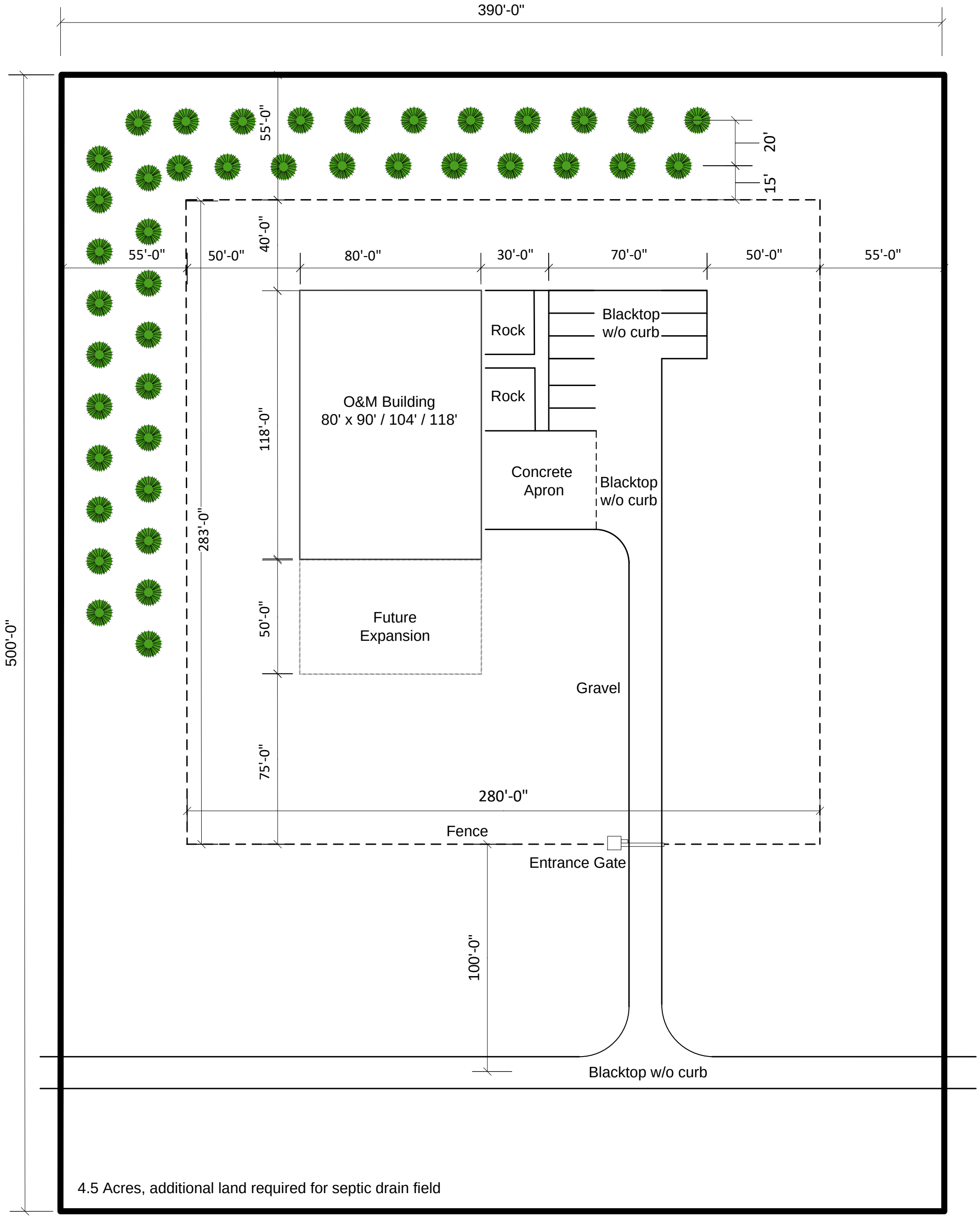


Figure 4: Typical O&M building exterior layout.

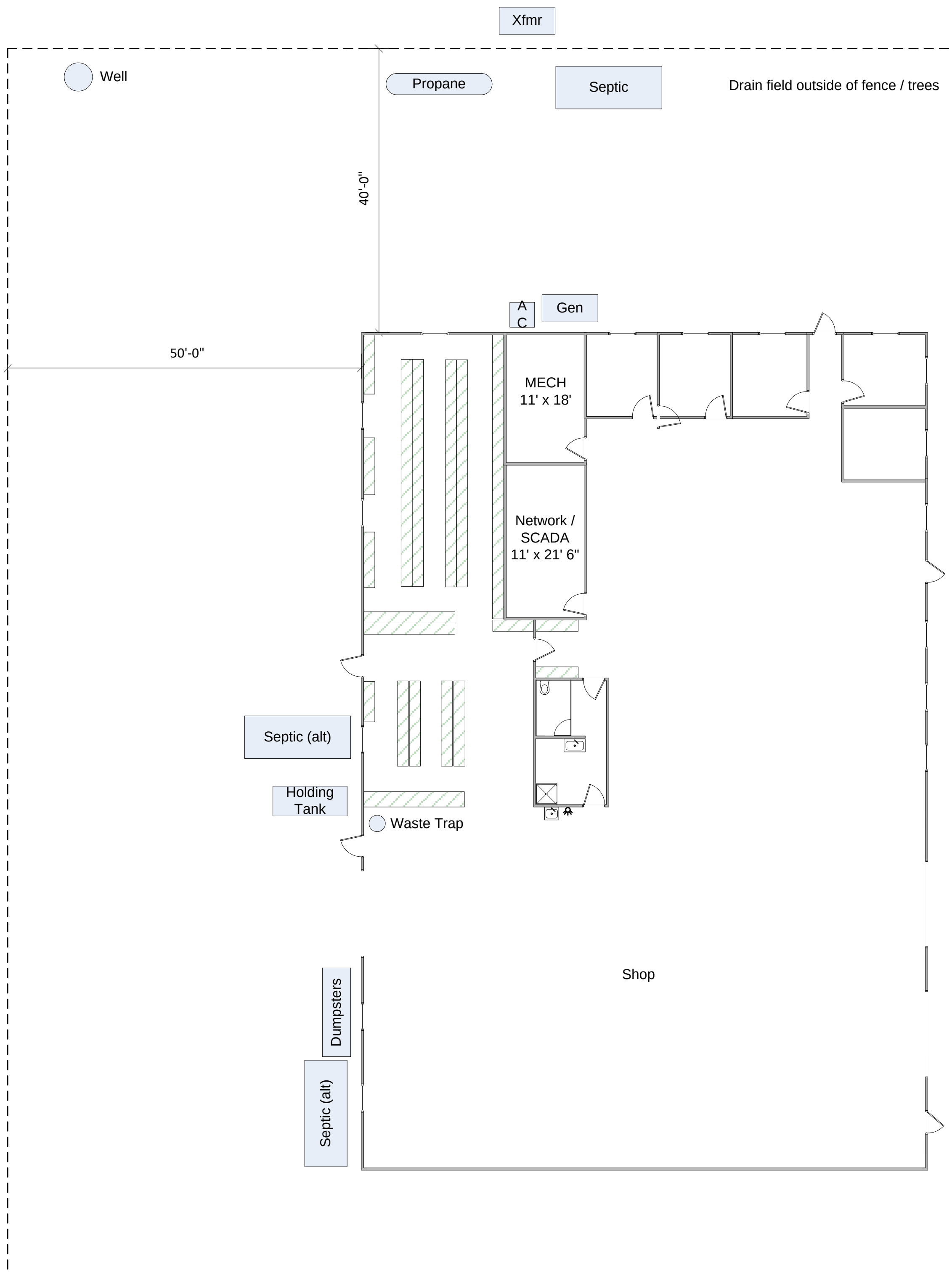


Figure 54: O&M building exterior utility layout.

1.2. Civil/Grading

1.2.1. Provide for excavation, grading, and backfilling as necessary for the construction of the Project, including coordination of installation of all utility services. Provide proper grade so that water shall drain away from the building.

1.2.2. Provide bollards around all exterior septic and plumbing systems including, but not limited to, holding tanks, septic tanks, and drain fields.

1.2.3. Drain field shall be sectioned off and protected from all construction equipment and traffic to prevent unnecessary soil compaction in the area.

1.2.4. Any fill necessary for yard development shall be clean granular fill supplied by Contractor.

1.2.5. Footing design shall be in accordance with the Geotechnical Report and associated soil testing.

1.2.6. Contractor shall provide drive accesses, as required, and shall obtain any necessary permits.

1.2.7. Provide lawns and planting for new building. Work shall be performed as follows:

1.2.7.1. Spread fertile topsoil stripped from site over all seeded grass and sod areas to a minimum of 4”.

1.2.7.2. Select vegetation shall be suitable for the location and climate and be free of weeds. Select vegetation shall be established on all disturbed land on the O&M property outside of the security fence. The Contractor shall submit the select vegetation type to be used for approval prior to planting. Disturbed areas shall be vegetated within the specified time period as indicated in the project SWPPP to minimize/eliminate runoff. All vegetated areas shall be free of weeds.

1.2.7.3. In NSP and PSCo regions, plant evergreen trees around the exterior of the fence enclosure on north and west sides of the building in order to provide protection during the winter season. On the west side of the building, the trees shall extend past the future building expansion area while the trees on the north side shall extend 100 ft beyond the building. Shrubs shall be planted on the remaining sides. Minimum tree height shall be 8 feet. Trees shall be planted every 18 feet in two rows separated by 20 feet, staggered between rows.

1.2.7.3.1. Watering and periodic inspections shall be performed and documented in a maintenance log on a bi-weekly basis.

1.2.7.4. Washed rock with landscaping fabric shall be used between the sidewalk and East wall of the building.

1.2.7.5. Landscape plan shall be submitted for approval by Owner prior to construction.

1.2.8. Provide concrete apron in front of garage doors and bituminous paved driveway and parking area for 8 cars. Work shall be performed as follows:

1.2.8.1. Contractor shall perform final grading as necessary for proper drainage, and furnish and install base and wearing surface complete, compacted, and rolled as per standards of the State’s Department of Transportation.

1.2.8.2. Area receiving concrete or bituminous paving shall have an 8” compacted base meeting Section **Error! Reference source not found.** and the paving shall be applied in two layers: 3” of plant mixed bituminous base and 1 1/2” of plant mixed bituminous surfacing.

1.2.8.3. Concrete and bituminous paving shall meet design and installation requirements per the State’s Department of Transportation Standard Specification in which the project is located.

1.2.8.4. Slope 1/8” per foot away from the building.

1.2.8.5. Stripe all parking positions as required for handicap and standard parking. Handicap parking stall shall be an end stall if possible.

1.2.9. Gravel areas shall have a minimum of 6” of compacted base or crushed gravel per Section **Error! Reference source not found.** and shall have elevations graded to accomplish a proper drainage pattern. Slope 1/8” per foot.

1.2.10. Security fencing information can be found in Section **Error! Reference source not found.**.

1.2.11. Provide 6” diameter guard posts constructed of 1/4” thick steel pipe, filled with concrete, at overhead doors interior and exterior to building. Guard posts shall be a minimum of 4 feet above the concrete and shall be designed and installed to prevent frost heave at exterior applications. Paint guard posts yellow.

1.2.12. Exterior Walls

1.2.12.1. Exterior walls shall be insulated 26 gauge pre-finished metal panel. Color selected by Owner.

1.2.12.2. Exterior walls shall have an R value in accordance with the current International Energy Code with Local and State Building Code amendments.

1.2.12.3. Exterior office area walls shall be spray foamed at least 1” thick to seal air gaps up to a height of 10 ft in the NSP region.

1.2.13. Roof System

1.2.13.1. Roof to be a standing seam metal-roof sloped with gable ends. All roofing materials are to be installed and constructed to provide a ten-year guarantee against leakage.

1.2.13.2. The roof shall have an overall R value in accordance with the current International Energy Code with Local and State Building Code amendments.

1.2.13.3. Roof sloped to drain.

1.2.13.4. Gutters provided in areas over walkways, doors, exterior equipment, or office windows. Gutters on the east wall shall only have 2 discharge locations, 1 at each end of the building to prevent ice buildup on the concrete and flooding of the rock area. Double down spouts may be required and overtopping of the gutters is acceptable during heavy rain. Include erosion measures, rock and/or splash block, from each down spout on the building.

1.2.13.5. Gutters shall incorporate back-up drain scuppers.

1.2.13.6. Detail roof edge to prevent built up snow drop-off.

1.2.13.7. Provide awnings over building access doors located on non-gable end walls. Awnings are to be directly attached to building walls, i.e. no exterior columns. Awnings shall be constructed of light gage steel.

1.2.13.8. Provide perimeter fascia with factory applied baked enamel finish and constructed of 24 gauge steel minimum. Owner will select color from manufacturer's standard colors.

1.2.13.9. Provide insulated roof curbing as required for all roof-mounted equipment.

1.2.14. Interior Walls

1.2.14.1. All interior walls shall be constructed as shown in the Design Documents.

1.2.14.2. All masonry walls are to be constructed of a minimum of 8" standard weight block.

1.2.14.3. Stud and sheet rock walls are to be framed with 3 5/8" 18 gauge metal studs, 24" o.c., and covered with 5/8" gypsum board taped and sanded to accept paint or vinyl. Provide 3 1/2" thick sound control butt insulation (FHC 25/50) as manufactured by U.S. Gypsum or equal in all walls.

1.2.14.4. All interior shop walls, to include the office/shop wall, shall be finished with white 29 gauge liner panels that extend to the ceiling.

1.2.14.5. Interior shop ceiling shall be finished with white 29 gauge liner panels

1.2.14.6. The SCADA room shall be protected with ½" thick layer of plywood under the drywall.

1.2.14.7. Men's locker room shall be built to provide an effective storm shelter and safe room constructed of 8" reinforced masonry walls or 6" reinforced concrete wall, 6" hollow core precast plank or 18 gauge roof joists and 18 gauge metal roof decking with 6" minimum concrete slab, footing depths to withstand overturning/uplift and designed to withstand wind gusts during an extreme event. Design shall be in accordance with International Code Council 500 (ICC) and FEMA P-361 Safe Rooms for Tornados and Hurricanes – Guidance for Community and Residential Safe Rooms. The locker room roof shall be used for storage and signage with roof deck rating shall be posted.

1.2.15. Doors and Windows

1.2.15.1. All doors and hardware shall comply with table below.

1.2.15.2. All doors and frames shall meet building code requirements for fire ratings. Minimum door width shall be 36".

1.2.15.3. All doors shall have locking capabilities.

1.2.15.4. All exterior doors shall push open to the north and west into the prevailing wind direction.

1.2.15.5. All exterior doors and windows shall be properly insulated to meet current energy code requirements and shall be installed per manufacturer's recommendations.

1.2.15.6. Storm shelter doors shall be equipped with 3 latch points operated by a single handle, and include a deadbolt lock.

1.2.15.7. Steel Frames and Doors

Hollow metal work shall be as manufactured by Steelcraft Mfg. or equal SDI Member, as approved. Frames shall be welded unit type with a minimum thickness of 16 gauge. Exterior hollow metal doors shall be insulated (U value of 0.24 or less). All exterior doors shall be weather-stripped. Interior hollow metal doors shall be a minimum thickness of 18 gauge. Doors constructed of aluminum are not allowed.

1.2.15.8. Interior Wood Doors

Provide flush 5-ply door construction with solid particle core bonded to stiles and rails using Type 1 waterproof glue, conforming to AWI Type PC-5. Quality grade to be AWI Premium, 1 3/4” thickness, with AWI Grade A oak face veneer on all sides and edges. All interior doors except the bathrooms, SCADA, and Mechanical shall have a vertical ¼ light glass.

1.2.15.9. Overhead Doors

Provide 24 gauge factory finished (color selected by Owner) steel insulated overhead doors with 2 foot panel sections. Minimum R value to be 4.0. Doors to have perimeter brush seal weather-stripping, and bottom astragals. Doors to have chain releases so they can be opened and closed by hand in case of power failure. Provide heavy duty cycling springs. Doors to be manufactured by Overhead Door, or equal. Provide power operators with complete control. Provide one set of controls for each door with open-close-stop functions. Provide photoelectric sensors and automatic close function.

1.2.15.10. Door Glass Lights

Provide tempered clear float glass, ASTM C1048, Type I, Class 1, q3, Kind FT, horizontally tempered, 1/4” thick, as required for door glass lights.

1.2.15.11. Door Hardware

Provide the following hardware by the listed manufacturers or approved equals:

1.2.15.11.1. Butts -- Stanley FBB199, US26D, 1 1/2 pair

1.2.15.11.2. Closer -- LCN 4010/4111 Series, Exposed overhead surface type, Alum., see table below for applicable locations.

1.2.15.11.3. Kick Plates -- Hiawatha 10” x 34”, US32D

1.2.15.11.4. Stops and Holders -- Ives, US32D

1.2.15.11.5. Push-Pulls -- Hiawatha, US32D, ADA approved

1.2.15.11.6. Lock Sets -- Schlage L9000 Series, US26D, mortised (no substitutions), Function as noted on Design Documents, ADA approved lever. All exterior doors and SCADA room lock sets shall be card reader capable and comply with security system requirements. Owner shall supply additional requirements.

1.2.15.11.7. Passage Sets -- Schlage L9010 Passage Function, US26D, mortised (no substitutions), ADA approved lever

1.2.15.11.8. All locks shall be master keyed with a restrictive key way master keying system as directed by Owner.

1.2.15.11.9. All required blank plates.

1.2.15.12. Door Detail – Install per the following table:

Location	**Material**	**Light**	**Closure**	**Handle**
Breakroom to Hall	Wood	1/4	N	Lever
Breakroom to Shop	Metal	1/4	Y	Lever
Exterior excl Vestibule	Metal	1/4	Y	Lever Lock / Card
Hall to Shop ceiling	Metal	1/4	Y	Lever
Mechanical	Wood	None	N	Lever
Offices & Conference	Wood	1/4	N	Lever Lock
Restroom - Guest	Wood	None	Y	Lever Lock
Restroom – Mens	Metal	None	Y	Lever lock w/3 point
Restroom – Womens	Metal	None	Y	Lever
Restroom – Womens to Hall	Wood	None	Y	Lever
SCADA	Wood	None	Y	Lever Lock / Card
Vestibule – Exterior	Metal	1/2	Y	Lever
Vestibule – Interior	Metal	1/2	Y	Lever Lock / Card

1.2.15.13. Exterior Windows

All windows shall be of vinyl construction. Face shall snap out for easy glass replacement. Windows shall be tinted insulated glass units; IGCC Class CBA when tested per ASTM E773 and E774; dual sealed unit with primary polyisobutylene seal, secondary silicone seal. Provide outer and inner lights of ¼” thick tinted glass conforming to ASTM C1036 Type I, Class 1, q3; and a ½” argon filled airspace; total thickness of 1”. Windows shall have a U value in accordance with the current International Energy Code with state building code amendments.

Operable windows shall be gliding type and shall be located in all offices and break room.

1.2.16. Admin Area Desk

1.2.16.1. Construct a built in reception style desk with studs and drywall for the veritical frame and 24” deep countertops for the sit down desk and 15” deep countertops for the walk up portion. Overall height to be 42”.

1.2.17. Finishes

1.2.17.1. Ceramic Tile

1.2.17.1.1. Ceramic tile shall be installed, grouted, cleaned, protected, and cured per standard specifications of the American National Standards Institute (ANSI) and the Tile Council of America (TCA). Grout shall be Latex-Portland Cement Tile Grout as made by Custom Building Products, Mapei Corp. or approved equal. Grout and ceramic tile colors to be selected by Owner.

1.2.17.2. Floor Tile

1.2.17.2.1. Provide ceramic standard mosaic floor tile with smooth, all-purpose edge. Tile shall be 1’ x 1’ unglazed as manufactured by American Olean or approved equal. Provide all special shapes as required.

1.2.17.3. Wall Tile

1.2.17.3.1. Provide standard glazed 6” x 6” or 4” x 4” wall tile as manufactured by American Olean or approved equal. Provide all special shapes as required. Wall tile shall cover all locker rooms and unisex bathrooms to a minimum height of 4’-6” from the top of finished floor.

1.2.17.4. Ceiling Treatment

1.2.17.4.1. For ceilings outside the high bay area, but excluding the SCADA room, Vestibule, and Mechanical Room, provide a lay-in type ceiling. Lay-in ceiling shall be a 24” x 24” with 15/16” exposed white grid system. Grid system shall be USG Interiors or approved equal. Acoustical panels shall be non-combustible (Flame Spread A), smooth-texture with reveal edge, factory white finish similar to USG Interiors, Millennia ClimaPlus 76705, 2’ x 2’ x ¾”, SLT edge. Acoustical ceiling panels to have a minimum Noise Reduction Coefficient (NRC) rating of 0.7, Ceiling Attenuation Class (CAC) of 35 minimum and Light Reflectance of 85 (LR-1).

1.2.17.4.2. SCADA room and the Vestibule ceiling shall be covered with 5/8 gypsum board taped and sanded to accept paint or vinyl and backed with 3 ½ thick sound control butt insulation (FHC 25/50) as manufactured by U.S. Gypsum or equal.

1.2.17.4.3. Mechanical Room ceiling to be metal panel or drywall at full building height.

1.2.17.5. Resilient Flooring

1.2.17.5.1. Clean and prepare floors as necessary for proper application of vinyl tile. Provide 12” x 12” x 1/8” thick vinyl composition tile (VCT) similar to Armstrong “Excelon” or Tarkett “Expressions.” Owner will select colors from manufacturer’s standard colors.

1.2.17.6. Carpet

1.2.17.6.1. The following manufacturers meet Owner’s standard for carpet tiles:

Constantine Commercial

Mannington

Lees

1.2.17.6.2. Yarn

100% advanced generation nylon such as type 6.6 produce by:

BASF

DuPont

Monsanto

1.2.17.6.3. Minimum yarn wt. 26 oz.

1.2.17.6.4. Minimum construction features

Pile height 0.170 to 0.28 inches

1/8 gauge with 8 stitches per inch or,

1/10 gauge with 10 stitches per inch

1.2.17.6.5. Primary Backing Synthetic

Polypropylene

1.2.17.6.6. Vinyl Base

Provide 4” high vinyl base as manufactured by VPI, Johnsonite or approved equal. Use coved base with vinyl composition tile (VCT) and carpet tiles. Colors to be selected by Owner from manufacturer’s standard colors.

1.2.17.7. Paint

1.2.17.7.1. Strictly follow manufacturer’s recommendations for surface preparation and paint application. Colors to be selected by Owner. Paint to be Benjamin Moore, Sherwin-Williams or approved equal.

1.2.17.7.2. Wood

Sand and prepare surfaces to receive finish. All finished hardwood to receive one coat of stain, one coat of sealer, and two coats of varnish.

1.2.17.7.3. Metal

All metal doorframes and doors and miscellaneous metals shall receive one coat of primer and two coats of enamel.

1.2.17.7.4. Interior Walls

Masonry interior walls shall receive one coat of block filler and two coats of finish paint. Gypsum board walls shall receive one coat of primer and two coats of finish paint.

1.2.17.7.5. Exterior Walls

Exterior walls to be finished as required by the exterior wall material. If exterior walls are masonry, apply one coat of block filler and two coats of enamel.

1.2.17.8. Millwork

1.2.17.8.1. Provide custom millwork in the breakroom consisting of upper and lower cabinets with stove and fridge cutouts in the location shown on floor plan Figures 10-12. Cabinets shall fill the area from wall to wall, include a short upper cabinet for a microwave over the stove, and be similar in arrange to the reference picture at the end of this section. Millwork shall be, of quality fire retardant particleboard core finished with wood veneer (AWI “premium” grade) or plastic laminate (NEMA LD 3, GP-50 for horizontal surfaces and GP-28 for vertical surfaces). Pattern and color selected by Owner. Tops to be 1 3/4” thick and sides to be 3/4” thick. Countertops and Vanities are to have a 4” backsplash. Provide adequate bracing hidden from view.

1.2.17.9. Lockers – 72” tall lockers shall be installed in both restrooms and shall be wall hung with an integrated bench. Owner to specify quantity relative to building size.

1.2.17.10. Finish Schedule – See Table 1, all final colors subject to Owner approval.

Table 1: Finish schedule.

Material	Color	Location
Acoustical grid	White	
Acoustical tile	White w/reveal edge	
Canopy	Brown	
Canopy soffit	White	
Carpet tile	Dark blue speckled w/various	Offices, conference
Ceramic floor tile	Matt dark grey, light black	Restrooms, vestibule
Ceramic grout	Pewter	Restrooms, vestibule
Ceramic wall tile	Matte grey / smoke	Restrooms
Door hardware	Satin Nickel	
Laminate cabinet	Honey oak to light cherry	Break room
Laminate countertop	Matte black marble	Break room, restrooms, admin
Locker	Tan	Restrooms
Locker bench	Honey oak	
Metal roof panel	Galvalume	Roof
Metal trim	Tan	Exterior
Metal wall panel	Tan	Exterior
Metal wall panel	White	Shop/parts walls and ceiling
Outlet cover	Light almond	All but shop/parts
Outlet cover	Steel grey	Shop, parts
Overhead door	Brown	Shop
Paint	SW 6101 Sands of Time	Vestibule, admin, hallways
Paint	SW 7059 Unusual Grey	All other areas
Plumbing fixture	Satin Nickel	
Steel door and frame	Black	
Toilet Partition	Slate	
VCT	Tan	Breakroom, SCADA, hallways
Vinyl base	Black	
Wood door	Light cherry	

1.3. Structural

1.3.1. The Work under this section shall include the complete construction of all concrete work on the Project for concrete footings, floors, sidewalks, and all necessary accessories, setting of anchor bolts, ties, etc.

1.3.1.1. All concrete shall have a minimum compressive strength per Section **Error! Reference source not found.**:

1.3.1.2. Provide two (2) coats of sealer over all concrete slab-on-grade areas per manufacturer's recommendations, except those areas receiving floor finishes, e.g. VCT tile, carpet, etc. Sealer to be Sonneborn, Tremco, or equal.

1.3.1.3. Provide cork expansion joint material, ASTM D1752-67, Type II in expansion joints for interior work as required, and seal over with Vulkem 116 or equal. Provide fiber expansion joint material, Flexcell or equal in expansion joints for exterior work as required, and seal over with Vulkem 200 or equal.

1.3.1.4. Concrete reinforcement shall be shop fabricated per design drawings. Field bending of reinforcement shall be in accordance with applicable sections of ACI 318. Shop drawings shall be submitted for review prior to construction.

1.3.1.5. Column anchor bolts, dowels, reinforcement, embed plates, etc. shall be supported by chairs, bolsters, bar supports, spacers, etc. prior to concrete placement. "Wet Setting" of reinforcement, dowels, anchor bolts, embed plates, etc. is not allowed.

1.3.1.6. Embeds for shop floor drain shall be galvanized.

1.3.1.7. Floor slab and aprons to be 6" thick minimum, and sidewalks to be 4" thick minimum.

1.3.1.8. Slope exterior concrete surfaces away from the building. Sidewalk slope shall be at least ¼" per foot while driving paths and parking lots shall be sloped at least 1/8" per foot.

1.3.1.9. Concrete Specialties

1.3.1.9.1. Provide concrete steps or aprons at personnel door(s), overhead doors, and at bottom of stairs.

1.3.1.10. Construction

1.3.1.10.1. Contractor shall require that the concrete subcontractor has a minimum of 3 years of experience with commercial concrete construction and concrete floor finishing.

1.3.2. Foundation wall and under slab insulation, when required by location, shall be extruded polystyrene board insulation, ASTM C578, Type IV, 1.6 pcf density minimum, "k" factor of 0.20 at 75 deg. F (R-5), 25 psi minimum compressive strength, 0.3 percent maximum water absorption by volume, square edges, manufacturer's standard board size, such as Styrofoam SM manufactured by Dow Chemical Co., Foamular 250 manufactured by Owens Corning, or approved equal. Thickness noted on Design Documents. Install on the perimeter of the foundation and wrap around under the concrete slab floor 4'-0".

1.4. Electrical

1.4.1. All Electrical Works shall be in accordance with the regulations of the latest edition of the National Electrical Code and all state and local codes. All wiring to be copper and in conduit.

1.4.2. Service Entrance

1.4.2.1. The local utility shall provide a transformer and primary service to the transformer. Contractor shall provide the secondary service into the building and is responsible for verifying the entrance location with the local utility. Contractor shall be responsible for the coordination with the local utility on the placement of the transformer. Contractor shall coordinate with local utility in metering installation.

1.4.2.2. The electrical service to this building shall be single phase and sized to accommodate all electrical loads with 30% contingency and a 400 amp minimum. The service entrance equipment shall be grounded per code, and the grounding conductor installed in conduit.

1.4.3. Power Distribution

1.4.3.1. Provide a Square D or equal panel board type NQOD.

1.4.3.2. Provide panel board identification with an engraved plastic laminate nameplate.

1.4.3.3. Panelboards shall have Square D QO breakers rated for a minimum of 10,000 A.I.C. at 240V Panel boards to be suitable for use as service entrance equipment and shall have a hinged door and lock.

1.4.3.4. Panel boards shall have a minimum of 42 circuits and a 200A minimum bus rating. Contractor shall size breakers and provide power for all electrical loads.

1.4.3.5. Provide a typed directory of circuits mounted behind clear plastic inside the panel board door.

1.4.4. Lighting System

1.4.4.1. Provide lighting throughout the building as follows:

1.4.4.1.1. All rooms except shop, parts storage, and mechanical room: Lay-in type 2, 3, or 4 lamp LED fixtures with parabolic lens, electronic ballasts, T-8 lamps, lighting level 40 foot-candles at 3 feet off floor, Lithonia or equal.

1.4.4.1.2. Shop, parts storage, and mechanical room: Industrial type 2 lamp, 4 and/or 8 foot long LED fixture with baked enamel reflector, electronic ballast, T-8 lamps, lighting level 20 foot-candles at 3 feet off floor, Lithonia or equal.

1.4.4.1.3. Exterior: LED wall mounted fixtures suitable for outdoor wet location centered on each exterior wall (quantity 4), prismatic lens, factory installed photo electric control on each fixture.

1.4.4.1.4. Exit Lights: LED type exit lights.

1.4.4.1.5. Recessed can light with shower trim in each shower stall.

1.4.5. Wiring Devices

1.4.5.1. Shop to have quiet toggle wall switches. Switches shall be rated at 15 or 20 A, 120 VAC. Switches shall be similar to Hubbell 1221 Series. Receptacles shall be similar to Hubbell 5262 Series.

1.4.5.2. Furnish and install occupancy sensors in offices, conference room, break room, mechanical room, SCADA room, small parts room, locker rooms and restrooms.

1.4.5.3. Switches and receptacles shall be light almond in all areas except the shop, which shall be gray. Cover plates shall match switches and receptacles in all areas except for shop and parts storage areas where the covers shall be galvanized steel.

1.4.5.4. Provide a 240 VAC outlet in the shop to the south of the west garage door and to the south of the man door from the office to the parts area.

1.4.5.5. Provide a 240 VAC outlet in the Men's Locker room for the stackable washer and dryer unit.

1.4.5.6. Provide one 120 VAC exterior receptacle on each side and in between the two shop overhead doors and one 120 VAC exterior receptacle on each of the remaining 3 sides of the building.

1.4.5.7. Provide a 120 VAC flush mount floor receptacle in the center of the conference and break rooms.

1.4.5.8. Provide two 120 VAC twist lock 30A receptacles and one 120 VAC 20A duplex receptacle to Owner corporate network rack. Receptacles shall be mounted in 4 square boxes. Owner to confirm mounting locations.

1.4.5.9. Provide two 120 or 240 VAC 30A circuits and one 120 VAC 20A circuit to each Turbine Supplier server cabinet. Confirm size with Turbine Supplier.

1.4.5.10. Provide 5 lug ground bar that is grounded directly to the service ground mounted on the wall of the SCADA room.

1.4.6. Communications/Data Telephone System

1.4.6.1. Contractor shall provide all necessary wire and conduit/raceway including conduit for communications/data needs. Communication circuits shall be ran in cable tray above ceiling with conduit extending down into walls.

1.4.6.2. A single wall box with 2 data ports is required in each office, parts room, admin area, and conference room.

1.4.6.3. The break room shall have 2 wall boxes with 2 data ports each with both located on the wall between the break room and the shop.

1.4.6.4. Flush mounted floor boxes with 3 data ports shall be installed in the center of the conference room.

1.4.6.5. Flush mounted floor boxes with 7 data ports shall be installed in the center of the break room.

1.4.6.6. Provide a telephone jack in each of the wall and floor boxes listed above.

1.4.6.7. All Ethernet wiring shall be Cat 6 type cable.

1.4.6.8. Coordinate installation work with local telephone Owner and Owner's Communication Technicians.

1.4.6.9. Owner will order communication circuits.

1.4.7. Low Voltage Wiring

1.4.7.1. Provide all low voltage wiring for HVAC control and run in conduit.

1.4.8. Back-up Generator

1.4.8.1. Contractor shall supply and install a propane powered Generac, or Owner approved equivalent, back-up generator with the extreme cold weather kit. Generator capacity shall be 40kVA

1.4.8.2. Contractor shall supply and install an automatic transfer switch and a propane vaporizer.

1.4.8.3. All items related to the backup generator require Owner approval.

1.5. Mechanical

1.5.1. Plumbing

1.5.1.1. Contractor shall furnish and install all plumbing work in strict accordance with the State Plumbing Code and requirement of the municipality.

1.5.1.2. Contractor shall be responsible for the proper designing, sizing, and installation of all piping and equipment, specialties, etc. to provide a complete and professional plumbing design and installation.

1.5.1.3. Vehicle parking area of shop shall include a floor trench drain that flows into a minimum 260 gallon oil and water separator located to the south of the west wall garage door and then into a holding tank located outside to the north of the west wall shop door. Minimum trench width shall be 12” and depth shall be 8" below the bottom of the grating at the low point. Grating shall be galvanized.

1.5.1.4. Mechanical Room floor drain shall be positioned to allow all equipment to drain to it without the use of a condensate pump or in the walk path to the slop sink.

1.5.1.5. Provide drain in SCADA room for wall mount AC unit.

1.5.1.6. Drain line from the building to the septic tank shall be at a depth to prevent freezing from HVAC condensate flow.

1.5.1.7. The following piping shall be insulated when required by location: domestic water, refrigerant, roof drain piping.

1.5.1.8. Domestic water and refrigerant piping shall be type L copper tubing with soldered joints and fittings using lead-free No. 95-5 solders. All valves shall have brass bodies and shall be designed for a working pressure of 125 PSI. Alternatively, domestic water pipe material may be PEX type upon owner approval.

1.5.1.9. All water supply lines shall be insulated with foam pipe insulation when required by location.

1.5.1.10. Water closets – furnish floor mount, elongated rim, vitreous china water closet with tank and solid plastic open front seat. Unit to be the Toto brand. Units are to be suitable for the handicapped and mounted in accordance with ADA requirements.

1.5.1.11. Urinal – Furnish wall hung, vitreous china washout urinal and flush valve. Unit to be equal to American Standard Lynbrook 6601 with Sloan Royal Model 180-ESS flush valve.

1.5.1.12. Lavatories – Lavatory consoles are to be furnished per Design Documents. Vanity surface is to be a high-pressure plastic laminate, color and design to be selected by Owner. Lavatory unit to be vitreous china, front overflow unit. Provide fauctet and pop-up drain assembly. Console and faucet shall conform to all code requirements for the handicapped. Stand-alone sink units are not acceptable.

1.5.1.13. Water Heater – Furnish a U.L. listed tank less water heater. Unit and its installation to conform to all code requirements.

1.5.1.14. Slop Sink - Provide a 36" x 24" x 10" molded stone service basin with shelf and vinyl bumper guards on exposed faces. Equip with Chicago chrome plated service mixing faucet with vacuum breaker, wall brace, pail hook, and 3/4" hose thread on spout with 30" long 5/8" rubber hose with 3/4" chrome coupling. Provide 24" high water proof wall boards above sink basin on wall(s) adjacent to the sink along with a mop hanger above unit with three (3) rubber tool grips. Service basin to be Fiat or equal. Sink shall be located in the mechanical room.

1.5.1.15. Wash Tub - Provide a 24" x 24" wash tub in the shop between the bathroom doors. Sink shall have both hot and cold water supplied to it, along with a drain. A separate cold water hose bib shall be located next to the sink.

1.5.1.16. Eye Wash - Provide a wall mount eye wash station with drain next to the shop sink. Eyewash shall meet all applicable OSHA regulations and supply temperate water. Mixing valve shall be near the unit and accessible from ground level.

1.5.1.17. Hose Bibs – Provide freeze less hose bibs, one on each side of the building.

1.5.1.18. Domestic water, waste, and vent piping fittings and joints shall be in accordance with the State Plumbing Code and applicable local ordinances. Insulate hot and cold domestic water pipes with 1" minimum fiberglass insulation by Certainteed or equal insulation when required by location.

1.5.1.19. Break Room Sink -- Provide Elkay LR series or equal Stainless Steel sink with duo strainer and faucet.

1.5.1.20. Shower -- Provide molded fiberglass shower cabinets complete with 32" x 32" base with drain, door, Chicago or equal flow saver shower head with single lever hot and cold water operator, soap dish, and shampoo bottle holder. Cabinet to be approximately 6'-6" high and shall be seamless, rustproof, and leak proof.

1.5.1.21. Washer and Dryer hookups – Provide hot and cold water and drain hookups for stackable W/D unit in the Men's Locker Room.

1.5.1.22. Cleanout -- Provide cleanouts in areas behind water closets and as required by code.

1.5.1.23. Faucets – All faucets shall be dual handle controlled. Auto sensing devices shall not be used.

1.5.1.24. All plumbing faucets, fixtures, etc. shall be of commercial grade. Brand, type, style and color shall be approved by Owner prior to installation.

1.5.2. HVAC

1.5.2.1. Heating, ventilation, and air conditioning work shall be done in strict accordance with all applicable codes, including the State Mechanical Code, requirements of the municipality, and ASHRAE recommendations.

1.5.2.2. HVAC system shall be designed and sized to meet regional climate conditions. See Section 1.5.2.4.3 for Northern States Power regional HVAC system requirements.

1.5.2.3. Recommended Manufacturers

1.5.2.3.1. Trane

1.5.2.3.2. McQuay

1.5.2.3.3. AAON

1.5.2.3.4. York

1.5.2.4. General

1.5.2.4.1. Multi-zone air distribution using variable air volume (VAV)

1.5.2.4.2. Good indoor air quality design

1.5.2.4.3. All thermostat locations shall be in room programmable units with a minimum 5-2 day program and be hard-wired to a circuit board zone controller. Wireless devices are not allowed.

1.5.2.5. In-floor Heat

1.5.2.5.1. Hydronic in-floor radiant heat system shall be installed in regions subject to prolonged freezing conditions and shall be manufactured by Wirsbo or equivalent, and zoned to match forced air zones (zones to be approved by Owner).

1.5.2.5.2. Propane or gas boiler with at least 92% efficiency

1.5.2.5.3. Radiant or forced air propane or gas heaters shall be installed in the shop area in regions where radiant floor heat is not used. Placement and quantity to depend on climate and be approved by Owner.

1.5.2.6. Forced Air Furnace

1.5.2.6.1. Propane or gas furnace with at least 92% efficiency

1.5.2.6.2. 30% efficient pleated 4 inch throw away filter

1.5.2.6.3. Supply and return casing

1.5.2.6.4. Variable speed supply air drive with premium efficiency motor

1.5.2.6.5. Economizer package

1.5.2.7. Air Conditioner

1.5.2.7.1. Minimum EER or SEER ratings for package cooling unit to meet current Code requirements

1.5.2.7.2. Low-ambient operation control

1.5.2.7.3. 5 year compressor warranty

1.5.2.8. SCADA Room

1.5.2.8.1. Ductless mini-split air conditioning unit. Condensing unit to be mounted on the ground in shop area along the bathroom wall..

1.5.2.9. Shop Ventilation

1.5.2.9.1. Provide shop ventilation system with CO detector with manual override timer.

1.5.2.10. Exhaust Fans

1.5.2.10.1. Provide Greenheck vent set exhaust fans, complete with insulated roof curbs, bird screens, and back draft dampers. Restroom fans shall provide a ventilation rate meeting current Mechanical Code and ASHRAE requirements for restroom areas. Exhaust fans shall be controlled by the room automatic light switch. Provide for make-up air. Units shall be U.L. listed. Exhaust ductwork shall have 1-1/2” exterior insulation with foil extending from the roof curb to at least 6’-0” from the roof curb.

1.5.2.11. Ductwork Systems

1.5.2.11.1. All ductwork, construction, and installation shall be in accordance with latest SMACNA standards. Ductwork shall be isolated from fans and furnace via flexible connections. Ductwork shall be equipped with fire dampers as required by codes. Branch ducts in mains shall be equipped with dampers for balancing. Flex duct shall be used for the run outs to supply air diffusers. Flex duct runs shall be no longer than 5’-0” long. Each run out to each diffuser shall be equipped with a butterfly type balancing damper. Supply air ductwork shall be insulated with minimum 1-1/2” thick glass fiber exterior duct insulation with foil vapor barrier. Insulation conductivity not to exceed 0.25 BTU/in./sq. ft./hr. at a mean temperature to 75° F.

1.5.2.12. Diffusers

1.5.2.12.1. Provide Price, Titus, Hart & Cooley or equal square lay-in 2’ x 2’ adjustable pattern supply air diffusers.

1.5.2.12.2. Diffusers shall provide ability to manually adjust air flow in each room.

1.5.2.13. Return air ducts shall be wall mounted near the floor.

1.5.3. Security and Fire Alarm system

1.5.3.1.1. Building and Site shall include a security system provided and installed by VTI Security.

1.5.3.1.2. The system shall include card readers, associated door handles and locks, and fixed interior cameras on all exterior doors and all controlled access areas within the building as specified by Owner, two exterior mounted PTZ tower cameras and 1 fixed exterior camera with locations specified by Owner, operable entrance gate with loop detector, photo eye sensor, and call box with external dialing capabilities and pin hole camera.

1.5.3.1.3. The security system shall have a UPS, local control pad and monitor, video recording capabilities, and be linked to Owner's Security Operations Center.

1.5.3.1.4. Smoke detectors shall be installed throughout the building in a quantity large enough to effectively detect a fire.

1.5.3.1.5. Detectors shall be hardwired to a central alarm panel in the Mechanical Room, and be supplied with all necessary equipment to send an alarm signal to the Xcel Energy Security Operations Center.

1.6. Submittals

1.6.1. Contractor shall submit construction drawings for approval by Owner prior to construction.

1.6.2. Contractor shall submit to Owner copies of all equipment operating and maintenance manuals.

1.6.3. Contractor is responsible for submitting all extended warranty certificates of equipment.

1.6.4. Contractor shall submit a training plan for the O&M building operations and conduct training with select Owner personnel after the building is completed.

1.6.5. See Section **Error! Reference source not found.** for more submittals information.

1.7. Reference Pictures

1.0 PURPOSE

1.1 To reduce the vulnerability of cyber-attack, specific requirements for cyber-security administration, monitoring, protection and oversight are applied to cyber assets within electric generating facilities.

1.2 This policy implements cyber-security requirements of the NERC Critical Infrastructure Protection (CIP) reliability and compliance program, standard CIP-003-8, "Cyber-Security – Security Management Controls" applicable to facilities designated at the low impact level. In addition, selected principles as recommended by the National Institute of Standards and Technology (NIST) are included, such as: isolation of mission-critical systems from public access; a clear delineation of logical security boundaries; use of a protected, layered architecture; least privilege access control, information protection, and operation under the assumption that any external network connection is insecure. A generalized reference architecture depicting the concepts of this policy is shown in Attachment 1.

2.0 APPLICABILITY

2.1 This policy applies to all Xcel Energy Bulk Electric System (BES) generating facilities that meet the following conditions:

2.1.1 Are identified as CIP regulated at the low impact level under the corporate program for BES Cyber System Identification and Categorization [CIP-002-5.1a].

2.1.2 Contain BES Cyber Systems (BCSs) that provide named reliability operating services. For Energy Supply, these services are in the following categories: Dynamic Response to BES conditions; Controlling Frequency; Controlling Voltage; Monitoring and Control; Restoration of the BES; and Situational Awareness [CIP-002-5.1a].

2.1.3 Utilizes microprocessor based data acquisition systems that collect or store potentially sensitive or proprietary information. This includes, but is not limited to unit and equipment operating status, production and consumption rates and environmental data.

2.2 Facilities regulated by the U.S. Nuclear Regulatory Commission are exempt from this policy.

3.0 RESPONSIBILITIES

3.1 Performance Optimization Fleet Engineering Director is responsible for designating a Regional System Administrator for each operating region (SPS, PSCo, and NSP).

3.2 Regional Systems Administrators (or delegate) are responsible to develop and document a Plant Process Network Cyber Security Plan in compliance with this policy, and initiate review and approval by Regional System Administrators. This shall include, but not be limited to:

3.2.1 Limit BCS access to those staff who need access to perform their jobs; the type and level granted shall be the minimum level required to perform the assigned work. User Name and Password authentication shall be used for all access to any device on a BCS plant network. For these systems, the default manufacturer's password shall be changed to unique and strong passwords, where technically feasible (exceptions are documented). If a unique login is not technically feasible or will prevent an individual from being able to perform their job responsibilities in a reasonable manner a documented exception will be required.

3.2.2 Provide guidance, development assistance, and approvals for Plant Process Network Cyber Security Plans.

3.2.3 Firewall administration, including final approval and implementation of rule sets and changes to them, as justified by business need.

3.2.4 Documenting the business justification and approval for rules not being logged

3.2.5 Rules that are turned off, including factory defaults, should be properly documented

3.2.6 Compliance review and approval of the plant cyber-security plan every 15 calendar months.

3.2.7 Investigation and disposition of suspected cyber-security incidents, notification of the Cyber Defense Center (CDC) if indicated, and filing of required forms in ProjectWise.

3.2.8 Logical access to each plant BCS network shall be managed by the designated Regional System Administrator and backup, who shall review and approve the rule change form submitted by the plant network administrator where applicable.

3.3 Energy Supply CIP Senior Consultant is responsible for:

3.3.1 Review and update of this policy every 15 calendar months.

3.3.2 Update LMS course: “Plant Network Cyber-Security” every 15 months

3.3.3 Review administrator access for Regional System Administrators every 15 months

3.4 Plant Managers and Directors are responsible to provide equipment, software, and facility resources as needed to support requirements of this policy.

3.5 Plant improvement projects Project Initiators are responsible to plan for cyber-security compliance at the project initiation stage, and incorporate cyber-security implementation tasks required to comply with this policy into the project cost and schedule prior to funding and approval. Project planning for cyber-security shall employ the Enterprise Project Management (EPM) system, in accordance with policy “Screening of Projects for Impact on NERC Compliance Program (XES 7.405)”.

4.0 REQUIREMENTS

4.1 CIP 003 – 8 Requirements

4.1.1 Requirement 1.2.1 - Cyber-Security Awareness: All Regional Systems Administrators, delegates, and their management supporting execution of this policy shall maintain current completion status to LMS course: “Plant Network Cyber-Security”, ESNERC006, to maintain awareness of cyber-security requirements, on a refresh interval not to exceed 15 months. Corporate Program “XEL-PRO-CIP Training and Awareness Program covers the Awareness requirements for Low-Impact cyber systems.

4.1.2 Requirement 1.2.2 - Physical Security: Adherence to the “XEL-PRO-CIP Physical Security of Low Impact BES Cyber Systems” “policy is required to ensure adequate physical security at BES plants. Electronic locks and keys have been implemented at all of the plant physical security perimeters. Electronic keys have been assigned to plants and are to be logged in and out using electronic logging (eLog). Where keys were not assigned to plants they were assigned to individuals and to be used by that individual only.

4.1.3 Requirement 1.2.3 - Electronic Access Controls: only permit necessary inbound and outbound electronic access when using a routable protocol entering or leaving the asset between low impact BES Cyber System(s) and a Cyber Asset outside the asset containing low impact BES Cyber System(s). Only authorized, authenticated access to plant networks is permitted. All external communication links shall be reviewed, justified by confirmed business need, approved by Regional System Administrators, and documented and stored in the approved secure repository.

4.1.3.1 Plant network connections shall be protected by a stateful firewall, denied by default, with approved access allowed, as approved by the Regional Systems Administrator.

4.1.3.2 Direct internet access by any device on the BCS is prohibited.

4.1.3.3 Firewall ruleset change requests shall be submitted for Regional System Administrator approval and action using the active form “ES Firewall rule change request form, EPR 4.200A02”. The Regional System Administrators or designee shall file the completed forms, after disposition of the request, in the approved secure repository.

4.1.4 Requirement 1.2.4 - Cyber-Security Incident Response: All suspected cyber-security incidents shall be reported to the Regional System Administrators or delegate immediately upon suspicion of anomalous activity.

Anomalous activity is that which remains unexplained after normal plant investigation, and includes the unexpected:

4.1.4.1 loss of execution of system functions;

4.1.4.2 loss of network connections;

4.1.4.3 detection of new, unauthorized external connections;

4.1.4.4 unauthorized system access,

4.1.4.5 antivirus / malware alerts; or

4.1.4.6 general abnormal activity.

The Regional System Administrator has lead responsibility to investigate the suspected cyber incident and complete the investigation within two weeks of identification. Incident responses shall be documented using the EPR 4.200A04 “Energy Supply Cyber-Security Incident Response Checklist”. If the reported cyber incident is suspected to be of malicious intent, and not the result of an inadvertent error or equipment failure, the Regional Systems Administrator shall engage the Cyber Defense Center Hotline at (303) 571-7171, and lead or assist in the subsequent investigation and mitigating actions. Energy Supply shall participate in cyber-security incident response drills at least once every 36 calendar months as led by the involved corporate team

4.1.5 Requirement 1.2.5 - Transient Cyber Assets and Removable Media malicious code risk mitigation: Antivirus software including manual or automatic updates, OR application whitelisting, OR another method to mitigated malicious code shall be used on any device plugged into a BES Cyber System

4.1.5.1 For transient cyber assets managed by party other than Xcel Energy a review will be conducted of antivirus update, OR review of the antivirus update process, OR review of application whitelisting, OR review of use of live operating system and software executable only from read-only media, OR review of system hardening, OR other methods to mitigate the introduction or malicious code

4.1.6 Requirement 1.2.6 - CIP Exceptional Circumstances: Xcel Energy Supply follows the *Exceptional Circumstances Procedure* to review and document situations that may warrant suspension or delay in implementing certain compliance requirements as allowed by CIP standards.

4.1.7 Requirement 2 - Cyber Security Plans: each Regional System Administrator or delegate shall prepare and update a plant process network cybersecurity plan every 15 calendar months.

The Regional Systems Administrator shall review and approve the plan to ensure the required elements as stated in this policy and template EPR 4.200A01 ‘Plant Process Network Cyber-Security Plan Template’ are addressed. The plan shall be filed in a designated document repository location approved for protected Confidential and Confidential Restricted information. Plan content shall include:

4.1.7.1 An inventory of all systems with external connectivity (individual devices do not need to be listed).

4.1.7.2 An inventory of all plant network electronic access points. All assets containing low impact BES Cyber systems shall implement electronic access controls to permit only necessary inbound and outbound electronic access when using a routable protocol entering or leaving the asset between low impact BES Cyber System(s) and a Cyber Asset outside the asset containing low impact BES Cyber System(s). These access controls shall be identified and shown in cyber-security plans.

4.1.7.3 A network diagram that clearly shows the physical connection the electronic access point, the electronic security perimeter, and all devices to which logical access is provided. Plant network communication access points shall be clearly identified if they control BCS logical access. Inbound and outbound traffic through the access point shall be limited to essential communications only. The network diagram may group devices by system or functionality, to show overall connectivity.

4.1.7.4 The plan shall identify and reference procedures to perform system backup and recovery of BCSs. System backup shall be performed at least every 15 months, or, no less than prior to and after every major controls modification. Backup media shall be protected from unexpected catastrophic failure.

4.1.8 Requirement 3 – CIP Senior Manager Approval: The CIP Senior Manager is David Harkness and evidence of this can be found here: XEL-EVD-CIP Senior Manager Delegation

4.1.9 Requirement 4 – CIP Senior Manager Approval Delegation: Adherence to the XEL-PRO-CIP Delegation of Authority Procedure will be observed for the Delegation of Authority for Energy Supply

4.2 Additional Security Practices

4.2.1 Internal Connectivity: Plant control networks containing cyber assets with generation capacity that exceeds 1500 MW in a single Interconnection will be evaluated for a higher classification. Reasonable effort is made in order to maintain a low classification including but not limited to sectionalizing.

4.2.2 Remote Station Control: plant control networks shall not control more than one other BES facility, remote from the facility. Remote plant controls shall be isolated from the host plant network. [CIP-002-5.1a]

4.2.3 Use of Security Zones: Whenever possible, equipment of similar function and security access control needs should be placed in the same subnet

4.2.4 Operating System and Application Whitelisting: BCS servers should be configured so that only those programs that are needed for operation and are trusted are installed.

4.2.5 Remote Access to Plant Networks: Remote access to plant networks shall be restricted to those authorized with an approved business need, documented and controlled. Use of an Xcel Energy computer with current cyber-security endpoint protections, an encrypted connection, and user authentication is required. When available, additional controls should be applied, including:

4.2.5.1 Restriction to only required processes and applications, using role based access control; and

4.2.5.2 Use of an intermediate system, such as a jump server, to limit installed applications to those needed, that has native malware protection, and requires a separate user authentication prior to connection to plant networks.

4.2.6 Current Operating Systems, Applications and Hardware: Plant networks should have current operating, hardware and software systems that are supported by the involved manufacturers to provide current antivirus and malware signatures and operational patches. A plant improvement project request shall be submitted using the EPM system if any plant network equipment is no longer supported by the vendor and requires upgrade in order to maintain current cyber-security protections.

4.2.7 Patch Management and virus/malware definitions: Regional System Administrators or delegate shall update patch and virus/malware definitions for BCS networks, in accordance with instructions provided by systems vendors. A description of patch activity completed each year and reference to instructions used for BCS patches shall be documented per the annual network inspection checklist, EPR 4.200A03. If virus and patch updates cannot be maintained on a current basis, exceptions shall be documented with justification on the inspection checklist. A direct connection from a BCS to an external network for patch and virus/malware signature download is not permitted. Updates shall be performed by use of removable media that are used to transfer the updates from a WAN connection to the BCS network. The media shall be scanned to detect malicious code on Removable Media using a Cyber Asset other than a BES Cyber System; and mitigation of the threat of detected malicious code on the Removable Media prior to connecting Removable Media.

4.2.8 Plant network inspection: At least every 15 months, physical network inspections shall be performed to confirm current configuration of all external connections. The inspection shall be performed in accordance with the “Plant Network Cyber-Security Inspection Checklist” EPR 4.200A03.

4.2.9 Information Security: All outputs of this procedure (plant cyber-security plans, inspection checklists, suspected cyber-security incident checklists, firewall ruleset changes) shall be controlled in accordance with the corporate program for Confidential and Confidential Restricted Information Protection.

5.0 RECORDS

5.1 A cyber-security plan EPR 4.200A01, will be completed and approved by the Regional System Administrator, and filed in the ProjectWise repository designated for Confidential and Confidential Restricted Information.

5.2 Each Regional System Administrator or designee shall maintain records in the Energy Supply ProjectWise folder for Confidential and Confidential Restricted Information as follows:

5.2.1 Firewall connection change requests, approvals, and business justifications as documented in the completed form, EPR 4.200A02.

5.2.2 Completed cyber-security inspection checklists, EPR 4.200A03.

5.2.3 Suspected Cyber Incident investigation and reporting activities, completed form EPR 4.200A04.

6.0 REFERENCES AND DEFINITIONS

6.1 Bulk Electric System (BES) Generators: All units connected to the grid at 100kv or greater and have a gross nameplate rating greater than 20Mva; and dispersed generation facilities with multiple units that have an aggregate gross nameplate rating greater than 75Mva connected to a common bus, and connected to the grid at greater than 100 kV. In depth BES definition with inclusion and exclusions can be found on the NERC website.

6.2 National Institute of Standards and Technology (NIST) Cyber-Security Guides: Engineering Principles for Information Technology Security, NIST Special Publication 800-27; NIST Special Publication 800-82, Guide to Industrial Control Systems Security; and NIST-Guidelines on Firewalls and Firewall Policy.

6.3 BES Cyber Assets (BCAs): Programmable electronic devices essential to the reliable operation of a BES plant, including the hardware, software, and data in those devices. A BCA is a device that if rendered unavailable, degraded or misused, would create a generation outage or de-rate within 15 minutes.

6.4 BES Cyber Systems (BCS): One or more BES Cyber Assets logically grouped into a functional system that perform one or more of the following Reliability Operating Services (BROS):

6.4.1 Dynamic Response to BES Conditions (e.g. Automatic Generation Control (AGC) and Energy Management Systems(EMS), PSS/AVR systems)

6.4.2 Controlling Frequency (e.g. Real Power, such as automatic governors)

6.4.3 Controlling Voltage (e.g. Reactive power, such as AVR/PSS systems)

6.4.4 Monitoring and Control (e. g. Plant BCS)

6.4.5 Restoration of BES (e. g. Blackstart facility BCS)

6.4.6 Situational Awareness (e.g. AGC/EMS/plant DCS)

6.5 Cyber-Security Incident: Any malicious act or suspicious event that: Compromises, or was an attempt to compromise, the Electronic Security Perimeter or Physical Security Perimeter, or, Disrupts, or was an attempt to disrupt, the operation of a BES Cyber System. [NERC Glossary]

6.6 Transient Cyber Asset (TCA): a cyber asset that is: capable of transmitting or transferring executable code, not included in a BES Cyber System, and directly connected (e.g. using Ethernet, serial, Universal Serial Bus, or wireless including near field or Bluetooth communication) for 30 consecutive calendar days or less to a BES Cyber Asset (NERC Glossary modified to exclude high and medium references)

6.7 Removable Media: storage media that: are not Cyber Assets, are capable of transferring executable code, can be used to store, copy, move or access date, and are directly connected for 30 consecutive calendar days or less to a BES Cyber Asset. (NERC Glossary modified to exclude high and medium impact references)

6.8 Security Zone: In networking, a security zone isolates one or more network devices (zone A) from one or more other security zones (zone B,C,D,etc.). Each of these other zones also consists of one or more network devices. Each zone that you define can be as enormous as the entire Internet or as small as a single device (or even as small as the particular individual using a specific device).

6.9 Regional System Administrator: The Fleet Engineering lead for network security monitoring and technical support assigned in each of the three Xcel operating regions: NSP, PSCo, and SPS.

6.10 Plant Network: The interconnected microprocessor based generator control systems and supporting systems that provide functions such as data acquisition, unit and equipment operating status, equipment optimization, performance monitoring, production and consumption rates and environmental monitoring.

6.11 EPR 4.200A01 Plant Network Cyber-Security Plan Template located on the Performance Optimization Policy Index web page.

6.12 EPR 4.200A02 ES Firewall Rule Change Request located on the Performance Optimization Policy Index web page.

6.13 EPR 4.200A03 Annual Plant Network Cyber-Security Inspection Checklist located on the Performance Optimization Policy Index web page.

6.14 EPR 4.200A04 Energy Supply Cyber-Security Incident Response Checklist located on the Performance Optimization Policy Index web page.

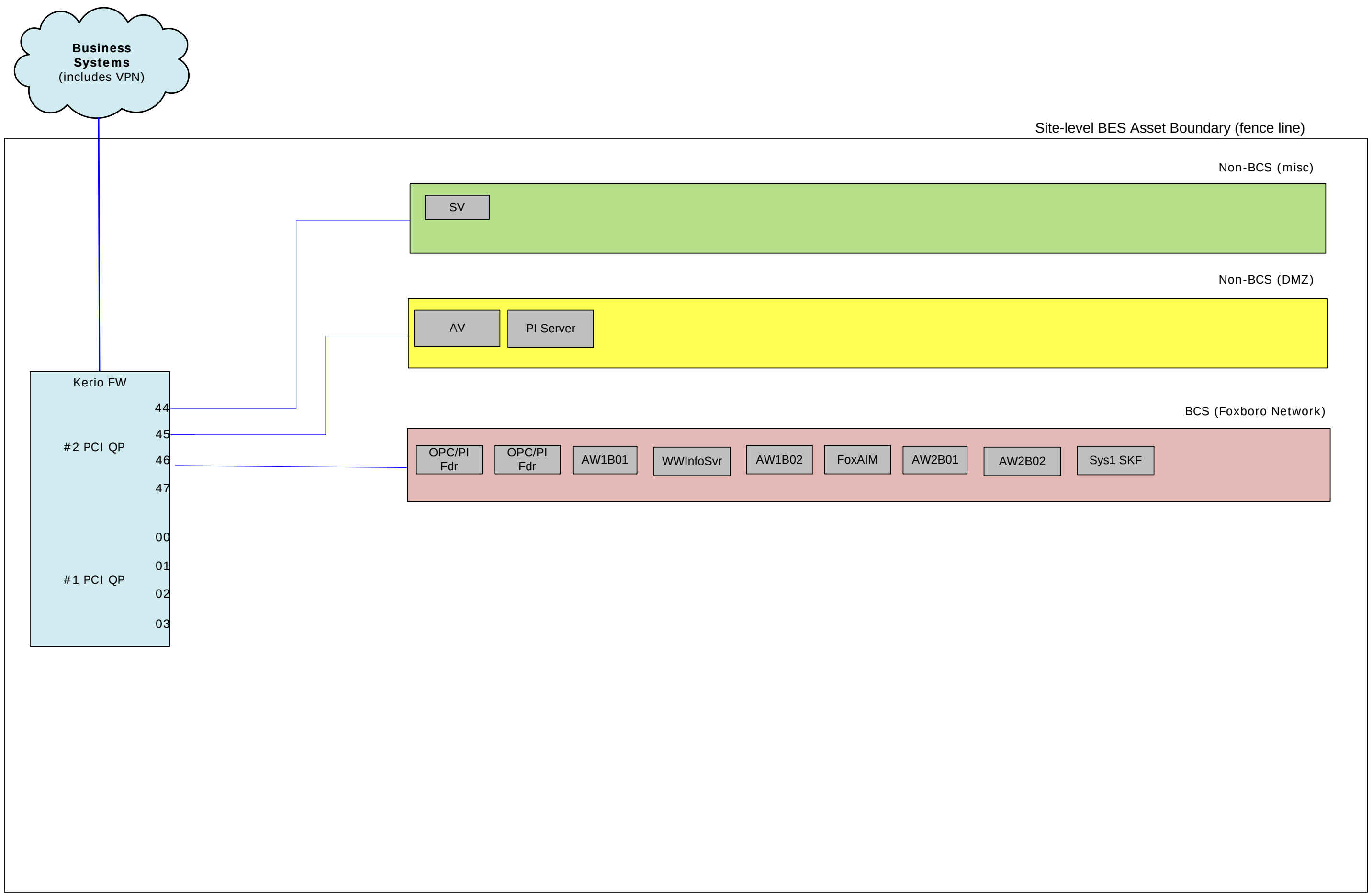
7.0 REVISION HISTORY

Date	Revision	Change
04/12/2013	1.0	Original Issue Supersedes ESO 4.200 to align accountabilities with re-organization. Included best practice security requirements from various sources, including FERC Order and NIST, in preparation step to begin alignment with expected future cyber-security requirements. Detailed requirements moved from this policy to supporting plant cyber-security plan template EPR 4.200_A01.
04/27/2015	1.1	Implementation phase is complete. Deleted note regarding implementation plan in section 1.2. Deleted section 5.0 ‘Implementation Plan’ in its entirety.
09/29/2015	2.0	Updated formatting to comply with XES 1.100P01 Configuration Management for ES Policies and Procedures. Sections re-ordered to improve readability. Revision to align with CIP version 6 requirements and/or Internal Audit Observations as follows: • Revised EPR 4.200A01 Plant Network Cyber-Security Plan Template to document system access and type as required in new NERC terms of LERCs, LEAPs, and BROS;

Date	Revision	Change
		• Added EPR 4.200A02 ES Firewall Rule Change Request to document Energy Supply firewall rule changes; • Added EPR 4.200A03 Annual Plant Network Cyber-Security Inspection Checklist to document patch management instructions and activities; • Added EPR 4.200A04 Energy Supply Cyber-Security Incident Response Checklist to document potential cyber-security incidents and notification of required parties if indicated; and • Added EPR 4.200A05 Modem Session Log to document modem sessions. • Updated definition section to align with NERC terms.
04/11/2017	3.0	• Minor clarifications for accuracy to NERC Standard verbiage. • Changed Annual references to 15 calendar months. • Removed reference to Work Orders in section 4.11 due to move from SAP to Maximo. Added reference to corporate Physical Security Policy and Corporate Awareness Program. Updated formatting to comply with XES 1.100P01 Configuration Management for ES Policies and Procedures. Sections re-ordered to improve readability. Revision to align with CIP version 6 requirements and/or Internal Audit Observations as follows: • Revised EPR 4.200A01 Plant Network Cyber-Security Plan Template to document system access and type as required in new NERC terms of LERCs, LEAPs, and BROS; • Added EPR 4.200A02 ES Firewall Rule Change Request to document Energy Supply firewall rule changes; • Added EPR 4.200A03 Annual Plant Network Cyber-Security Inspection Checklist to document patch management instructions and activities; • Added EPR 4.200A04 Energy Supply Cyber-Security Incident Response Checklist to document potential cyber-security incidents and notification of required parties if indicated; and • Added EPR 4.200A05 Modem Session Log to document modem sessions. • Updated definition section to align with NERC terms.
07/03/2018	4.0	• Revisions to address the new NERC Standard version CIP-003-7. • Removed LERC and LEAP references and definitions, as they

Date	Revision	Change
		are no longer NERC defined terms. • Modified or removed references as necessary to how they are actually being completed. • Updated SOC to Cyber Defense Center • Removed language relating to dial-up and modem commitments • Updated Architecture Diagram • Minor clarifications for accuracy to NERC Standard verbiage. • Changed Annual references to 15 calendar months. • Removed reference to Work Orders in section 4.11 due to move from SAP to Maximo. • Added reference to corporate Physical Security Policy and Corporate Awareness Program.
10/10/2019	5.0	• Updated all CIP version references to CIP 003-8 • Updated architecture of document to capture all responsibilities in one section • Updated CIP requirement for clarity as to what the requirements are and what process is in place to meet these requirements • Added section on Transient Cyber Assets and removable media

Attachment 1 – Reference Architecture



Appendix U - SCADA Responsibility Table

X - Primary Responsibility
S - Supporting Responsibility

	Task/Item	Completion Date (Estimated)	Buyer SOW	Contractor SOW
O&M SCADA ROOM in Sustation Electrical Enclosure	O&M wall mounted fiber patch panel for fiber from substation (purchase, install, configure, and commission)			X
	Order data connections			X
	Incoming fiber/copper connections to Telco demarc location from Telco pedestal (Install and test)		S	X
	Telco demarc; provides T1, high speed internet, and POTS (install and commission) Contractor is required to make commercially reasonable efforts to procure commercially available internet services. Buyer shall be responsible for costs of such services from 3rd parties.		S	X
	Ethernet jumpers from Buyer corporate network rack to Telco demarc (purchase and install)	After Buyer corporate network rack is installed	X	
	Installation of Buyer corporate network rack (purchase, install, configure, and commission)	After SCADA room is complete	X	
	Power to Buyer corporate network rack and controller server rack (install and test)			X
	RJ11 wall mounted patch panel (purchase, install, configure, and commission)	After SCADA room is complete	X	
	Overhead cable management system (purchase and install)			X
	Server rack (purchase, install, configure, and commission)			X
	Develop and distribute IP scheme	Prior to Buyer corporate network equipment being shipped to site	X	
	VPN access list and site specific requirements	Before Buyer corporate network rack is installed	X	S
	O&M security details (i.e. cyberlocks, cameras, keycard scanners, etc.)	Before security system installation begins	X	
	Security system equipment; the rack mounted equipment is installed in the Buyer corporate network rack (install and commission)	After Buyer corporate network rack is installed	X	
MET Station	Met station controller Cat 6 terminations			X
	1 IP managed met station controller media converter (purchase, install, configure, and commission)			X
	Met station controller data logger (purchase, install, configure, and commission)			X
	Instrumentation wiring, junction box and instrumentation between met station controller and met tower (install, terminate, and test)			X
	Met station controller data points list	Before Installation of met station controller and met tower.	S	X
Substation	Fiber terminations to rack mounted patch panel			X
	OPGW fiber from substation to interconnect substation, if applicable (purchase, install, and commission)			X
	OPGW fiber termination at interconnection substation slice box, if applicable (purchase, install, and commission)			X
	OPGW fiber terminations at substation splice box (purchase, install, and commission)			X
	Attenuation (OTDR) reports for all fiber installations terminated by Contractor			X
	Provide media converter information from interconnection substation	Before T-Line installation	X	
	Buyer corporate network and telephone (purchase, install, configure, program, and commission)	Immediately when substation EEE is available.	X	
	Power and ethernet cable as well as associated raceway and terminal blocks for the Buyer corporate network, telephone, and revenue meter (purchase, install, and test)			X
	Relay, RTU, ORION, check-meters, etc. (purchase, install, configure, and commission)			X
	SEL 735 check meter (procure and install)	Immediately when substation EEE is available.		X
	Fiber patch, ethernet, and serial cables for all communication connections in substation (purchase) solar control system related cables including the serial cable to Turbine Supplier park controller			X
	RTU/EMS points list (develop, upload, and test)			X
	Deliver RTU/EMS points list to Buyer EMS group to incorporate project into the Buyer system	After points list is finalized.	X	
	All communication with substation equipment to include Buyer provided equipment. (install and test)			X
	Develop and distribute IP scheme	Before installation begins	X	
Inverters	Fiber to Inverter Skids			X
	Fiber terminations in inverter splice boxes; terminate all spares (purchase, install and test)			X
	Attenuation/OTDR report			X
	Design optical path diagram; coordinated with Contractor			X
	Fiber commissioning; coordinate with Contractor if issues arise			X

PSCo 2021 ERP
Minimum Requirements for Battery Energy Storage System (BESS) Build-Own-Transfer Proposals

Engineering, Procurement, and Construction Technical Specification

408092.75.0750

THIS GENERIC SPECIFICATION IS DESIGNED TO PROVIDE A BASIS FOR A VARIETY OF BATTERY ENERGY STORAGE SYSTEMS (BESS) APPLICATIONS AND MUST BE CUSTOMIZED FOR THE SPECIFIC PROJECT REQUIREMENTS AND SITE CONDITIONS BY THE ENGINEER OF RECORD PRIOR TO FINALIZING THEIR DESIGN.

Rev. A

3/26/2021

Table of Contents

LIST OF ATTACHMENTS

1.0 GENERAL

1.1 General Description

A. The Scope of Work of this project is for the Engineering, Procurement, and Construction (EPC) of a XX MW / XX MWhr grid connected, battery energy storage project including (MV / HV) interconnect to an adjacent (Distribution / Transmission) switchyard (MODIFY TO MATCH BESS APPLICATION).

B. Contractor shall implement the project using a non-occupiable, containerized solution specified in 6.0 *Non-Occupiable Container Requirements*.

C. Contractor shall also provide pricing options to implement the project based upon:
   1. Contractor furnishing all project equipment including batteries, and
   2. Main power transformers, batteries, battery racks, and BMS equipment supplied as Company Furnished equipment to be integrated by the Contractor into a turn-key installation.

1.2 Work Included in Contractors Scope

Contractor's scope shall include but not be limited to the following:

A. Site Preparation and Utility tie-ins

B. All required foundations & civil work

C. Design, Furnish and install Battery Energy Storage System (BESS) non-occupiable equipment enclosures including:
   1. Lighting, raceway, and auxiliary systems
   2. HVAC/Cooling system
   3. Off-gas detection, Fire detection & suppression system as applicable

D. Design, Furnish and install Battery Energy Storage System (BESS) equipment including:
   1. Batteries, Racks, and BMS equipment
   2. DC main disconnects
   3. DC bus / cable interconnections between racks and disconnect
   4. Bi-directional inverters
   5. Metering, Relaying and Protection Panels, as required
   6. Auxiliary electrical distribution system and cabling
   7. Grounding Transformers (As Required)

E. Design, Furnish and Install an AC collection system including cable, raceway and transformers AND/OR DC Link/coupling system if connected to an existing inverter(s) at a renewable facility.

F. Design, Furnish and Install a new utility switchyard/substation or the modifications that are required to interconnect the BESS to an existing switchyard/substation including [but not limited to] MV or HV breakers and disconnects, surge arresters, grounding transformers, CTs and VTs, etc. (CONFORM TO APPLICATION)

G. Design, Furnish and Install all required metering, telemetry, and Site Controller equipment including any required modifications to the existing telemetry hardware and software.

H. Perform start-up checks utilizing OEM factory representatives as required and commission the facility.

I. Complete, perform & provide all applicable NERC testing and compliance reports for review by Company. Reports shall provide NERC related support documentation in a manner that is thorough, well organized, complete, and include explanations that support the conclusions reached. Reports shall be suitable for use in presenting to NERC audit personnel.
J. Complying with all requirements outline in Company's interconnection requirements (AttachmentD)

1.3 Work Not in Contractor's scope

The basis of Contractor's bid shall be to provide a turnkey installation including main power transformers, batteries, racks, and the Battery Management System (BMS).

Contractor shall also provide pricing to implement the project incorporating Company-furnished main power transformers, batteries, racks, and BMS.

1.4 Permits and Agreements

A. Company will obtain --
   1. Operating permits
B. Contractor shall obtain and pay for –
   1. Building Permits
   2. Construction Permits
   3. Local Permits
   4. Licenses as required for engineering and construction activities
   5. Utility Interconnection Agreement
   6. Land Use and Rights-of-Way
   7. Environmental permits

1.5 Equipment

A. Design equipment in accordance with generally accepted industry standards for energy storage facilities.
B. Systems and operations shall be designed in compliance with equipment OEM's requirements and applicable industry standards.
C. Equipment shall be of proven design. Experimental, prototype, or one of a kind designs are not acceptable.
D. Permanent equipment shall be new and unused.
E. OEM shall be able to demonstrate at least 5 installations of comparable size within the Continental United States of America which have achieved commercial operation as defined by the owning utility or Power Purchase Agreement (PPA) off-taker.
F. Contractor shall verify that all equipment procured as part of this contract shall comply with Department of Energy regulations Pursuant to Executive Order 13920. (XCEL TO REVIEW/REVISE BASED ON CURRENT STANDING OF EXECUTIVE ORDER)

1.6 Use and Operation

A. Method of usage to be one full charge/discharge cycle per day with ### full cycles per year. Up to two and a half (2.5) times as many recommended cycles can be expected in any 48-hour period, i.e. two full cycles in one day with rest to finish out 48-hour period. (UPDATE PER PROJECTED USE CASE)

B. Project to be designed for full nameplate capacity at Commercial Operation Date. Contractor shall provide the OEM's annual battery life degradation schedule and curves for expected use scenario and an additional schedule and curves based on 10% over cycling per year, and 20 periods of 10% over cycling per 48-hour period over a year (396 cycles per year).

2.0 PROJECT DESIGN CONDITIONS

2.1 Site Location / Interconnecting Provisions

Project Name	
Company	
Project Location	
Latitude / Longitude	
Elevation	
Energy Storage Capability at POI	
HV/MV Interconnection Voltage	
LV Station Service Voltage	
Point of Interconnection (POI)	(The electrical point of connection for which the performance requirement will be measured)

2.2 Site Conditions

Parameter	Data
Nearest ASHRAE weather data location	
Temperature Range (10yr Extreme, Max/Min)	
Relative Humidity Range	
Heating Dry Bulb Temperature Design, 99% occurrence	
Cooling Temperature Design, 1% occurrence, DB/WB	
Design Wind Speed	
Rainfall	
Seismic	

2.3 Site Arrangement

A. The detailed project arrangement shall be determined by the EPC Contractor in consultation with the Company's representatives.

B. Contractor is advised that the site is unmanned and there is no source of water available at the project site. (UPDATE PER SITE CONDITIONS)

C. BESS containers shall be separated from all structures, other BESS containers, and other equipment by a minimum of ten feet (10') of separation in accordance with NFPA 855.

2.4 Seismic

Seismic loads and element design criteria shall be in accordance with applicable sections of the IBC, ASCE 7, AISC, and related or referenced documents for equipment, buildings, and structures.

2.5 Dead Loads

A. Dead loads shall be considered as being the weight of the structure and supported equipment of a permanent or semi-permanent nature including tanks, wall panels, partitions, roofing, piping, drains, electrical trays, and the contents of tanks measured at full capacity. However, the contents of tanks shall not be considered effective in resisting uplift.

B. Dead loads shall be determined using the minimum design dead loads and unit weights from the International Building Code (IBC and ASCE 7)

2.6 Live Loads

A. Live loads are produced by the use and occupancy of the building or structure including movable and transitory loads such as the weight of people, portable equipment, and tools; and mobile equipment or parts which may be moved over or placed on floors during maintenance operations.

B. The live loads used in the design of buildings and structures shall be the maximum loads likely to be imposed by the intended use or occupancy but shall not be less than the minimum live loads prescribed in the IBC and ASCE 7.

2.7 Soil and Hydrostatic Loads

A. The design of below-grade structures shall consider the effects of lateral soil pressures considering also appropriate allowances for possible surcharges due to adjacent fixed or moving loads.

B. Structures below the water table shall also be designed to resist the effects of hydrostatic pressure and buoyancy based on expected extreme groundwater conditions.

2.8 Wind Loads

A. Wind loads shall be computed in accordance with International Building Code (IBC and ASCE 7. A step function of pressure with height shall be used.

B. Design wind pressures shall be determined by applying velocity pressures for the design wind speed to the appropriate design equations for, respectively, the building or structure's main wind-force resisting system, other buildings, components and cladding, and for other construction considering the appropriate design coefficients and factors.

2.9 Snow Loads

A. The effects of drifting sliding, partial, and imbalanced snow loads shall be considered as set forth in IBC and ASCE 7.

B. Rain-on-snow surcharge shall also be considered as set forth herein except where locally adopted requirements are more stringent.

2.10 Rain Loads

A. Roofs and similar nearly horizontal surfaces shall be designed considering the potential ponding instability according to IBC and ASCE 7.

2.11 Construction Loads

A. The integrity of structures shall be maintained during construction without use of temporary framing struts, ties, or cable bracing insofar as possible.

B. Should construction or crane access considerations dictate the use of temporary structural systems; identify such situations and provide criteria that it intends to use to determine requirements for the temporary system.

C. Special consideration shall be given to ensure the stability and integrity of structures during any periods involving temporary bracing systems.

D. Assumed construction loads shall not be less stringent than those recommended in ASCE 7, International Building Code (IBC) or other generally recognized structure design agencies.

3.0 SCOPE OF WORK/DIVISION OF RESPONSIBILITY

3.1 General Description

A. Contractor's Scope of Work includes design, engineering, procurement, construction, construction management, commissioning, startup, testing, demonstration testing and operator training.

B. If Company furnishes the main power transformers, batteries, racks, and BMS, Contractor shall also be responsible for receiving, unloading, storing, installing, checkout, commissioning, startup, and testing of Company-furnished equipment unless expressly stated otherwise.

C. For the avoidance of doubt, Contractor's scope includes all work necessary to provide a fully operational BESS facility except where explicitly noted otherwise.

3.2 Items Provided by Others

Items furnished by others and not in this scope of supply include the following:

A. Conceptual/Basic Layout

B. Potential for Company to directly purchase main power transformers,

C. batteries, racks, and BMS and free-issue to Contractor for installation and commissioning.

D. Permits as described in Section 1.0.

3.3 Safety Requirements

A. The Contractor shall comply with the Company's site safety requirements.

B. Contractor shall be responsible for site control as well as site safety training for any personnel that come onto the work site.

C. Report weekly on safety statistics including the number of safety walks, job safety assessments, and any incidents.

3.4 Electrical and Control

A. The electric system should be configured in a manner similar to the conceptual One-Line Diagram. The one-line should be considered conceptual in nature and is not intended to show all details required. The conceptual One-Line diagram is not intended to limit Contractor's flexibility in design.

B. Contractor's scope includes engineering, procurement, installation, and commissioning of the BESS scope including (MV or HV) interconnect to an adjacent switchyard (MODIFY TO MATCH BESS APPLICATION).

3.5 Civil / Structural

A. Contractor shall contract a 3rd party to perform a geotechnical investigation of the site. The design and installation of the facility shall be pursuant to the geotechnical report findings. A copy of the geotechnical report shall be made available to the Company.

B. Contractor is responsible to prepare the site as required. Contractor shall clear, grub, and perform earthwork activities as necessary to create a site that is suitable for construction.

C. Contractor is responsible to develop a site-specific storm water runoff plan and to protect the site against erosion during construction. The Contractor shall be responsible for final grading of site, maintaining the storm water drainage system, and completion of storm water drainage system in accordance with the site permits. Contractor shall obtain the stormwater permit and is responsible for closure of the stormwater permit.

D. Costs for the handling and disposal of any existing contaminated soils or other materials not identified in the soils report shall not be included in the Contract Price. Unforeseen conditions shall be treated as additional scope of work in accordance with the Contract documents.

E. Contractor is responsible to survey the site and establish site control geometry as necessary to perform the work. The survey data shall be provided as on-ground (surface) values with an equation to convert from ellipsoidal heights (State Plane Ground) to orthometric heights (State Plane Grid). Horizontal and vertical accuracy shall be Second Order Class II per the National Map Accuracy Standards (NMAS).

F. Dewatering and shoring of excavation works shall be the responsibility of the Contractor.

3.6 Engineering

A. Perform all engineering and design work required for a complete and operating facility, unless noted otherwise. Construction design documents shall be sealed by registered Professional Engineers licensed in the state where the project is located at.

B. Contractor shall provide a complete list of design deliverables with delivery dates to the Company.

3.7 Procurement

A. Except for equipment specifically listed as Company furnished, Contractor shall be responsible for the procurement of non-engineered equipment and engineered equipment, including freight to the site, unloading, and storage that is required to complete the project. Contractor shall also be responsible for unloading and onsite storage of any Company-furnished equipment.

B. Contractor shall procure all bulk materials whether intended for permanent installation or temporary installation that is needed for the erection of the systems and components.

C. The Contractor shall be responsible for performing the vendor shop inspections for the Contractor-furnished equipment. The Contractor's standard shop inspection reports shall be utilized and distributed to the Company. Notify Company of Factory Acceptance Tests (FAT) for equipment at least two weeks in advance of start of the FAT tests. The Company may elect to attend such tests at their cost and sole discretion, unless stipulated otherwise.

D. Submit to Company a binder and corresponding electronic files containing recommended operating spare parts lists including pricing, lead times, and contact information for equipment supplied by the Contractor. Company shall be able to purchase these spare parts from the Contractor or suppliers for the prices noted during the first year of operation.

3.8 Construction

A. Perform construction and erection work required for a complete operating facility, including management and responsibility for quality and time of performance for subcontracted work.

B. The Contractor shall be responsible for all indirect construction costs such as supervision, equipment, taxes, utilities, facilities, and other indirect items needed. This includes costs for personnel, construction equipment, including mobilization and demobilization, temporary buildings, temporary utilities, scaffolding, project job office expenses, employee travel and per diem expenses, and quality control testing, such as for concrete and welding.

C. Temporary construction office facilities, furnishings, janitorial services, and supplies shall be furnished by the Contractor.

D. Contractor shall provide temporary office space for two persons for use by Company and/or Company's representative during the period of site construction. (MODIFYTOMATCHBESSAPPLICATION)

3.9 Special Inspections

A. The Company may engage one or more qualified Special Inspectors to verify compliance with requirements specified or indicated. These services do not relieve the Contractor of responsibility for compliance with other document requirements.

B. Requirements for the Contractor to provide quality-assurance and quality-control services are not limited by provisions of this Section.

C. The Contractor shall coordinate the inspection and testing services with the progress of the work. The Contractor shall provide notice to the testing agency to allow scheduling of personnel such that it does not create delays in work.

D. The Contractor shall be responsible for scheduling and coordinating the review and acceptance by the Authority Having Jurisdiction (AHJ).

E. The Contractor shall be responsible for providing a BESS Hazard Mitigation analysis in accordance with NFPA-855 requirements for installations that meet Hazard Mitigation analysis criteria as described but not limited to NFPA-855 section 4.1.4.1.

F. The Contractor shall be responsible for costs of:

1. Re-testing and re-inspection of materials, work, or products that do not meet the requirements of the Contract Documents and shop drawings / submittal data.
2. Review of proposed repair and / or replacement procedures by the inspectors and testing agencies.
3. Repair or replacement of work that does not meet the requirements of the Contract Documents, Special Inspector's, or AHJ's requirements.

3.10 Commissioning and Startup

A. Startup shall include activities, procedures, and tests required to bring installed systems and equipment to a state of readiness for Company acceptance and commercial operation. It is the Contractor's responsibility to comply with the battery manufacturer's requirements as well as any applicable NERC/FERC requirements.

B. Contractor shall prepare written commissioning and testing procedures and submit for Company review and acceptance a minimum of 30 days prior to commencement of pre-commissioning tests.

C. Contractor shall comply with all interconnecting Utility requirements and/or system conditions that may be present.

3.11 Training

A. Contractor is responsible for training plant staff on the operation, maintenance, and repair of equipment furnished as part of the Works.

B. Training shall include both classroom and hands-on training for at least ten (10) persons.

C. Contractor shall allow Company representatives to shadow Contractor's startup personnel during commissioning activities. Participation by Company's trainees is at Company's option and does not relieve Contractor of responsibility to properly commission the facility.

3.12 Specifications and Standards

A. Reference to standards or manuals of any society, organization, or association, whether such reference be specific or by implication, shall mean the latest standard, manual, or code in effect as of the time of the Contractor's performance of the Work, unless specifically stated otherwise.

B. References to any standard or code and specifically to the International Building Code (IBC) shall mean the version of that code or standards adopted and modified by the local Authority Having Jurisdiction (AHJ).

4.0 SITE WORK

4.1 General

A. This section covers initial site work, maintenance of drainage systems during construction, and final site work.
B. The site grading and drainage plan shall conform to the requirements of the permits.
C. Site drainage facilities shall be designed to convey the runoff from a 4 percent probability (25 year) 24-hour storm event unless specific federal, state, or local regulations are more stringent.

4.2 Codes and Standards

Erosion and sediment control, grading, drainage, and storm water management; design, construction, and maintenance shall be in accordance with requirements set forth by state and local environmental management agencies and Environmental Protection Agency (EPA).

4.3 Fencing

(REMOVE SECTION 5.3 If BESS is to be constructed in a secure area, unless required by applicable local laws or Utility requirements)

A. A security fence at least 6 ft high with suitable gates shall be provided around the project site boundary during construction. Temporary or permanent fencing may be provided at Contractor's option.
B. Fencing shall be isolated or grounded at Contractor's option to ensure safety with respect to touch potentials. Special precautions shall be taken where fence abuts an existing electrical substation fence and near overhead transmission lines.
C. The permanent security fence shall have an overall height of approximately 8 feet including 3 strands of barbed wire mounted on 45-degree extension arms at top extending outward.
D. Other Applicable Company Standards

4.4 Dewatering

A. Contractor shall provide temporary dewatering if required for any work requiring excavation below the groundwater table.
B. The dewatering plan must be approved by the reviewing agencies prior to any dewatering activities being undertaken.

4.5 Grading and Drainage

A. The site shall be graded to convey storm water runoff away from permanent facilities. Minimum slopes shall be based on surface type. Provide a minimum 1 percent overall slope.
B. Areas that do not lend themselves to grading for surface drainage shall be provided with catch basins and underground piping. Maximum earth slopes shall be set based on slope stability and maintainability requirements. The steepest unimproved slope shall be limited to 3:1 height to vertical ratio.
C. Channels and ditches shall be designed and shown on the drawings.

D. Culverts shall generally be reinforced concrete, corrugated metal, or smooth-lined corrugated HDPE pipes.

E. Grating and guards shall be provided for fall protection at channels and ditches.

4.6 Heavy Loads

A. Roadway sub grades, pavements, and structures shall be designed for HS20 loads.

B. Contractor shall be responsible for repair of damage to any existing roads caused by hauling of battery containers, mobilization / demobilization of cranes, or other heavy loads.

4.7 Compaction

Unless the Contractor's geotechnical report allows for lower compaction requirements, the following minimums shall be adhered to. Submit for Company review any requests for alternative values.

	Minimum Compaction in Accordance with ASTM D6981557 Standard Modified Proctor (%)
Unauthorized excavation	95
Fills and embankments	90
Trench subgrades	90
Trench subgrades beneath roads	95
Subgrades beneath roads	95
Structure backfill (around walls and structures)	95
Compacted sand fill	95
Trench backfill (crushed rock)	75 (relative density)
Trench backfill (cohesive and sand material)	90
Trench backfill (traversing paved areas)	95
Compacted rock fill	75 (relative density)
Structural fill (beneath structures)	98

4.8 Roads

A. Contractor shall be responsible for the cost, construction, maintenance, and improvement of all facilities and improvements necessary for access to and from the Facility Site and for performance of the work. Contractor shall be responsible for providing Buyer sufficient access to the site for the performance of routine maintenance and sufficient space within the facility during such times as not to interfere with Company activities.

B. Road construction shall be similar to existing access road unless greater load carrying capability is required due to battery / container loads.

C. Horizontal and vertical alignment shall be based on anticipated traffic and design speed for each road.

D. The minimum road design criteria to be considered are as follows:
   1. Intersection Radius: 40 ft (12 m) from radius to inside edge or trafficked surface
   2. Maximum Grade: 3% primary access routes; 6% for limited length secondary routes

4.9 Landscaping and Restoration

A. Provide finish landscaping for the site according to local ordinances and practices applicable to typical industrial facilities.

B. Areas of the site, including lay-down areas not specifically addressed by a landscaping plan or other requirements shall be restored to a condition acceptable to the Company as part of the demobilization from the site. This condition should also allow for closure of the Stormwater Permit.

4.10 Existing Conditions

A. This project may have below grade pre-existing conditions not indicated on any drawings, maps or other documents, or in locations different than where indicated.

B. Prior to any excavation activities, all known underground utilities shall be positively located using “soft dig” techniques to minimize the likelihood of a utility strike.

5.0 SUBSTRUCTURE REQUIREMENTS

5.1 General

Design and construct of reinforced concrete or other acceptable method to resist the loadings imposed by the building, structure, or equipment being supported.

5.2 Considerations

Foundation design shall consider the following:

1. Soil bearing capacities
2. Pile or pier capacities
3. Active, at-rest, and passive lateral earth pressures
4. Allowable settlements
5. Building, structure, equipment, and environmental loading
6. Equipment operating characteristics and performance criteria
7. Access and maintenance
8. Temporary construction loading

5.3 Analysis

A. Minimum factors of safety against overturning and sliding shall be 1.5 and 1.25, respectively, but in no case less than those prescribed by the International Building Code (IBC).

B. Geotechnical exploration, testing, and analysis information shall be used to determine the most suitable foundation system. Elastic (short-term) and consolidation (long-term) foundation settlements shall be calculated and limited to the following design values:
   1. Total settlement: 1.5 in
   2. Differential settlement: 0.1 percent slope between column support points

5.4 Slab-on-Grade

A. Care shall be taken to provide suitable base construction and to align and locate expansion and control joints as recommended in these references to minimize uncontrolled cracking.

B. Slabs-on-grade that are open or generally exposed to the environment shall be sloped to prevent the accumulation of standing water. Interior slabs do not require sloping.

5.5 Foundations

A. Prepare detailed foundation design criteria for each foundation type on the basis of on an independent geotechnical exploration program, performed by Contractor.

B. Interpretation or use of any preliminary boring information is solely the responsibility of the Contractor.

C. Foundations may be either cast in place or precast. All foundations shall be reinforced at a minimum to the temperature and shrinkage requirements of ACI 318.

D. Pile, post, or earth screw type equipment base foundations typically found in the renewable energy industry are acceptable alternatives to concrete foundations. Contactor shall provide safe access provisions to any equipment bases elevated above grade by more than the height of the equipment base.

5.6 Equipment Bases

A. Equipment bases may be site constructed of concrete, pre-fabricated concrete, or may be a structural metal skid furnished as part of the equipment.

B. Equipment bases shall consider all additional loads encountered during transport to the site and placement into final position.

6.0 NON-OCCUPIABLE CONTAINER REQUIREMENTS

6.1 General

A. This section covers the minimum requirements for containerized Battery Energy Storage Systems.
B. Containers should be shipped fully assembled to the extent practical, except for loading of the battery modules in the field.
C. Air conditioning units may be removed for shipment if required.

6.2 Materials

A. Container foundations may be formed in place concrete, pre-cast concrete, piers, or earth augers at the engineer of records option.
B. Foundations shall meet local building codes with respect to frost depth. Placement of containers directly on compacted fill is not allowed.
C. Container structural base may be pre-cast concrete or a structural steel system with steel decking.
D. Container walls and roof may be pre-cast concrete, steel, or hybrid construction.
E. All materials shall be non-flammable
F. Materials shall be suitable for a minimum 20-year lifetime.

6.3 Occupancy Class

A. It is the intent that containerized systems be classified as equipment enclosures rather than occupiable buildings.
B. The layout of equipment in containerized systems shall be such that personnel cannot occupy the enclosure. Containerized systems arranged to provide interior working space are strongly discouraged. If central aisle containers are provided, aisle width shall meet NEC required working space.
C. Access to battery modules and other equipment should be via doors arranged along the length of the container such that personnel are not required to enter the container to perform maintenance.

6.4 Partition Walls

A. If a skid assembly includes "central inverter" power conversion equipment and battery racks on a single skid, designs which include a fire-rated partition wall between batteries and power conversion equipment are preferred.

6.5 Windows

A. Windows are not required. Arrangements that allow the main DC disconnect position to be viewed or operated without opening doors are preferred.

6.6 Doors

A. Doors are not required for personnel ingress/egress.
B. Doors for equipment access should be provided along the long sides of the container. Doors arranged in "French Door" fashion are preferred.

C. Door opening width shall be as required to provide access to battery racks for module installation and removal.
D. Doors shall be lockable and keyed alike.
E. Exterior hardware shall be stainless steel.

6.7 Floor Coverings

A. Floors shall be non-combustible.

6.8 Fire Detection and Suppression

A. Containerized BESS systems shall be provided with fire detection systems as specified in 9.0 Fire Detection and Suppression.
B. Containerized BESS systems shall be provided with clean agent fire suppression systems as specified in 9.0 Fire Detection and Suppression.
C. Fire detection schemes incorporating early off-gas detection and interlock to shut down affected BESS equipment prior to fire or smoke detection are encouraged.

6.9 HVAC

A. HVAC systems shall be in accordance with 11.0 HVAC.

6.10 Security System

A. Security cameras shall be provided and located such that the entire site area is visible.
B. Security cameras shall be able to be monitored remotely at Company's operations center

7.0 CONCRETE

7.1 General

Design and construct concrete structures in accordance with Building Code Requirements for Structural Concrete.

7.2 Codes and Standards

A. Specifications for materials shall generally conform to the standard specifications of the American Society for Testing and Materials (ASTM) and American Concrete Institute (ACI).
B. Field and laboratory testing procedures for materials shall follow standard ASTM specifications and the American Society for Nondestructive Testing (ASNT) procedures and practices.
C. Design loadings shall be in accordance with the loading criteria as stipulated in International Building Code (IBC).
D. Design and placement of structural concrete shall follow the recommended practices and the latest specifications and standards of the International Building Code (IBC).
E. Other recognized standards shall be followed where required to serve as guidelines for design, fabrication, and construction when not in conflict with the listed standards.
F. Other Applicable Company Standards

7.3 Design Criteria

A. Controlled Low-Strength Material (CLSM) can be used in nonstructural applications where limited strength is acceptable, its use would not be detrimental to the finished or adjacent construction and involves materials and placement methods commonly used and accepted in the region where the project is located.
B. Design concrete structures based on the following mix class:

Mix Class	Usage	f'c - 28 Day Strength psi (bar)	Maximum Coarse Aggregate Size in. (mm)	Maximum Water to Cement Ratio
A-1	Lean concrete for work slabs (mud mats), fill, duct banks	2,000 (138)	3/8 (9.5)	0.55
B-1	General usage	4,000 [1] (276)	3/4 (19.1)	0.48
Grout		5,000 (345)	-	-
CLSM	Selected nonstructural applications	300 max (21)	-	-

Note 1 – Strength shall be greater if required for durability per Chapter 4 of ACI 318

7.4 Materials

A. Refer to table for the material, application, and requirements that must be met:

Material	Application	Requirements
Cement	In accordance with mix design, local supply	ASTM C150, (Type as required by soil condition and exposure conditions).
Water	In accordance with mix design, local supply	Potable or Non-potable
Aggregate	In accordance with mix design, local supply	ASTM C33.
Fly Ash	In accordance with mix design, local supply	ASTM C618.
Reinforcing steel, main reinforcing	No. 4 through No. 10	ASTM A615, Grade 60.
Reinforcing steel, ties and stirrups	No. 4	ASTM A615, Grade 60.
Forms	For exposed concrete surfaces except flatwork	Plywood or modular steel dimensions to nearest inch.

B. Ready-mixed concrete shall conform to ASTM C94.
C. Hot and cold weather concreting shall be in accordance with the recommendations of ACI.

7.5 Reinforced Applications

A. Suspended slabs shall be two-way reinforced; 0.75 in (19 mm) minimum cover; 6 in (150 mm) minimum thickness; steel trowel finish; sprayed with curing compound.
B. Structural Beams shall be singly or doubly reinforced; 0.75 in (19 mm) minimum cover for interior locations, 1.5 in (38 mm) cover for exterior locations; beam width in 2 in (50 mm) increments, minimum 8 in (200 mm); beam depth in 2 in (50 mm) increments, minimum 12 in (300 mm); cured at least 72-hours in forms.
C. Grade Beams shall be singly or doubly reinforced; 1.5 in (38 mm) cover; beam width coordinated with excavator characteristics, minimum 8 in (200 mm); 4 in (100 mm) minimum thickness void form below elements spanning between piers or piles.
D. Spread footings shall be 6 in (150 mm) increments for footing dimensions less than 9 ft (2.8 m); 3 in (75 mm) cover for sides and bottoms cast against soil; 1.5 in (38 mm) bottom cover when cast against working slab or mud mat.
E. Concrete strength determination shall be in accordance with ASTM C39.
F. Use Type V cement when high-sulfate resistance concrete is required. If not available provide written documentation of the unavailability, and then use of concrete Type I or Type II cement with a maximum tricalcium aluminate (C_3A) content of 6 percent or less will be acceptable.

7.6 Finishes

A. Exposed Concrete Pads – Float Finish
B. Door Landing Stoops – Medium Broom Finish
C. Equipment Bases – Steel Trowel Finish
D. Steel troweled, surface hardened concrete shall be provided for exposed concrete construction in such areas as battery equipment areas, storage rooms, switchgear rooms, and mechanical rooms. Surface shall be non-slip; wet or dry.

7.7 Air-Entraining

A. Air-entraining agent shall be in accordance with ASTM C260.
B. Outdoor concrete shall include entrained air.

7.8 Grout

A. Use Portland, non-shrink cement for grout.
B. Metal shims shall be stainless steel.

8.0 METAL STRUCTURES

8.1 General

This section covers the minimum requirements for the design of metal framed structures and systems.

8.2 Codes and Standards

A. Design, fabrication, and erection of structural steel shall be in accordance with the recommended practices and specifications of:
   1. American National Standards Institute (ANSI)
   2. American Iron and Steel Institute (AISI)
   3. American Welding Society (AWS)
   4. American Society for Testing and Materials (ASTM)
   5. National Association of Corrosion Engineers (NACE)
   6. International Building Code (IBC)
   7. Occupational Safety and Health Association (OSHA)
   8. Other Applicable Company Standards

B. Other recognized standards shall be followed where required to serve as guidelines for design, fabrication, and construction when not in conflict with the listed standards.

C. The standards listed shall mean the latest version adopted by the state or local authorities including any amendments to, or modifications of the original document.

8.3 Design Criteria

A. Limit use of rigid frames to less critical applications such as pre-engineered metal buildings used primarily for enclosure purposes.

B. Utilize simple framing for such things as framed structures supporting equipment and utilities, either alone or in conjunction with enclosure materials.

C. Lateral forces imposed on buildings and structures shall be resisted through a system of horizontal and vertical bracing or horizontal diaphragms, and vertical bracing, shear walls or rigid frames.

D. Design member end connections for the forces and moments determined by engineering analysis.

E. Bolted connections shall be designed as bearing type with threads included in the shear plane except where slip-critical connections are required.

F. Bolted connections shall use 3/4 in (19 mm), 7/8 in (22 mm), or 1 in (25 mm) ASTM A325 (ISO R898 Class 8.8, or higher) bolts.

G. Large diameter or ASTM A490 (ISO R898 Class 10.9 or 12.9) bolts may be considered only when necessary to resist unusually large forces or reduce connection size.

H. Wedge anchors and epoxy or polymer mortared anchors shall be zinc plated or galvanized anchors are acceptable for interior applications; and stainless steel for exterior.

I. Anchor bolts installed during concrete placement shall be galvanized for their full length. Other materials may be used only as specifically approved by the Company.

J. Diagonal bracing that may impede equipment/material access is unacceptable.

8.4 Deflection Guidelines

A. Floor or roof members supporting plaster ceilings or masonry walls; 1/360 times the span considering live load only.
B. Isolated structural members supporting masonry walls; the lesser of 1/600 times the span or 0.3 in (8 mm) considering dead plus live load.
C. For other members; 1/240 times the span, considering live load only.
D. Metal wall panel girts:
   1. Vertical; 1/240 times the span except the lesser of 1/960 times the span or 3/8 in (9.5 mm) where located under or over glass or masonry walls where clearance and load bearing capabilities are a consideration.
   2. Horizontal; 1/180 times the span except the lesser of 1/360 times the span or 1.33 in (33 .8 mm) when located under or over glass.

8.5 Lateral Drift Guidelines

A. The following guidelines for lateral drift of major structures shall be followed unless more stringent criteria are required by local building codes.
B. Braced frames shall be designed to resist the specified lateral environmental loads while limiting lateral deflection to 1/200 of the story or building height.
C. Moment resisting frames, such as those commonly used in pre-engineered metal buildings, shall be designed to resist 75 percent (corresponding to a 10 year recurrence interval) of the specified lateral environmental loads while limiting lateral deflections to 1/120 of the story or building height.
D. In structures without interior walls or other nonstructural components in contact with or supported by a building frame, lateral deflection may be increased to 1/50 of the story or building height considering the allowed reduction in lateral environmental loads.

8.6 Materials

A. Structural steel shapes, plates, and appurtenances for general use shall conform to the multi-certification requirements for ASTM A36/ASTM A572, Grade 50, or ASTM A992.
B. High strength connection bolts shall conform to ASTM A325. Other bolts shall conform to ASTM A307, Grade A.
C. Coat bolts for resistance to rusting for a minimum of 30 years.
D. Bolted connections shall conform to Specification for Structural Joints; ASTM A-325 or A-490 Bolts, current edition.
E. Bolt tightening/pre-tensioning shall be accomplished by use of load indicating washers or the turn-of-nut method. For bolts tightened by the turn-of-nut method, a minimum of 10 percent shall be checked using a calibrated torque wrench.
F. Anchor bolts shall conform to ASTM F1554, Grade 36 and shall be galvanized for their full length. Embedded shapes and plates shall be of ASTM A36 material and shall be galvanized.
G. Expansion and chemically bonded anchors shall be stainless steel conforming to ASTM A276 or ASTM A493.
H. Welding electrodes shall have a minimum specified tensile strength of 70,000 psi (4827 bar).

I. Outdoor structural steel shall be hot-dip galvanized. Galvanizing shall be in accordance with the requirements of ASTM A123, ASTM A153, and/or ASTM A525 as applicable.
J. Galvanized steel fabrication or modification performed on site shall be sent out for re-galvanizing whenever the work process can be revised to permit doing so without resulting in an unacceptable construction delay.
K. When offsite re-galvanizing is not feasible, field application of galvanizing material will be acceptable, subject to the Company acceptance and provided the effective thickness, adhesion, and durability of the field applied galvanizing method proposed can be shown to be at least equal to that of undamaged adjacent areas.
L. Field applied galvanizing paint will be acceptable for installation touchup and will be acceptable for galvanizing of field fabrication repairs or modifications only if conformance with the above requirements can be demonstrated.
M. Galvanizing of nuts, washers, and bolts shall be in accordance with ASTM B695.
N. Corrosion-resistant steel shall be used where corrosion or abrasion may be expected, thus requiring the use of special steels. Corrosion-resistant stainless steels shall conform to ASTM A213, Type 316L, 2.75 percent minimum molybdenum content; or ASTM 240, Type 304 / 304L as appropriate for the application.

8.7 Grating, Guards, Handrails, and Toe Plates

A. Steel grating shall be welded rectangular steel bar with bearing bars at least 3/16 in wide by not less than 1-1/4 in (32 mm) deep.
B. Guards, handrails, and toe plates for exterior shall be constructed of galvanized steel. Interior may be painted steel or galvanized. Steel guards and handrails shall be fabricated from 1-1/2 in (38 mm) nominal diameter, ASTM A53, round steel pipe with joints mitered and welded to form a continuous railing system.
C. Grating shall be hot dip galvanized steel except in corrosive environments; which shall be of fiberglass reinforced plastic construction. Grating ends shall be banded.
D. Guards for non-public locations shall be a two-rail system with the top rail 42 in (1067 mm) above the walkway surface and the intermediate rail 21 in (533 mm) below the top rail.
E. Guard post spacing shall be proportional to the length of the protected horizontal opening and shall consider the specified lateral loading but shall not exceed 6 ft (1800 mm) center-to-center.
F. Handrail for open sides of stairs in non-public locations shall be a combination guardrail/handrail system in which the top and intermediate rails are provided in accordance with the preceding and, in addition, with a handrail, offset from the plane of the guards toward the center of the stair run by distance required for hand clearance and with its top 34 in (860 mm) above the nose of the treads.
G. Provide toe-plates for platforms and stairways.

8.8 Stairs, Ladders, and Deck

A. Stair treads shall be galvanized assemblies of steel grating with cast abrasive nosing. Treads and riser proportions shall be in accordance with the IBC.
B. Exterior ladders shall be galvanized, interior may be painted steel; fabricated from ASTM A36 bar rails, 2-1/2 in by 1/2 in (64 x 13 mm), with 0.75 in (19 mm) diameter rungs inserted and plug welded into holes punched or drilled through the ladder

rails. Ladder supports shall be spaced not more than 12 in (300 mm) vertically center-to-center.

C. Metal deck form shall conform to ASTM A446, Grade A or ASTM A611, Grade C. Metal deck shall be galvanized with a uniform coating having a weight of not less than 6 oz/sqft (316 g/sqm) on each surface.

8.9 Stenciling and Marking

A. Column identification by row letter and number shall be stenciled on four faces of exposed steel columns.

B. Letters and numbers shall be a minimum of 12 in (300 mm) tall.

9.0 FIRE DETECTION AND SUPPRESSION

9.1 General

A. Contractor shall be responsible to comply with all applicable fire and building Codes, including NFPA 855.

B. Contractor is advised that no source of water is available at the project site. If a water-based fire suppression system is required to meet local AHJ or Company's insurance requirements, Contractor shall design and install tankage and pumps as required (CONFORM TO SITE SPECIFIC INFORMATION).

C. This section covers the minimum requirements for the fixed suppression systems, early warning detection systems, alarm systems, and portable fire protection equipment.

D. Contractor shall provide design, approvals, permits, installation, testing, and training for a complete, operational, and code compliant fire detection, alarm, and protection system(s). The design and record documents shall be sealed by a professional fire protection engineer registered in the jurisdiction in which construction occurs.

E. The fire protection and alarm systems and design requirements shall be based upon each BESS area being H3 occupancy per International Building Code (IBC). Contractor shall confirm with code enforcement that this is the correct design.

9.2 Codes and Standards

A. Unless otherwise specified, the governing edition and addenda used shall be interpreted as the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply.

B. Any conflict between referenced codes or standards, or between the standards and these specifications, shall be referred in writing to Purchaser to determine which standard or specification requirements shall govern.

C. In addition to other codes and standards, design in accordance with Occupational Safety and Health Association (OSHA) and Americans Disabilities Act (ADA).

D. If not omitted by the local AHJ per allowance in NFPA-855, water based system shall be in accordance with NFPA 13; the design occupancy classification shall be Extra Hazard Group 2 (EH2).

E. Clean Agent systems shall be in accordance with NFPA 2001 2018 and NFPA 855 200.

F. Other Applicable Company Standards

G. The following shall be followed:

	Codes and Standards				
Description	**Local & State Fire Code**	**Local & State Building Code**	**AHJ**	**NFPA**	**UL, FM, ANSI, ASME, ASTM, NEMA, IEEE, AWS, AWWA, and DOT**
Overall design	X	X	X	X	
Fire detection system equipment components	X	X		X	X
Smoke/gas detection	X	X		X	
Heat detection	X	X		X	
Manual pull stations	X	X		X	
Notification/Indicating devices	X	X		X	
Sprinkler system	X	X	X	X	
Control panel initiating and indicating devices	X	X		X	
Pipe thread tolerances	X	X		X	
Hydrant flow tests	X	X	X	X	
Extinguishers	X	X		X	
Hose systems	X	X	X	X	
Fire alarm system wiring, initiating devices, notification appliances, solenoids, and signaling line circuits	X	X		X	
Testing of complete fire suppression and detection system	X	X	X	X	
Portable fire extinguishers	X	X		X	

9.3 Water-Based Systems

A. Water-based suppression requirements shall be provided in accordance with AHJ requirements, as NFPA-855 allows water-based suppression requirements to be omitted only if approved by the AHJ.

B. The sprinkler system shall be a double-interlock pre-action dry pipe sprinkler system with a minimum design density of 0.3 gpm/ft^2 over 2500 ft^2.

C. Piping systems shall be pressurized using air or nitrogen; and shall be constantly monitored. One of the following methods shall be employed.

1. Method 1: K-factor of K-8.0 fused sprinkler heads with temperature rating of 135^{o}F for heat detection. Activation of sprinkler head shall result in loss of pressure in the pipe, thereby providing one of the two signals needed at the fire alarm panel. Photoelectric smoke detection shall provide the other needed signal, thus allowing water to flow into the piping system.

2. Method 2: 135°F fixed electric temperature heat detectors will provide the initial signal as well as provide one of the two initiating signals needed to activate the pre-action sprinkler system. A K-factor of K-8.0 fused sprinkler heads with temperature rating of 145°F to 155°F shall provide the other required signal, thus allowing water to flow into the piping system. Water shall not be discharged into the area until the fixed heat detector and sprinkler head have activated. To ensure prompt recognition of a fire condition, the fixed electric heat detectors shall be spaced at half of their listed spacing (i.e.: A detector listed for 30ft spacing shall be installed at 15ft spacing).
3. Method 3: Use of Very Early Warning Air Sampling Smoke Detection System(i.e.: VESDA) with capability of providing two alarm points; one would be an initial general warning but it would not initiate the interlock system, the second alarm would be set equivalent to the set-point of a photoelectric smoke detector; which would be one of the initiating signals of the double interlock system. The second initiating signal shall be from K-factor of K-8.0 fused sprinkler head with a set-point of 135°F. Linear heat detection may be considered if its use and installation is acceptable to the Authority Having Jurisdiction (AHJ).
4. Method 4: Use of Off-gas detection system as alternative to smoke detection as the pre-action signal if acceptable to the Authority Having Jurisdiction.

D. All methods shall be provided with manual pull (MP) stations. MPs shall act as an alternative for one of the input signals for the pre-action system. MPs shall be located and spaced per applicable codes, standards, and local requirements.

E. Contractor shall include all wiring necessary to provide a complete system fire protection system. Wiring shall include power wiring to connect the specified termination points on the fire protection and detection systems to the plant electrical power, tie-ins to plant systems, and tie-ins to outside agencies.

F. Contractor shall verify the fire water supply is adequate for the new fire protection system(s) by performing flow testing.

G. In areas that are not continuously occupied, automatic smoke detection shall be provided at the location of each fire alarm control unit(s). Where ambient conditions prohibit installation of automatic smoke detection, automatic heat detection shall be permitted.

H. Detailed drawings and calculations shall be provided for each system. Drawings and calculations shall be updated at the completion of the job to show as-built configuration. All drawing, calculations and submitted documents shall bear the seal of a registered professional engineer, in the state constructed.

9.4 Clean Agent System

A. Clean agent fire suppression system shall be FM200, NOVEC 1230, or equal. CO_2 systems are not acceptable.

B. Non-occupiable container solution specified in Section 6.0 shall include a clean agent fire suppression system.

9.5 Valves

A. If valves are required as part of a water-based suppression system, valves installed between alarm initiating devices intended to signal activation of a system and the fire suppression system shall be electrically supervised.

B. Contractor shall verify that the design and physical locations of automatic or manual valves and piping network are acceptable to avoid hydraulic shock when the valves are actuated.

C. A permanently attached placard shall be provided on each valve indicating the location and hydraulic information.

9.6 Local Addressable Fire Alarm Control Panel

A. Local control panel(s) shall be furnished and installed to monitor systems. A minimum of one addressable local control panel shall be provided. A main fire control panel shall be located near facility main entrance. The main fire control panel shall monitor and annunciate all fire signals. The main fire control panel shall include as a minimum a distinctive Alarm, Trouble and Supervisory LED for each suppression and detection system.

B. Main fire panel shall remotely transmit and annunciate all Fire, Trouble and Supervisory conditions to a manned location as designated by Company and as required per applicable codes, standards, and local requirements

C. Each local control panel shall be tagged and be capable of operation as a stand-alone system with its own internal secondary power via battery backup. Panel(s) shall communicate together via OEM's internal network communication system. Each initiating device shall be addressable and communicate to local panel via SLC circuit

D. The addressable local control panel(s) shall monitor and annunciate; alarms, trouble, and supervisory signals for each of the fire protection and detection devices and systems. The panel shall be of modular construction, front accessible, and wall mounted. In addition, the panel shall have a minimum of two spare alarm zones requiring only field wiring for future use.

E. Automatic pre-action valves shall be actuated (opened) electrically upon receipt at the panel of fire indication from the detection system for the given hazard, and the control panel shall concurrently produce a fire alarm and initiate any required auxiliary shutdown functions that may be specified or required per applicable codes, standards, and local requirements.

F. The panel for each clean agent or pre-action sprinkler system shall also continuously monitor the off-normal conditions necessary to ensure the availability and proper operation of each system and to annunciate distinctly supervisory and trouble alarms as appropriate.

G. The following distinctive alarms, as a minimum, shall be provided as applicable at the local panel for each pre-action sprinkler system: (Equivalent shall be provided for Clean Agent system and detection systems)

Alarm Condition	Source	Type of Alarm
Fire detected	Heat detectors, smoke detectors, Very Early Air Sampling Smoke Detection, or Manual Pulls (Style D)	Fire
Solenoid energized (for automatic or remote manual systems only)	Local panel (Style B)	Fire

Alarm Condition	**Source**	**Type of Alarm**
Water flow	Water pressure switch (Style B)	Fire
System isolation gate valve (or alarm isolation valve) not fully open	Tamper switches (Style B)	Supervisory
Header isolation gate valve not fully open*	Tamper switch (Style B)	Supervisory
Low air pressure in sprinkler piping	Air pressure switch (Style B)	Supervisory
High air pressure in sprinkler piping	Air pressure switch (Style B)	Supervisory
Solenoid trouble (automatic or remote manual systems only)	Open or ground in wiring to solenoid (Style B)	Trouble
Strobe or Fire alarm bell/horn circuit trouble*	Open or ground in wiring to notification device (Style Y)	Trouble
Water pressure switch circuit trouble	Open or ground in wiring to switch (Style B)	Trouble
Low air pressure switch circuit trouble	Open or ground in wiring to switch (Style B)	Trouble
High air pressure switch circuit trouble	Open or ground in wiring to switch (Style B)	Trouble
Fire detector or MP circuit trouble	Open or ground in detector wiring (Style D)	Trouble
System isolation valve tamper switch circuit trouble	Open or ground in wiring to switch (Style B)	Trouble
Header isolation valve tamper switch circuit trouble	Open or ground in wiring to switch (Style B)	Trouble
Loss of primary power at panel/battery in use*	Local panel	Trouble
Battery voltage low	Low voltage in battery	Trouble
Battery short, charger, or wiring trouble	Open or ground in circuits	Trouble
System normal	Local panel	N/A
Lamp test	N/A	Switch
Acknowledge	N/A	Switch
System reset	N/A	Switch
*These alarms need not be duplicated when two or more suppression systems are controlled by one panel.		

H. Actuating devices and relays shall be furnished to provide annunciation per applicable codes, standards, and local requirements. Spare capacity shall be provided and internally wired.

I. Each local control panel shall continuously monitor its associated fire suppression and/or detection system(s) for fire alarms, supervisory signals, and circuit trouble signals.

1. Upon receipt of a fire alarm, the given panel shall activate appropriate system valves, auxiliary relay, strobes and fire alarm bells throughout the building.

2. Upon receipt of a trouble or supervisory signal, the panel shall activate individual indicating LEDs on the panel and a trouble horn at or near the panel. Trouble and supervisory signals shall be distinctive, i.e., the mixing of two or more signals on one circuit is not allowed.

J. Auxiliary shutdown functions, where required, shall be designed, furnished, and installed, as a minimum, per applicable codes, standards, and local requirements.

K. New panels shall include 10 percent spare I/O of each type. Indicated potential future expansion out cannot be considered as part of the spare capacity to meet this requirement.

L. Wiring and raceway between local panel(s) and remote relay, where required for such things as HVAC systems for auxiliary contacts, will be furnished and installed. Remote shutdown devices shall be located within 3 ft from device/system being shut down. Fire Contractor shall clearly note termination points and wiring on the drawings so other Contractors will be able to land wiring on shutdown relays.

M. Fire protection wiring shall include surge protection, per applicable codes, standards, and local requirements.

N. Upon receipt of any fire alarm signal from a fire detector, suppression system, flow switch, or pull station, the local alarm panel shall activate interior and exterior fire alarm horns/strobes.

9.7 Fire Detection and Alarm

A. Each independent fire detection system shall be designed to provide fire detection, MP and annunciation in each of the areas protected.

B. Each detection control panel shall continuously monitor its detection systems for fire or trouble condition and activate the appropriate fire or trouble alarm(s). These detection and alarm functions shall be performed independently of any other plant equipment or facility. All signals shall be annunciated on main fire control panel.

C. Airflow, ceiling height and slope, and ceiling constructions of the protected area shall be evaluated when selecting spacing and location of detectors. Refer to NFPA 72 for location criteria.

D. HVAC duct detectors shall be provided in the duct and wired to the local fire protection panel to initiate the appropriate response per applicable codes, standards, and local requirements. The fire alarm shutdown contacts shall be installed in a junction box next to the HVAC controller. Refer to NFPA 90A.

E. All Wiring shall be installed in ridged metallic conduit.

F. As a minimum, the following shall be provided:
   1. Smoke, heat, and HVAC duct detectors.
   2. Manual Pull Stations
   3. Early Warning Air Sampling Smoke detectors and sampling pipe network, if this is the method utilized.
   4. Fire detection circuits, wiring, raceway, conduit and supports as required for a complete system.
   5. Local control panel with distinctive alarm, trouble and supervisory LED's.
   6. Remote shutdown relays i and junction boxes.
   7. Notification devices (i.e.: Strobes, horns and bells).
   8. Connecting wire and raceway for electrical devices.
   9. All field devices shall be installed in a junction box.

G. Each fire detection and alarm control panel shall be provided with the capability to send alarms for remote annunciation of fire and trouble alarms. The following distinctive alarms shall be provided for remote monitoring purposes from each of the local panel, as required.

Alarm Condition	Source	Type of Alarm
Fire detected*	Area or duct smoke detector (Style B)*	Fire
Detector circuit trouble (short, open, or ground fault)	Panel (Style B)*	Trouble
Loss of ac power (battery in use)	Local panel	Trouble
Low or missing batteries	Low voltage in batteries/panel	Trouble
Battery short, charger, or wiring trouble	Open or ground in circuits	Trouble
Notification circuit trouble	Open or ground in wiring to indicating appliance	Trouble
System normal	Panel	N/A
Lamp test	N/A	Switch
Acknowledge	N/A	Switch
System reset	N/A	Switch
*NFPA Style D circuit, when detection is used as releasing device		

9.8 Fire Equipment

A. Fire hose stations shall be provided only if required by local AHJ or applicable codes, standards, and local requirements.
B. The Contractor shall furnish fire hose stations with fire hose, hose racks, and accessories per applicable codes, standards, and local requirements
C. Portable fire extinguishers shall be provided. Refer to NFPA 10 for extinguisher locations and spacing.
D. Submit certified drawings of fire hose stations, as applicable and portable fire extinguishers including dimensional data.

9.9 Materials

Component	Material
PIPING	
Sprinkler piping (downstream of isolation gate valve)	ASTM A53, Grade A or B, galvanized, seamless or welded (ERW); or ASTM A106, Grade B, galvanized. Minimum Schedule 40
Pre-action systems (downstream of isolation gate valve)	ASTM A53, Grade A or B, galvanized; seamless or welded (ERW); ASTM A106, Grade B, galvanized (no copper or brass tubing or piping). Minimum Schedule 40
Piping (upstream of the sprinkler and spray systems)	Black steel, ASTM A53, Grade B, seamless; or ASTM A106, Grade B, seamless. Minimum Schedule 40
FLANGES	
Flanges	Hot-dip galvanized following welding when connected to galvanized pipe
Piping 2 in (50.8 mm) and smaller	Screwed or shop welded.

Component	**Material**
Piping larger than 2 in (50.8 mm)	Welded flanges or shop welded connections
Pipe Accessories	
Sprinkler fittings - threaded or flanged; tees, couplings, elbows, caps, and reducers	Malleable iron, Class 150. Mitered fittings are not acceptable.
Sprinkler fittings	Galvanized, ASTM A153; no bushing, slip type, or clamp-on rubber gasketed fittings
Gaskets	Red rubber sheets, 1/16 in (1.6 mm) thick, full face, ASTM D2000, No. 2AA705A13L14
Thread sealant	Teflon ribbon, Optional for gas suppression piping: Loctite 592 sealant and primer NF-73656
Thread tolerances	Local Fire Code and standard pipe threads
Bolts and nuts	Steel machine bolts
Plugs	Square heads and of a metal dissimilar to fitting to which they are attached
Piping supports	Per State and Local Fire Code
Supplementary support beams (pipe support)	ASTM A36, fireproof construction
Riser lugs	ASME B31.1
Hanger rods	Per Fire Code
Water shields	Viking model B-1, or equivalent.
Valves	
Gate valves	OS&Y type, flanged ends
Control panels (local)	NEMA 4 or IP56

9.10 Testing

A. Contractor shall be present during testing. Contractor shall be responsible for costs associated with initial testing as well as costs to correct deficiencies and retest.

B. Contractor shall notify Company and AHJ (if required) at least 5 days in advance of beginning of each test. Final acceptance shall be determined by the Company.

C. Documentation of the inspections and tests shall be maintained by Contractor and furnished to Company. Defects found by these inspections and tests shall be re-inspected following repair by the same method and technique which originally identified the defect. Acceptance shall be based on identical acceptance criteria. Inspection and tests shall be in accordance with NFPA as a minimum. All parties necessary to sign off on test shall be obtained.

D. Testing shall be done by Contractor for:
   1. Testing and system acceptance of water-based fire protection systems
   2. Testing and system acceptance of fire alarm system
   3. Entire System
   4. Testing shall be performed on all piping and valves.

E. Piping and valves; each test shall be conducted for 2 hours at 200 psi (13.8 bar) or at 50 psi (3.5 bar) above the maximum static pressure, whichever is greater. The systems shall be visually inspected during the tests. There shall be no visible leakage or drop in gauge pressure during the tests.

F. The valves shall be tested along with the piping. Any blind flanges or removable plugs required for openings not closed by the valves and piping provided shall be furnished.

G. The pressurization equipment including water piping from the supply shall be furnished.

H. In addition to hydrostatic tests, perform air pressure tests on air pressurized piping and valves. Air pressure of 40 psi shall be established, and the pressure drop shall be measured. The pressure drop shall not exceed 1.5 psi (0.11 bar) in 24 hr.

I. The time to exhaust air and achieve continuous water flow shall not exceed 60 seconds.

J. Systems shall be tested in accordance with the manufacturer's recommendations and to verify proper alarm and annunciation.

K. Each control panel and independent detection system shall be tested in accordance with NFPA 72 after installation has been completed. Each initiating and notification device shall be checked for operation. Remote annunciation to main panel and to remote location shall be tested.

L. Testing of the detectors shall be by manufacturer's recommendations. Upon detector actuation, visual and audible annunciation of the independent detection system at the local and main fire control panel shall be verified. Each alarm circuit at the local and main fire control panel shall be tested to verify proper operation.

10.0 SPILL CONTAINMENT, AND FIRE WALLS

10.1 General

A. This section covers the requirements for spill containment and transformer fire walls.

B. At Contractor's option, transformers may be supplied with environmentally friendly less-flammable fluid (FR3, MIDEL 7131 or engineer approved equal) which may reduce spill containment and firewall requirements if approved by environmental permit. Contractor to verify fluid characteristics are appropriate for site environmental conditions.

10.2 Codes and Standards

A. Equipment, material, design, fabrication, erection, and testing shall conform to governing codes and standards, and minimum requirements of:
   1. International Building Code (IBC)
   2. Occupational Safety and Health Association (OSHA)
   3. American Society of Mechanical Engineers (ASME)
   4. American Society for Testing and Materials (ASTM)
   5. American Concrete Institute (ACI)
   6. American National Standards Institute (ANSI)
   7. State and Local Fire Code
   8. Environmental Protection Agency (EPA)
   9. Other Applicable Company Standards

B. The standards listed shall mean the latest version adopted by the state or local authorities including any amendments to, or modifications of the original document.

10.3 Design Requirements

A. Design shall comply with requirements for civil, structural, piping, and fire protection systems.

10.4 Transformer Spill Containment

A. Spill containment for transformers shall be based on the number of gallons (liters) of oil/fluid in the transformer.

B. Design shall comply with requirements for environmental, civil, structural, and fire protection systems.

C. Containment shall be sized to retain any fluid that may be accidentally spilled from the transformer plus a specified storm event rainfall depth, plus any applicable fire water. (UPDATE PER SITE SPECIFIC INFORMATION)

D. Containment may be combined to include multiple transformers or transformer areas; such that the containment meets requirements for the maximum containment needed for a single event.

10.5 Transformer Fire Walls

A. Refer to NFPA 850 for location and configuration of firewalls.

B. A minimum 2 hour fire barrier of appropriate height shall be provided between any transformer of sufficient oil volume and any building in accordance with applicable Codes or insurance requirements.

C. Adequate physical separation distance may be provided in lieu of fire barriers.

D. Transformers utilizing approved less-flammable fluids (e.g. FR3) shall follow minimum separation requirements of FM Global Loss Prevention Data Sheet 5-4.

11.0 HEATING, VENTILATION, AND AIR CONDITIONING

11.1 General

A. Heating, ventilating, and air conditioning (HVAC) systems shall be provided to ensure equipment OEMs' recommended environmental conditions are met at all times.

B. HVAC equipment and systems shall be heavy-duty, industrial grade design, construction, and installation designed to provide a minimum 20-year life expectancy.

C. Design calculations shall include air conditioning load calculations, heating load calculations, ventilation calculations, psychometric calculations, and pressure drop calculations.

11.2 Codes and Standards

A. Equipment, material, design, fabrication, erection, startup, and testing shall conform to governing codes and standards, and minimum requirements of:

1. State Energy Conservation Codes
2. International Building Code (IBC)
3. Occupational Safety and Health Association (OSHA)
4. American Society of Mechanical Engineers (ASME)
5. American Society for Testing and Materials (ASTM)
6. American National Standards Institute (ANSI)
7. State and Local Fire Codes
8. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
9. Other Applicable Company Standards

11.3 Design Requirements

A. Cooling equipment capacity shall be sized based on end-of-life battery state-of-health (70-80%) heat dissipation coincident with maximum design ambient heat gain.

B. Building or enclosure areas housing batteries shall be segregated into hot and cold aisles. Supply air measured at the battery rack cold aisle shall be maintained at 23C +/- 5C at all times, unless battery OEM specifically requires a different operating temperature. Each battery cold aisle temperature shall be measured at three locations equally spaced along the length of the row. Temperature sensors shall be located approximately 5 feet above the floor. All temperature measurements shall be recorded in the site data historian at 1-minute resolution. Data shall be stored a minimum of 6 months.

C. High efficiency filtration (80%, MERV 13) is required for HVAC units that provide a mixture of outside air and return air. For 100% recirculation style units only 30%, MERV 7 filters may be provided.

D. HVAC systems should be designed to operate in economizer (free cooling) mode whenever outdoor air temperature is within specified supply air temperature range.

E. Filter banks shall have differential pressure transmitters to monitor filter loading.

F. Heating calculations shall include a minimum 10% margin on capacity. Cooling calculations shall include a minimum 15% margin on sensible and latent capacity.

G. HVAC equipment shall be arranged to provide for maximum efficiency of operation and to provide easy access for performing routine maintenance.
H. System design shall be headered such that each HVAC unit is able to provide conditioned air to the entire space within a fire partition.
I. Equipment redundancy shall be provided such that failure of a single HVAC unit does not result in loss of more than 50% cooling capacity.
J. The HVAC control system shall monitor any equipment failures resulting in loss of cooling capacity. Diminished cooling capacity shall be interlocked with the Site Controller to limit battery charging/discharging rate as necessary to avoid cooling system overload. Battery state of health should be taken into consideration when developing charge/discharge rate limit.
K. The HVAC systems shall interface with fire protection systems in accordance with NFPA and other applicable codes. HVAC systems shall shut down and fire/smoke dampers shall close upon fire or smoke detection. Fire-fighting personnel shall be able to override system shutdown to ventilate the building space if required.

11.4 Testing

A. After installation, HVAC systems shall be functionally tested by NEBB certified technicians to verify proper operation.
B. Emphasis shall be placed on ensuring that cooling airflow is properly balanced to maintain cold aisle temperature within specified limits.
C. All temperature data points recorded in site data historian shall be functionally verified for proper operation.

12.0 GENERAL ELECTRICAL

12.1 General

A. This section describes the design criteria which shall be used for general electrical work related to this project.

B. Equipment and systems covered in this section are:
   1. Cable
   2. Earthing and Bonding
   3. Lightning Protection
   4. Conduit and Raceway
   5. Lighting and Wiring Devices

12.2 Codes and Standards

A. The Work shall be in accordance with applicable laws and regulations of the federal government and the state, local utility requirements for interconnection, and applicable local codes and ordinances. A partial listing of the codes and industry standards used for design and construction follow:
   1. National Electrical Code (NEC)
   2. International Building Code (IBC)
   3. American National Standards Institute (ANSI)
   4. Institute of Electrical and Electronics Engineers (IEEE)
   5. American Society for Testing and Materials (ASTM)
   6. State Energy Conservation Code
   7. Illuminating Engineering Society (IES)
   8. State and Local Fire Code
   9. Occupational Safety and Health Association (OSHA)
   10. Other Applicable Company Standards

B. Other recognized standards shall be utilized as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

C. The codes and industry standards used for design, fabrication, and construction shall be the codes and industry standards in effect at the date of this Contract.

D. The Company may be exempt from certain NEC requirements. The system electrical design shall be NEC compliant to the greatest extent possible and in accordance with all applicable standards. Deviations from the NEC must be approved by Company.

12.3 Cable Basic Requirements

A. Cable requirements are applicable to general (field) wiring only. Manufacturer's standard wiring practices are acceptable for equipment wiring.

B. Medium voltage cables shall be fully shielded and shields shall be grounded in accordance with IEEE 422.

C. Instrument cable shall be fully shielded to minimize electrical noise attenuation. Each pair of instrument conductors shall be shielded and each multi-pair cable assembly shall include an additional overall shield. Cable shields shall be electrically continuous. When two lengths of shielded cable are connected together at a terminal block, a point on the terminal block shall be used for connecting the shields. Instrument cable shields shall be grounded on one end only.

D. Medium voltage cable feeders along with their shields and equipment ground conductors shall be sized so that a short-circuit fault shall not result in cable damage prior to normal operation of fault interrupting devices.
E. Insulated conductors installed in cable tray shall have non-propagating and self-extinguishing characteristics. Cables shall meet the vertical cable tray flame test requirements of IEEE 383.
F. Thermocouple extension cable shall be used for extension leads from thermocouples to junction boxes and to instruments for measurements of temperature. Cables may be routed in trays, conduits, or ducts.
G. All cables shall be identified on each end with a unique cable ID and permanent cable tag.
H. Cable data such as year of manufacturing, manufacturer name, insulation material, rated voltage, and cross section shall be printed on the cable jacket at even spacing.
I. Cable conductor colors shall be in accordance with Company standards.

12.4 Power Cable

A. Medium voltage power cable shall be MV-105, 133% insulation, single copper or aluminum conductor, Class B stranded, shielded power cable. Cable shall meet AEIC CS8 and ICEA S-97-682 requirements and shall be UL listed for cable tray use. Cable shall meet the flame test requirements of IEEE 383.
B. Low voltage power cable shall supply power to loads at voltage levels of 480 volts ac and below and 250 volts dc and below. Power cable shall have XHHW or XHHW-2 Class B stranded copper conductor. Cable shall meet ICEA S-95-658 and shall meet the flame test requirements of UL VW-1 (8 AWG and smaller) and IEEE 383 (6 AWG and larger).
C. No MV cable splices are permitted unless explicitly approved by the Company.

12.5 Control and Instrumentation Cable

A. Control cable shall be used for control, metering, and relaying. Control cable shall have Class B stranded copper conductor, flame retardant insulation, flame and ultraviolet retardant overall jacket and shall be UL listed Type TC. Cable shall meet ICEA S-95-658 and UL 1277. The cable shall meet the flame test requirements of IEEE 383.
B. Control shall be multi-conductor and shall be UL listed Type TC.
C. Instrumentation cable shall be single or multi twisted pair or triad and shall be UL listed Type PLTC.
D. Metering and Relaying panel conductors shall be type SIS #14 AWG minimum or #12 AWG minimum for CT circuits .

12.6 Lighting and General Use Conductors

A. Insulation shall be rated 600 volt. Circuit runs shall be in conduit. Minimum conductor size shall be #12 AWG (4.0 mm^2).
B. Type THHN or THWN single conductor with copper conductor for low voltage general use circuits indoor or conditioned areas.
C. Lighting conductors in areas not normally accessible after construction may utilize properly supported type MC cable.

D. Grounding cable shall be Class B or C, Type THWN or THHN insulated and un-insulated soft drawn copper conductors sized as required.

12.7 Cable Connectors and Terminations

A. Power cables shall utilize standard two-hole pressure crimped connectors except when terminating to devices which are provided with clamp type connectors, such as molded case circuit breakers. Hole spacing shall be NEMA standard.

B. Medium voltage shielded cables shall not be spliced. Medium voltage terminations shall have stress relief system applied at the termination of the cables. Stress relief system shall be of the pre-formed cone type, cold shrink type suitable for the cable to which they are to be applied; Manufacturer shall be 3M.

C. Control and Instrument Terminations may utilize Contractor's / Manufacturers' standard.

D. Current Transformer (CT) terminations shall utilize ring lug terminals. Field CT circuits terminating in control and protection cabinets shall be terminated on shorting-type terminal blocks prior to continuation to protective devices.

12.8 Earthing and Bonding Requirements

A. The BESS earthing system shall be an interconnected network of bare copper conductor, copper-clad ground rods, foundation reinforcing steel, and other grounding electrodes present as defined by the NEC. The BESS facility earthing system shall be connected to anyadjacentgroundinggrids(ASAPPLICABLE).

B. Contractor shall perform calculations in accordance with IEEE 80 methods to demonstrate the BESS facility is safe from the perspective of touch, step, and transferred potentials. Calculations shall be submitted for Company review.

12.9 Lightning Protection Criteria

A. The requirement for lightning protection shall be evaluated based on a risk-based assessment such as that provided in NFPA 780 Annex L. If required, lightning protection shall be designed and installed in accordance with NFPA 780.

B. Lightning protection equipment shall conform to the requirements of Underwriters Laboratories Standards 96.

12.10 Conduit and Raceway

A. Cable tray design shall be based on the loads to be carried plus the dead weight of the tray system. In addition to, and concurrent with the load specified above, the tray shall be designed to withstand a concentrated load of 200 lbs. (90kg) at the mid-span, at the center of the rung or on either side rail. The safety factor for this load condition shall be at least 1.5 based on the ultimate capacity of the tray or any of its components as determined by test in accordance with NEMA load test VE-1-Sect 4.

B. Cable trays and fittings shall be the standardized products of a single manufacturer designed to permit easy assembly in the field.

C. Aluminum cable trays shall be manufactured of heat-treated ASTM B221 6063 aluminum alloy for extruded parts and ASTM B209 5052 alloy for parts fabricated from sheets. Rungs shall not be movable.

D. Minimum radius for tray bends and fittings shall be eight times the diameter of the largest non-shielded cable or 12 times the diameter of the largest shielded cable to be installed, whichever is the larger. Dropout fittings shall be provided where required to maintain the minimum cable bending radius.

E. In general, trays for cables of different voltage levels shall be stacked in descending order with the higher voltage at the highest elevation. Individual tray systems shall be established for the following services. Trays may be divided into multiple services by the use of continuous, metallic barriers.

1. Medium voltage power cables
2. Low voltage power cables
3. Low voltage control cable
4. Shielded instrumentation cables
5. Communication cables

F. Fire stops shall be provided where trays penetrate exterior walls or fire separation areas.

G. Except for indoor lighting and communications circuits, exposed conduit shall be rigid steel, hot-dipped galvanized.

H. Conduits for lighting, power, and general convenience circuits, and communications circuits in indoor areas may utilize Electrical Metallic Tubing (EMT), hot-dipped galvanized inside and outside. EMT shall not be used in hazardous areas or where subject to physical damage during and after installation.

I. Minimum conduit size shall be 3/4 in (20 mm) nominal diameter except for lighting fixture stems, which may be 1/2 in (16 mm) nominal diameter.

J. Conduits shall be routed such that they do not create a trip hazard.

K. Liquidtight flexible metallic conduit shall be used for connections to accessory devices, for connections to vibrating equipment, and across areas where expansion or movement of the conduit is required. Lengths shall not exceed 3 ft (900 mm).

12.11 Lighting and Wiring Devices

A. The lighting system shall provide personnel with illumination for operation under normal conditions and means of egress under emergency conditions.

B. Interior and exterior luminaries shall be LED type, mounted so they are easily accessible for maintenance to the maximum extent practical.

C. Emergency lighting shall be self-contained emergency lighting units including batteries and battery charger.

D. Lighting levels shall be designed in accordance with the Illuminating Engineering Society (IES) recommendations.

E. Outdoor fixtures shall include photoelectric sensors and motion detectors to keep lights off when not required.

F. Convenience receptacles shall be spaced in the battery storage area such that there is a maximum 100 ft (30.0 m) distance to a receptacle outlet, unless codes require otherwise. An accessible receptacle outlet shall be provided within 25 ft (7.6 m) of each HVAC unit.

12.12 Emergency Stop Switches (E-Stop)

A. Containerized BESS systems shall incorporate an E-stop function into the inverter control panel or local HMI. Containerized BESS system E-stops shall shut down only the affected BESS equipment train.

12.13 Earthing and Bonding Installation and Testing

A. Earthing conductors shall be copper and have a minimum cross-sectional area of #2/0 AWG.
B. Cable trays shall include a bare copper earthed conductor installed the entire length and connected to each section of tray and to station earth grid.
C. Major items of equipment transformers, relay and control panels, and panelboards shall contain copper earthed buses connected to the primary earthing system. Equipment with multiple sections such as low voltage switchboards shall connect earth bus to station grid at both ends.
D. Each row of battery racks shall be earthed at each end.
E. Metallic structures and equipment housings located on the roof of the building shall be connected to earthing system.
F. The site perimeter fence may be earthed or isolated at Contractor's option, subject to safe touch potential analysis. If the site fence is not earthed, then isolating sections shall be installed where the BESS site fence abuts the existing substation fence.
G. BESS container lightning protection system downcomers shall be terminated to the BESS earthing grid.
H. Earthing system connections shall be made with exothermic welds or non-reversible compression type fittings. Mechanical bolted connections are not permitted.
I. Earthing connections at the substation shall be exothermic weld. Earthing connections on the collection system may be irreversible crimp or exothermic weld.

12.14 Arc Flash Mitigation

A. Contractor shall perform an Arc Flash hazard analysis in accordance with IEEE 1584 for voltages up to 15kV. For voltages above 15kV, Kinectrics ARCPRO software must be utilized.
B. The system shall be designed such that a PPE level of no higher than Level 4 (40 cal/cm2) is required.
C. All electrical equipment shall be labeled in accordance with NFPA 70E. At a minimum, the following information shall be shown on equipment labels:
   1. Nominal system voltage
   2. Arc Flash Boundary
   3. Working distance
   4. Available incident energy at working distance
D. Methods shall be employed to reduce the arc flash hazards including:
   1. Maintenance Mode relay settings and a maintenance mode selector switch (Normal / Maintenance) with blue indicating light for medium voltage switchgear breakers.
   2. Bus differential relay protection.
   3. Transformer differential relay protection on the main power transformer.
   4. Provide remote racking systems for medium voltage draw-out circuit breakers. Remote racking system shall be Safe-T-Rack or Owner approved equal.
   5. Provide actuator to remotely operate pistol grip type breaker Open / Close switches. CBS Arc Safe Chicken Switch or Owner approved equal.

13.0 PADMOUNTED TRANSFORMERS

13.1 General

A. This document specifies the scope of supply and the major design and performance parameters for the Step-Up transformers and the facility station service transformer.

B. Basic design shall be outdoor oil-immersed 3-phase pad mounted distribution transformers designed for daisy-chain or loop feed on the HV side (AS APPLICABLE).

13.2 Applicable Standards

A. Characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of ANSI, IEEE, NEMA, and Department of Energy standards, as applicable.

B. Specifically, but not limited to:
1. IEEE C57.12.00, and associated applicable parts
2. C57.12.28
3. C57.12.34
4. C57.12.90 for standard testing
5. C57.12.91
6. C57.154
7. NEMA TR1
8. NEMA 260

13.3 Design Requirements

A. Inverter step-up transformers shall be naturally cooled. Cooling fans shall not be required for continuous operation to achieve maximum rating.

B. Transformers shall be suitable for bi-directional operation.

C. Transformers shall be sized to continuously accept inverter rated kVA output between .9 leading and .9 lagging power factor without overload.

D. Inverter step-up transformers shall be suitable for operation at up to 5% harmonics on both the HV and LV winding at the transformer full load rating.

E. Transformers shall be provided with six high voltage bushings, 600A minimum. HV connections shall be made via elbow disconnects.

F. The Power Conversion System (PCS) step-up transformer voltage ratio shall be selected to match the substation interconnection voltage without use of intermediate step-up transformers. (APPLICABLEFORHV/SUBSTATION INTERCONNECT)

G. During detailed design, Contractor shall perform an electrical harmonics study to confirm that the proposed PCS system does not cause harmonic resonance when paralleled with the Company's existing equipment. If required, the addition of air core tuning reactors or other mitigating measures shall be engineered and provided by Contractor. (APPLICABLEFORCONNECTIONTOINTERMITTENTGENERATION)

13.4 Testing

A. Perform standard factory tests in accordance with IEEE C57.12.90. Furnish tests reports per submittal requirements.

13.5 Loss Evaluation

A. Transformers will be continuously energized when BESS facility is in standby mode. No-load losses should be minimized to extent practical. Bidders shall include no-load and load loss data for BESS transformers. Owner will evaluate the transformer losses using values of $4000/KW for no-load losses and $2000/KW at rated full load output.

13.6 Transformer Data Sheets

Contractor shall submit information in “Vendor Data” column with Proposal.

14.0 METERING AND PROTECTION

14.1 General

A. This section covers the basic system protection requirements.

B. Contractor shall coordinate with interconnection work to ensure equipment is provided which meets the overall intent of the project and utility interconnection requirements.

14.2 Codes and Standards

A. The design and specification of work shall be in accordance with applicable laws and regulations of the governing bodies, local utility requirements for interconnection, and applicable local codes and ordinances.

B. A listing of the codes and industry standards to be used in design and construction:
1. American National Standards institute (ANSI)
2. American Society for Testing and Materials (ASTM)
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electrical Manufacturers Association (NEMA)
5. National Fire Protection Association (NFPA)
6. State and Local Fire Code
7. National Electrical Safety Code (NESC)
8. Occupational Safety and Health Act (OSHA)
9. Underwriters Laboratories, Inc. (UL)
10. National Electrical Code (NEC)
11. Other Applicable Company Standards

C. Other recognized standards shall be utilized as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

D. The Company may be exempt from certain NEC guidelines. The system electrical design shall be NEC compliant to the greatest extent possible and in accordance with all applicable legal requirements.

E. The codes and industry standards used for design, fabrication, and construction shall be the codes and industry standards in effect at the date of this Contract.

14.3 Overall System Protection

A. Contractor shall perform system analysis from the point of interconnection (POI) down to the BESS inverters and station auxiliary LV buses. Where system information is not available, Contractor shall assume an infinite bus at the Substation high voltage bus. Relay settings shall be based on actual system interconnection values which will be provided prior to setting relays.

B. Contractor shall perform initial and final electrical system studies. The scope shall include studies required to design and specify the plant auxiliary electric system within the site boundaries. Studies include, but are not limited to, load flow, feeder and equipment sizing duty calculations, short circuit and protective device coordination, and arc flash.

C. Contractor shall develop relay settings for protection and control devices within Contractor's supply scope. Protection and control settings for the breaker at the POI shall be coordinated with Company's existing protection and control scheme. Contractor shall implement settings into relays and test all relays prior to operation.

D. Protective relays shall be solid-state microprocessor type, flush mounted. Protective relays shall be as manufactured by Schweitzer Engineering Laboratories (SEL) or Company approved alternate.

E. Each item of the electrical system shall be provided with a back-up protection that is responsive to electrical faults thus allowing isolation of the faulted item in a timely manner, before major damage is sustained. This is not required to be a separate relay and may form part of the transformer or feeder protection, e.g. over-current and earth fault.

F. Alarm/trouble contacts from each breaker and relay shall be remotely alarmed via SCADA. All protective devices shall be synchronized to the substation same time source via IRIG-B signal.

G. Any devices used to isolate electrical equipment for maintenance shall have a visible airgap or means of visual disconnect.

H. Zig-Zag Grounding Transformers shall be provided as required on each Bus to facilitate ground fault detection. BESS protection shall trip and prevent further operation of BESS if grounding system is unavailable. Grounding transformers shall be automatically removed from service when BESS is not in service and shall be interlocked with turbine generator grounding system and generator circuit breaker to ensure only one grounding system is active at any given time.

   i. KVA Rating as required for effective grounding of AC collection circuits. All grounding transformers to have the same KVA rating, etc. and be interchangeable.
   ii. KVA Rating as required for effective grounding of AC collection circuits. All grounding transformers to have the same KVA rating, etc. and be interchangeable.
   iii. Pedestals for padmount transformers shall be fiberglass, pre-cast, or poured concrete.
   iv. Grounding transformers shall be sized to keep the collection feeder voltage rise during a fault to less than 1.39pu voltage as per IEEE C62.92.1-2000.

14.4 Metering

Contractor shall provide bi-directional, revenue grade metering at each point of interconnection in the form of a SEL-735 Power Quality and Revenue Meter. Contractor shall also provide provisions for an Company supplied revenue meter (Schneider Electric ION-8500) or Company approved alternate.

BESS facility auxiliary power consumption shall be separately metered, also with an SEL-735 revenue grade meter.

15.0 LOW VOLTAGE ELECTRICAL DISTRIBUTION

15.1 General

This section covers the low voltage distribution equipment

15.2 Codes and Standards

A. The design and specification of work shall be in accordance with applicable laws and regulations of the governing bodies, local utility requirements for interconnection, and applicable local codes and ordinances.

B. A listing of the codes and industry standards to be used in design and construction:

1. American National Standards institute (ANSI)
2. American Society for Testing and Materials (ASTM)
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electrical Manufacturers Association (NEMA)
5. National Fire Protection Association (NFPA)
6. State and Local Fire Codes
7. National Electrical Safety Code (NESC)
8. National Electrical Code (NEC)
9. Occupational Safety and Health Act (OSHA)
10. Underwriters Laboratories, Inc. (UL)
11. Other Applicable Company Standards

C. Other recognized standards shall be utilized as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

F. The codes and industry standards used for design, fabrication, and construction shall be the codes and industry standards in effect at the date of this Contract.

G. The Owner may be exempt from certain NEC requirements. The system electrical design shall be NEC compliant to the greatest extent possible and in accordance with all applicable standards. Deviations from the NEC must be approved by Owner.

15.3 Design Requirements

A. The LV distribution system shall be fed from a dedicated station service transformer. The LV system capacity shall be primarily determined by Contractor's BESS HVAC design. See oneline diagram for additional information.

B. Auxiliary power consumption shall be metered separately.

15.4 Low Voltage Panelboards

A. Panelboards shall be dead-front, fixed mounted circuit breaker type.

B. Breaker operating handles shall be accessible through a door that can latch and lock. A panel directory shall be placed inside the panelboard door. Circuit breaker assignments shall be consistent with design drawings.

16.0 MEDIUM/HIGH VOLTAGE EQUIPMENT AND INTERCONNECTION

16.1 General

A. This section covers the scope of work associated with the interconnection of the BESS to the Company's substation. The Contractor shall be responsible for ensuring compliance with the utility and system operator interface requirements.

B. Work shall include Engineering, Procurement, and Construction and shall include:
1. Site Work
2. Grounding
3. Steel Structures
4. MV and HV Equipment
5. Metering and Protection
6. Instrument Transformers
7. Overhead Lines and Underground Lines
8. Foundations
9. Commissioning and Start-up

C. Coordinate ratings and design requirements with interconnection utility. Equipment shall meet at least the minimum requirements. Single-line diagram (s) are provided for reference to show the limits of the anticipated work.

D. The codes and industry standards used for the design, fabrication, and construction shall be the codes and industry standards in effect at the start date of the work.

16.2 Codes and Standards

A. The design and specification of work shall be in accordance with applicable laws and regulations of the governing bodies, local utility requirements for interconnection, and applicable local codes and ordinances.

B. A listing of the codes and industry standards to be used in design and construction:
1. American National Standards institute (ANSI)
2. American Society for Testing and Materials (ASTM)
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electrical Manufacturers Association (NEMA)
5. National Fire Protection Association (NFPA)
6. State and Local Fire Codes
7. National Electrical Safety Code (NESC)
8. National Electrical Code (NEC)
9. Occupational Safety and Health Act (OSHA)
10. Underwriters Laboratories, Inc. (UL)
11. Other Applicable Company Standards

C. Other recognized standards shall be utilized as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

D. The codes and industry standards used for design, fabrication, and construction shall be the codes and industry standards in effect at the date of this Contract.

E. The Owner may be exempt from certain NEC requirements. The system electrical design shall be NEC compliant to the greatest extent possible and in accordance with all applicable standards. Deviations from the NEC must be approved by Owner.

16.3 Submittals

A. Provide submittals in accordance with project submittal requirements.

B. Preliminary and detail design engineering and construction documents, to include:
   1. Nameplate data.
   2. Schematic design drawings for Company review.
   3. Detailed construction drawings for Company review.
   4. Protection coordination study, selectivity, and settings.
   5. Final sealed and signed conform to construction record drawings at the completion of the project.
   6. Test Reports
   7. Operation and Maintenance Manuals.

C. Relay protection shall include such things as the study report, time coordination curves, settings, setting manuals, setting files for downloading into relays, and programming of protection devices.

D. Documentation for each relay, meter, or programmable controller furnished or altered under this contract shall include supporting calculations and/or methodology for each setting that differs from the relay vendor's factory default settings. In addition, a logic drawing shall be provided that clearly documents all custom logic and the logic driving all relay output. Relay output includes; contact outputs, virtual outputs, LED targets, and LCD display message.

16.4 Site Work

A. Excavate as required for new breaker and takeoff structure foundations.

B. After completion of foundations, structures, ground grid; underground duct bank/precast cable trench and conduits, and other permanently installed equipment, the areas shall be backfilled and compacted to 95% modified proctor to an elevation of 6 in below finished grade.

C. All areas within the substation shall be finished with 6 in of cleaned, crushed rock to match existing substation surfacing. The rock must have a minimum of 3 fractured faces and must meet the minimum requirements for appropriate step/touch potentials.

16.5 Grounding

A. All new above grade structures shall be connected to the substation grounding grid with #4/0 AWG bare copper conductors.

B. Manual disconnect switch operators shall have a potential equalizing (switching) mat installed. Switching mats shall be constructed from galvanized 4 ft x 6 ft metal grating set level on top of the stone yard surface and connected to the ground grid and to the switch handle / operator ground.

16.6 SF6 Circuit Breakers (APPLICABLEFORHVINTERCONNECTIONS)

A. Provide three phase, freestanding, SF6 dead tank breaker, complete.

B. Install breakers on new concrete foundation.

C. Equip breakers with the number of multi-ratio current transformers (MRCT) required for use in protective relaying or metering.

16.7 Islanding Switchgear (APPLICABLE FOR MV INTERCONNECTIONS)

A. Provide three phase, freestanding, metal clad switchgear lineup
B. Switchgear shall be outdoor, arc rated construction
C. Switchgear shall include vacuum circuit breakers, instrument transformers, and protective relaying

16.8 Instrument Transformers

A. Current and voltage transformers are required for protection and metering. High accuracy CTs shall be required for revenue metering.
B. Current and voltage transformers shall meet the utility interconnection requirements for both type and accuracy class. Accuracy class shall be maintained for any tap position on a multi-ratio CT, specifically for metering applications during lightly loaded conditions.
C. Protection and metering CTs should be separate.

16.9 Underground Raceway

A. All underground circuits installed in the substation shall be encased in conduit, ductbank, or a cable trench.
B. Duct banks shall be concrete encased. Cable trench shall have covers rated for the appropriate loads that may be encountered.
C. The AC collection circuits from the BESS to the substation may be direct buried after exiting the substation.

16.10 Foundations

A. Foundations shall be provided as specified in other Sections of this specification.
B. Substation foundations shall extend at least 12 in (300 mm) above finished grade.

17.0 BATTERIES, RACKS, AND BMS

17.1 General

A. This section establishes the minimum functional specifications for the Batteries, Racks, and Battery Management System (BMS).

B. The system supplied under these specifications is a pilot project and will be used by the Company to test various operating modes / use cases as described more fully in Section 20.0, Site Controller.

17.2 Batteries

A. Battery cell/module design shall be of proven technology and shall have been installed in similar applications for a minimum of one year. It is expected that battery cells/modules are sourced from recognized "Tier 1" manufacturers. It is expected that replacement modules of the same design or of a directly compatible design will be readily available from the manufacturer for a minimum of 10 years such that rack modifications are not required.

B. Battery racks shall be factory pre-assembled into vertical sections. Rack dimensions shall be manufacturer's standard, designed for installation into a building or environmental enclosure arranged in back-to-back rows. Racks shall include all bracing required for the site seismic conditions and to ensure racks cannot tip during module installation. Racks shall be suitable for installation directly onto a finished concrete floor with tolerances specified in other sections of this specification. Racks shall be anchored using drilled concrete anchors and leveling shims as required. Rack design shall include provisions to protect personnel from inadvertent contact with exposed energized parts, such as ventilated doors or insulated covers over live parts.

Table 1- Minimum Battery Functional Specifications	
Description	**Requirements**
Intended use	INSERT USE

Table 1- Minimum Battery Functional Specifications	
Description	**Requirements**
Applications / Use Cases	Primary application is energy time-shift and arbitrage (C = 0.25) Secondary application is intermittent generation smoothing and ramp rate control. (C = 0.5) Additional use cases include Automatic Voltage Regulation and Autonomous Frequency Regulation. (C = 0.5) The battery will be operated at Charge/Discharge rates ranging from 2 hours to 4 hours by varying the power flow through the inverters. Maximum C rate is 0.5. (C-rate is a measure of the rate at which a battery is discharged relative to its maximum capacity. The c rate is calculated as the inverse of battery discharge rate in hours. i.e. a battery that discharges in 2 hours would have a C rate of ½ = 0.5.)
Beginning of Life Power	XX MW
Beginning of Life Energy	40 MWhr useable depth of discharge (DOD) @ 0.5C
Minimum End of Life Energy	EPC to provide expected degradation curves based on specified Duty Cycle with proposal.
Duty Cycle	200 cycles of full depth of charge/discharge per year at 0.25C, plus 10 cycles per day within +/- 15 percent range DOD (of 50% nominal SOC) at 0.5C
Charging Method	Constant Current / Constant Voltage
Discharging Method	Constant Current
Design Life	Component life 20 years.
Inverter Nominal Voltage Range	900-1200 VDC nominal
Battery Maximum Continuous Discharge to Inverter	3100 A nominal
Warranty requirements	Manufacturer Standard
Installation	Indoors, XXXX feet altitude
Design Ambient (battery enclosure)	23C +/- 5C
Design Humidity (battery enclosure)	20 – 100%, non-condensing
Seismic Data	Refer to Section 2.4

17.3 Racks

A. Each rack section (or pair of sections for long duration systems) shall include a load-break disconnecting means to allow isolation of the rack's modules from the DC bus by the Battery Management System.

17.4 Battery Management System

A. The Battery Management System (BMS) shall be the battery OEM's standard product, providing the following functions at a minimum:
   1. Measurement of Battery operating parameters
   2. Measurement of battery cell voltages
   3. Measurement of battery cell temperatures
   4. Measurement of battery string current
   5. Measurement of battery string voltage
   6. Calculation of battery string State of Charge (SOC)
   7. Calculation of battery string State of Health (SOH).
   8. Cell Balancing
   9. Battery Protection from the following:
      a. Cell under voltage
      b. Cell over temperature
      c. Cell under temperature
      d. Cell over current
   10. Pre-charge protection

B. At a minimum, the BMS shall monitor the data points listed in **Table 2**. The BMS shall monitor all data points required and store data a minimum of 24 hours of pre- and post- event (or as required by the battery OEM) for root cause / post mortem analysis and warranty claim disposition. Data points shall also be transmitted to the Site Controller / Historian for long term data storage and retrieval.

C. Rack BMS to System BMS communication protocol shall be manufacturer standard.

D. System BMS to Site Controller communication protocol shall be Modbus TCP/IP or alternate as approved by Purchaser.

Table 2- Minimum BMS Functional Specifications

Description	**Points to be Monitored.** *Sample interval 1 second.*
System Level	Fault Status
	Alarm Status
	System Current
	System Voltage
Each Rack or String	Rack Voltage
	Rack Current
	Rack SOC
	Rack SOH
	Rack Fault Status

Table 2- Minimum BMS Functional Specifications	
Description	**Points to be Monitored.** *Sample interval 1 second.*
	Rack Alarm Status
	Maximum Cell Voltage Value
	Maximum Cell Voltage Position
	Minimum Cell Voltage Value
	Minimum Cell Voltage Position
	Maximum Cell Temperature Value
	Maximum Cell Temperature Position
	Minimum Cell Temperature Value
	Minimum Cell Temperature Position
	Rack DC Switch Status

18.0 POWER CONVERSION SYSTEM

18.1 General

A. This section establishes the minimum functional specifications for the BESS Power Conversion Systems (PCS).

B. The PCS, in conjunction with the BESS Site Controller, shall be capable of automatic, unattended operation. The PCS shall include all necessary self-protective and self-diagnostic features to protect itself from damage in the event of component failure or from operating beyond equipment ratings, whether due to internal or external causes.

C. The PCS system shall include provisions for isolation on both the AC and DC terminals. Disconnecting provisions shall be capable of being locked out to facilitate Company's LOTO process for maintenance work. Filter capacitors shall be provided with bleeder resistors or other means of discharging to less than 50 volts within approximately one minute of de-energization.

18.2 Codes and Standards

A. UL 1741

B. IEEE 1547

C. IEEE 519

D. Other Applicable Company Standards

18.3 Inverters

A. The inverters supplied under these specifications will be used by the Company to test various BESS operating modes as part of a pilot project. Operating in conjunction with the Site Controller, the PCS shall be able to operate in all modes specified in Section 20.0.

B. Inverters shall be of proven technology and shall have been installed in similar applications for a minimum of one year. The PCS must be sourced from recognized "Tier 1" manufacturers such as those provided in the approved supplier list.

C. Inverters shall have a design life of not less than 20 years and shall be suitable for installation in an outdoor environment. It is expected that replacement components will be readily available from the manufacturer for the design lifetime.

18.4 PCS Specifications

A. The PCS internal cooling system design may be the manufacturer's standard, provided that failure of a single cooling fan does not cause more than 50% derating of the affected PCS's power rating.

B. The PCS transformer shall meet the requirements of Section 13.0- Pad Mounted Transformers.

C. The PCS shall meet the requirements of the following:

Table 3- Minimum PCS Functional Specifications

Description	Requirements
Intended use	Utility Scale Grid Interactive Storage System Pilot

Table 3- Minimum PCS Functional Specifications	
Description	**Requirements**
Applications / Use Cases	Primary application is energy time-shift and arbitrage (C = 0.25) Secondary application is intermittent generation smoothing and ramp rate control. (C = 0.5) Additional use cases include Automatic Voltage Regulation and Autonomous Frequency Regulation. (C = 0.5) The battery will be operated at Charge/Discharge rates ranging from 2 hours to 4 hours by varying the power flow through the inverters. Maximum C rate is 0.5.
Project Power Rating	XXMW across power factor range of .95 lagging to .95 leading without active power de-rating
Reactive Capability	Inverters shall be capable of operation between 0.8 lagging to 0.8 leading power factor with active power de-rating
Inverter Form Factor	Central or distributed (rack / string) are acceptable.
Charging Method	Constant Current / Constant Voltage
Discharging Method	Constant Current
Design Life	Component life 20 years.
Inverter Nominal Voltage Range, DC	To be coordinated with Company-furnished battery
Inverter Nominal Voltage, AC	As selected by EPC
Warranty requirements	Manufacturer Standard
Installation	Outdoors, XXX feet altitude
Design Ambient	See Section 2.0.
Design Humidity	See Section 2.0.
Seismic Data	See Section 2.0.

19.0 Bi Directional Inverters/ DC-DC Converters

19.1 General

A. Operating in conjunction with the Site Controller, the PCS shall be able to operate in all modes specified in Section 20.0.

B. Inverters/converters shall be of proven technology and shall have been installed in similar applications for a minimum of one year. It is expected that PCS are sourced from recognized manufacturers as listed in Attachment D.

C. Inverters/converters shall have a design life of not less than 20 years and shall be suitable for installation in an outdoor environment. It is expected that replacement components will be readily available from the manufacturer for the design lifetime.

20.0 SITE CONTROLLER

20.1 General

A. This section establishes the minimum functional specifications for the BESS Site Controller.

B. The BESS system supplied under these specifications will be used by the Company to test various operating modes as part of a pilot project. The Site Controller shall coordinate with the PCS and BMS to perform the functions specified in this section.

C. The Site Controller shall interface with the Company's remote dispatch system. Contractor may coordinate revisions to the Company's existing SCADA remote interface gateway or may furnish a new gateway. The remote interface gateway shall be a SEL RTAC 3530 or equal. Communication with Company's remote dispatch system shall utilize DNP3 Ethernet protocol.

D. The Site Controller shall aggregate the operation of the individual Power Conversion Systems such that the BESS may be remotely operated as if a single asset. The Site Controller shall include a data historian function able to store a minimum of 1 month of required BESS operating data locally. The Site Controller shall include a local HMI station and shall be located in a separate control enclosure. .

E. The Site Controller hardware and application software shall be of proven technology and shall have been installed in similar applications for a minimum of one year.

20.2 Operating Modes

A. At a minimum, the Site Controller shall provide the following BESS operating modes:

1. ***Direct Remote Control (Modular Energy System Architecture (MESA) function 9).*** In the Direct Remote Control mode, the BESS responds directly to signals from a remote dispatch system in the same way a conventional dispatchable generation asset is controlled. Because a BESS is a bi-directional generation asset, the remote dispatch system must provide a real-time "signed" dispatch signal commanding the BESS to charge (negative value), discharge (positive value), or remain idle (0) as necessary. The rate of charge/discharge is determined by the magnitude of the dispatch signal. Both the real power output (MW) and reactive power output (controllable as power factor) may be adjusted; operating at power factors less than unity reduce the BESS MW output rating to maintain inverter MVA within its rating.
   In this mode, the BESS relies upon the remote system to determine the optimum operating mode of the BESS in consideration of real time price signals, battery state-of-charge, and any upcoming scheduled operating modes having higher priority.

2. ***Scheduled Charge/Discharge Mode (MESA function 23)*** -- Charging and discharging direction and magnitude is controlled according to a fixed time schedule. The local site controller shall store at least 20 user-defined schedules, any of which may be selected locally or via SCADA command. For each schedule, the user shall have the ability to set the time of day at which the charge or discharge is to begin and desired charge or discharge rate vs. time.

3. ***Frequency Bias (droop) Mode (MESA function 18)*** -- The local site controller shall contain a droop control function with adjustable proportional gain (droop) and dead band settings. When Frequency Bias is enabled, the present charge or discharge setting is biased by an amount proportional to measured system frequency. For example, with the droop controller set at 5%, a 5% drop in system frequency (3 Hz) would cause a control bias of 100% of discharge rating (20 MW), assuming the battery is at a sufficient state-of-charge. Frequency fluctuations within an adjustable dead band range shall have no effect. The Frequency Bias mode can be enabled or disabled, and when enabled shall operate concurrently with any other active control mode.

4. ***Frequency Response Mode (MESA function 8)*** --(need to discuss whether the battery will be controlled directly by the remote dispatch system for this mode, or operate autonomously. If autonomously, the Frequency Bias mode above would provide the same functionality. Another possibility is to add a feature such that the amount of power and/or energy that the BESS provides autonomously to support system frequency is limited (for example, limit MW to xx% of rating, or limit the amount of discharged energy to xx% DOD. The benefit to being dispatched vs. operating autonomously is that Xcel could receive revenue under a market structure similar to PJM Reg D if dispatched whereas autonomous operation might be difficult to meter and be compensated for.)

5. ***Power Smoothing mode (MESA function 16)*** --This function is intended to decrease the rate of change and smooth the output of intermittent generation resources. The BESS charges or discharges in proportion to the error between the moving average generation and the instantaneous generation at the POI, subject to an adjustable deadband. The degree of response (gain) is Operator adjustable to allow matching the amount of smoothing possible given the relative capacity of the battery based upon its real time state of charge vs. the variation in intermittent generation.

6. ***Ramp Rate Limiter mode (similar to MESA function 16)*** – The BESS is used to limit the rate of change of generation output from intermittent generation resources. The BESS is operated at a selected nominal state of charge, such that it can be charged to limit the "ramp up" and discharged to limit "ramp down" rate of change in intermittent generation respectively. The intermittent generation ramp rate is continuously calculated by comparing the current intermittent generation against the previous 1-minute average generation. If the intermittent generation ramp rate exceeds the setpoint value, the controller commands the BESS to charge or discharge only as required to limit the up or down ramp to the setpoint value. No action is taken for intermittent generation ramp rates less than the setpoint value.

7. ***Automatic Voltage Regulation (AVR) (MESA function 20)***- The BESS operates autonomously to maintain the substation bus voltage at setpoint by adjusting the BESS power factor setting. Setpoint voltage and high/low voltage dead band range are adjustable. The Voltage Regulation mode does not have a direct control on the BESS MW setting, and may be operated simultaneously with other control modes. When the local AVR mode is

disabled, the BESS active and reactive power output are separately controllable via SCADA dispatch commands within the BESS's MVA rating (Direct Remote Control function 9).

20.3 SCADA Interface

20.3.1 Remote Control Interface

The BESS control system mode selection shall be possible locally via the site controller HMI or via the remote SCADA system.

The Site Controller shall locally store the data points listed in Section 17.0, **Table 2** at a collection interval of once per second.

The Site Controller shall aggregate the rack / string level data listed in **Table 2** and transmit to the remote dispatch system via SCADA RTAC at a two second intervals.

The SCADA interface must be fully capable of communicating with all required Company energy management systems.

(Table of required SCADA control points and data points to be transmitted from/to remote dispatch will be added here.).

21.0 TELECOMMUNICATIONS AND NETWORK

21.1 General

A. Contractor's scope includes design, equipment, and installation of a complete local area network to allow monitoring of the BESS facility from a remote location.

B. System and subsystems provided by Contractor shall be designed and configured for unmanned operation of the facility.

C. communication connections to the remote System Operator shall connect serially via DNP 3.0 or Modbus TCP to the switchgear SEL-3530 (RTAC).

D. Network media internal to equipment enclosures may be implemented via CAT 6 cables.

E. Terminations to equipment shall be made using pre-fabricated patch cables. CAT 6 cables exiting equipment shall first terminate on a patch panel.

F. Fiber installed underground on the premises shall be installed in conduit. Bends and risers extending above ground shall be metallic conduit.

G. Fiber installed in buildings or enclosures may be routed in inner-duct supported in instrument and control trays.

H. Network communications leaving the project site shall be implemented using fiber optic cable installed in HDPE or similar underground conduit following regional practices for telecommunications installations.

22.0 SUBMITTALS

22.1 General

A. This section defines the requirements for engineering design and vendor submittals.
B. Submittals shall be in English.
C. Contractor has sole responsibility to meet completion date requirements and to supply material and equipment that conforms to Contract. Company's review does not constitute a waiver of Company rights with respect to nonconforming Work.
D. Contractor shall furnish expected document submittal list and schedule to Company within 60 days of award.
E. All design documents must use Company drawing templates & follow all Company drawing standards.

22.2 Drawings

A. Project-specific drawings shall be submitted including the following information as applicable:
1. Type
2. Ratings
3. Size
4. Quantities
5. Physical arrangement
6. Weights
7. Shipping breakdown / splits
8. Operation of components and systems
9. Materials and coatings
10. External connections
11. Interconnection with other services
12. Anchorages, supports and fastening
13. Installation and coordination with other equipment and materials.

22.3 Catalog Pages / Manufacturer Cut Sheets

A. Manufacturer catalog pages, i.e. cut sheets, are not an acceptable substitute for engineering design documents, except for standard non-engineered products.
B. Catalog pages must be submitted with a cover page clearly indicating the tag number and description of the item(s) covered by the catalog sheet.
C. If multiple components are shown on same page, the applicable line items shall be clearly identified.

22.4 Formats and Quantities

A. Electronic copies of documents and drawings shall be in .PDF format.
B. Final, record copy of project-specific design drawings shall be submitted in .PDF and native CAD format.
C. Contractor shall submit electronic copies plus one hard copy of the "*Issued For Construction*", drawings to Company at the same time they are issued to the field. *"Issued For Construction"* documents and any subsequent revision shall be signed and sealed by the engineer of record.

D. Final "Conformed to Construction Record" (As-built) documents shall be provided to Company. These documents shall be sealed by the engineer of record; and shall be considered the final record set. Each document issued "For Construction", whether any changes were made during construction or not; shall be revised and sealed for the record set.

22.5 Operation and Maintenance Manuals

A. Prior to final acceptance, prepare and submit three hard copies and one editable electronic file copies of the operations and maintenance manuals that adequately describe the installed equipment and systems.
B. An initial draft of this manual shall be available for review and acceptance prior to the start of testing and commissioning, in order that it may be used for that purpose.
C. As a minimum, such manuals shall include recommended procedures for operation, maintenance, and inspection of the equipment; present pertinent safety considerations; and provide descriptions of major systems, including major equipment, normal operating parameters, and significant control logic.

22.6 Equipment Lists

A. Submit one electronic file of equipment lists, piping lists, valve lists, cable, circuit, and raceway lists, and instrument lists.
B. Resubmit electronic file of any list as revisions are made and issue for construction.
C. Lists shall be electronic sortable data files in either MS-Excel or MS-Access formats.

22.7 Design Calculations

A. Engineering and design calculations prepared during the design are required as submittals.
B. Such calculations include architectural, structural, civil, electrical, and mechanical.

22.8 Bid Submittal List

The contractor is asked to submit the following items with their bid

A. General outline drawing showing overall estimated size and configuration of the BESS container
B. Description, manufacturer's name, and standard descriptive literature for all major BESS system components
C. List of components with lead times longer than 30 days that will be ordered and shipped from another manufacturing facility for assembly in the final plant
D. List of origin of major components, factory manufactured or assembled
E. Location of factory providing the BESS container assembly
F. List of recommended spare parts
G. List of special and maintenance tools to be furnished
H. Supplier's previous experience with proposed equipment
I. List of factory tests
J. Complete description of the extent of shop assembly of components
K. Battery cell data sheet (dimensions, weight, float, and charging voltages etc.)

L. Description of any field assembly work required, including sectional shipments and accessories shipped loose. Include an estimate of man-hours required to complete the field assembly per container
M. Special storage requirements, if applicable
N. Subcontractor list, if applicable
O. Preliminary milestone schedule
P. Staggered shipping schedule, if applicable
Q. Current projected shop loading and shop capacity curves
R. Description of company overview, history, and qualifications
S. Project key team members and org chart
T. Information on bidders Information Security Program
U. Information on the Bidder's Safety program
V. Information on the Bidder's QA/QC program
W. Craft labor rate sheets
X. Financial information such as balance sheet, income statement, sales volume, etc.
Y. Itemized EPC budgetary cost estimate
Z. Overall Bill of Materials
AA. Details of continuing service contracts available to support BESS system after installation
BB. Complete Datasheets provided below

List of Attachments

[RESERVED FOR FUTURE SITE SPECIFIC DOCUMENTS]

Attachment A – Overall Site Arrangement
Attachment B – Building Arrangement
Attachment C – Overall One Line Diagram
Attachment D – Not Used
Attachment E – Acceptable Suppliers
Attachment F – Company Safety Standards
Attachment G – Loading Profile
Attachment H – Equipment Data Sheets and Contractor Fill-in Data

Bidder Fill in Data to be submitted with Proposal:

Table 4- Vendor Supplied Data

Description	Data	Units
System Specification		
Aux Power Requirement per rack		kW
Beginning of Life Number of Battery Racks		each
Rack Dimensions		ft, L x W x H each rack
Communication Methodology, BMS to Site Controller		Provide Description
DC Roundtrip Efficiency @ 0.5C, BOL		%, Roundtrip
DC Roundtrip Efficiency @ 0.5C, EOL		%, Roundtrip
DC Roundtrip Efficiency @ 0.25C, BOL		%, Roundtrip
DC Roundtrip Efficiency @ 0.25C, EOL		%, Roundtrip
Cycle Life at 10% useable DOD		Cycles
Cycle Life at 50% useable DOD		Cycles
Cycle Life at 80% useable DOD		Cycles
Cycle Life at 100% useable DOD		Cycles
Capacity vs. C-Rate		Provide Curve
Operating Temperature Range		Deg. C
Storage Temperature Range		Deg. C
Self-Discharge Rate		%/month
Cell/ Module Specification		
Cell / Module Manufacturer		
Model Number		
Module / Tray Dimensions		W x H x D, in (mm)
Module / Tray Weight		Lb (kg)
Nominal Capacity		Ah
Nominal Voltage		V
Energy		Wh
Operating Voltage Range		V
Specific Energy Density (@ 1C, 25 deg C)		Wh/lbs (Kg)
Chemistry		
Battery Rack Specification		
Rack Mfg./Part/Configuration Number		
Modules per Rack		each

Table 4- Vendor Supplied Data

Description	**Data**	**Units**
Number of Racks supplied		each
Dimensions		W x H x D, in (mm)
Weight		Lbs (kg)
Voltage Operating Range		V
Power, nominal		W
Energy @ BOL		kWhr
DC Short Circuit Current at rack disconnect		A
Heat dissipation per rack @ C/2		kW
Heat dissipation per rack @ C/4		kW

Table 4- Vendor Supplied Data		
Description	**Data**	**Units**
System Specification		
PCS Manufacturer		N/A
Model Number		N/A
Operating efficiency		%
Standby power consumption		watts
Auxiliary power supply requirements		describe
AC Parameters		
AC Power @ 40C		kVA / kW
Max AC Current		Amps
Short term Overload capability		describe
Short Circuit capability		P.U.. Amps / mS
AC Voltage		Volts
Current Harmonic Distortion (per IEEE 519)		%
Power Factor operating range		Leading / Lagging
Isolating Provisions		describe
Method of Connection to Inverter Transformer		describe
DC Parameters		
DC Voltage Range		Volts
Maximum DC Voltage		Volts
Maximum DC continuous current		Amps
Battery connection provisions		describe
Isolating Provisions		describe
Physical Parameters		
Cabinet Dimensions		W x D x H inches (mm)
Cabinet Weight		Lbs (kg)
Cooling System		describe
Cabinet Degree of Protection		NEMA / IP
Permissible Ambient Temperature		C
Permissible Humidity Range		%
Noise Level		dBA @ 3 feet

Table 4- Vendor Supplied Data		
Description	**Data**	**Units**
Communications Interface		
Local HMI		describe
PCS to BMS protocol		describe
PCS to Site Controller		Describe available options
Physical I/O		Describe available options
Certifications		
UL 1741		Yes/no
IEEE 1547		Yes/no
Other, list		describe
Other Data to be submitted with Proposal		
Active / Reactive Power “D” Curve		
Temperature De-rating Curve		
Outline Drawing		
List of Recommended Preventative Maintenance Inspections / schedule		

DATA SHEETS PAD MOUNTED TRANSFORMER		**Equipment Name: Inverter Step-Up Transformers**	
DESCRIPTION	**UNITS**	**SPEC DATA**	**VENDOR DATA**
Manufacturer	n/a	By manufacturer	
Catalog/Serial No.	n/a	By manufacturer	
Operating Frequency	Hz	60	
Capacity	KVA	3000	
Cooling Class	-	KNAN	
Design Base Temperature Measured by Thermometer	Deg. C	65	
Rise Temperature Measured by Thermometer	Deg. C	65	
Impedance @ nominal Voltage on Base Rating	Z%	5.75%	
X/R Ratio	-	By manufacturer	
Bi-Directional Power Flow	Y/N	Y	
Design Altitude	Ft.	Per Section 2.0	
Guaranteed Efficiency:			
@ 100% of Maximum MVA 65°C Rating	%	By manufacturer	
@ 75% of Maximum MVA 65°C Rating	%	By manufacturer	
@ 50% of Maximum MVA 65°C Rating	%	By manufacturer	
Voltage Regulation @ 100% of MVA Rating:			
@ Unity Power factor	%	By manufacturer	
@ 80% lagging power factor	%	By manufacturer	
@ 80% leading power factor	%	By manufacturer	
Excitation Current @ 100% Rated Voltage, based on Max. MVA 65°C Rating	%	By manufacturer	
Maximum Guaranteed Losses @ 100% Rated Voltage:			
No Load Losses	KW	By Manufacturer	
Load Loss Max. MVA 65°C Rating	KW	By Manufacturer	
Auxiliary Losses at Max. MVA, and 65°C Rating	KW	0	
Total losses at Max. MVA; cannot exceed	%	0.8	
Loss Evaluation (By Company)	$/kW	Proprietary	
Winding Data:			
Rated Voltage of HV Terminals (Nominal)	KV	34.5	
Rated Voltage of LV Terminals (At Full Load)	V	600, 3ph/3W	
Basic Impulse Level HV Terminals	KVBIL	120 KVBIL	
Connection HV Terminals (2 cables per phase)	Delta/wye	Delta	
Connection LV Terminals (9 cables per phase)	Delta/wye	Delta	
HV Taps:			
No. of Steps Above Nominal	Qty / %	2 @ + 2.5%	
No. of Steps Below Nominal	Qty / %	2 @ - 2.5%	

DATA SHEETS PAD MOUNTED TRANSFORMER		**Equipment Name: Inverter Step-Up Transformers**	
DESCRIPTION	**UNITS**	**SPEC DATA**	**VENDOR DATA**
Oil/Fluid – FM Approved	Type	Less Flammable Fluid	
Total Gallons of Fluid in System	gal	By manufacturer	
Core and Coil Construction Type	-	By manufacturer	
Type of Material Used in Coils	-	By manufacturer	
Approximate Weights:			
Fluid	lbs.	By manufacturer	
Total Transformer With Fluid	lbs.	By manufacturer	
Total Shipping Weight	lbs.	By manufacturer	
Weight of Largest Piece for Handling	lbs.	By manufacturer	
Method of Shipment	-	By manufacturer	
Approximate Dimensions:			
Overall Height	in	By manufacturer	
Overall Width	in	By manufacturer	
Overall Depth	in	By manufacturer	
Loop or Radial System Design (Deadfront)	-	Loop/Deadfront	
Standard Features and Accessories:			
Nameplate	-	Y	
Dial-type thermometer	-	Y	
Liquid level gauge	-	Y	
Pressure-vacuum gauge	-	Y	
1 in drain valve with sample valve	-	Y	
Pressure relief valve	-	Y	
Non-PCB label	-	Y	
1 in upper fill/filter press connection	-	Y	
<u>Options:</u>			
Surge Arrester-MOV Type	Y/N	N	
High Voltage Switch; Under Oil w/ Window	Y/N	N	
Primary Fuse Overcurrent Protection	Y/N	Y	
Shielding Between HV and LV Windings	Y/N	Y	
CTs on LV Bushings – Protection Class	Y/N	Y	
Alarm Contacts for Temp, Liquid Level, and pressure and vacuum gauges	Y/N	Y	

DATA SHEETS PAD MOUNTED TRANSFORMER		**Equipment Name: Inverter Step-Up Transformers**	
DESCRIPTION	**UNITS**	**SPEC DATA**	**VENDOR DATA**
List any Special Considerations System Power Flow will be such that transformer will charge and discharge Energy Storage Batteries through IGBT inverters with filters; meeting IEEE 1547	-	Watt and Var Bi-directional power flow	
List parts Requiring Field Assembly	-	By manufacturer	
Required Maintenance Tools Furnished	-	By manufacturer	

Attachment D- Approved Supplier List

UIPMENT	MANUFACTURER
HV Circuit Breaker	Siemens, ABB, GE/Alstom Grid
MV Circuit Breaker	ABB, Siemens, Schneider Electric, Powell, S&C, Eaton
Switch MOD	Southern States, Royal
Power Transformers	ABB, SPX, Siemens, Hyundai, SMIT, Prolec GE, Eaton
Insulators	Ohio Brass, Lapp, MacLean
T-line Hardware	Anderson, Fargo, Hubbell, Hughes Brothers
Steel T-line/Substation pole	Meyer-Thomas and Betts, Sabre-Ft. Worth Tower, Valmont Industries
Grip and AGS	Preformed
Electrical Equipment Enclosure	Powell, AZZ, Crown Technical Systems
Grounding Transformers	GE Prolec, Pacific Crest, ABB
Lighting	Crouse Hinds, Lithonia, Holophane, General Electric
Auxiliary Relays	Allen-Bradley, Cutler-Hammer, General Electric, Potter-Brumfield
Protective Relays	SEL, Basler, General Electric, Electroswitch
Relay Panels	SEL, Electrical Power Products (EP2), Systems Control, Western Controls, Keystone
Substation P&C Battery	C&D, GNB, Exide, BAE, Varta
Battery Charger	Exide, Ametek
Terminal Blocks	Allen-Bradley, Cutler-Hammer, General Electric, Potter-Brumfield
600V Cable	American Wire Group, Anixter, BICC/Cablec, General Cable, Houston Wire and Cable, Okonite, Southwire
Panelboards	Cutler-Hammer, General Electric, Square-D, ABB
Cable Tray	B-Line, PW Industries, T&B
Rubber Goods	3M, Richards, Cooper
Fiber Optic Cable	Commscope, Furukawa, Brugg
PTs and CCVTs	Kuhlman, ABB, Trench, Alstom, Arteche, ITEC
MV Cable	General Cable, Prysmian, Synergy, Southwire, WTEC
Junction Boxes	Nordic, Highline
Capacitor Banks and Cap Switchers	Cooper Power Systems, Southern States, GE and Eaton
Battery Energy Storage System	ABB, Inc. ,BYD, CATL, Flexgen Power Systems, Inc., Greensmith Energy Management Systems, Inc, S&C Electric Company, Inc. , Samsung, Schneider-Electric USA, Inc , Siemens / Fluence, Sungrow, Tesla, Younicos, Inc
Inverters/ Converters	Dynapower, Sungrow, Tmeic, Power Electronics
Medium Voltage Switchgear	S&C Electric Company, Inc, Powell, Eaton, ABB, Siemens, Schneider Electric

Item No.	Reference Document	Submittal Item	Submittal Dates: Calendar Days		Event	Due Date	LD's Apply?
Schedule of Submittals							
Commercial Submittals							
C01	General Terms and Conditions	Insurance Certificates	30	After	Effective Date		No
C02	General Terms and Conditions	Engineering/Procurement/Production/ Testing and Inspection/Shipping Schedule and Status Report	30	After	Effective Date with Monthly Updates		No
C03	General Terms and Conditions	Preshipment Inspection Notice	30	Before	Shipment of Equipment		No
C04	General Terms and Conditions	Electronic Material List	30	After	Effective Date with Monthly Updates		No
C05	General Terms and Conditions	Preventative Maintenance and Jobsite Handling and Storage Requirements, if Applicable		With	Electronic Material List		No
C06	General Terms and Conditions	Hazardous Materials MSDS or SDS Forms		With	Each Shipment		No
C07	General Terms and Conditions	Recommended Spare Parts List, with Unit Prices and Names of Suppliers, Necessary to Cover a Full Operations Maintenance Cycle **(2 Years)**	90	After	Effective Date		No
C08	General Terms and Conditions	Conditional Waiver and Release of Progress Payment		With	Each Invoice (Except Final Invoice)		No
C09	General Terms and Conditions	Unconditional Waiver and Release on Progress Payment		With	Each Invoice (Except First and Final Invoice)		No
C10	General Terms and Conditions	Conditional Waiver and Release on Final Payment		With	Final Invoice		No
C11	General Terms and Conditions	Unconditional Waiver and Release on Final Payment	10	Within	Final Payment		No
Technical Submittals							
	01500	**General**			.		
T01	01500	Vendor drawing and document submittal list with expected delivery date and applicable SOS items	5	after	Effective Date		No
T02	01500	Site arrangement drawings	60	after	Effective Date		No
T03	01500	Documentation of the route survey completed for each specified piece of equipment with description of obstacles and barriers to transport identified, plus time restrictions as required	45	after	Effective Date		No
T04	01500	Confirmation that all licenses and permits required for transport of each piece of equipment to be transported have been applied for or that such permits are not required	60	after	Effective Date		No

Item No.	Reference Document	Submittal Item	Submittal Dates				LD's Apply?
			Calendar Days		Event	Due Date	
T05	01500	Detailed plan for the heavy-haul, lifting and rigging, and rough-set installation as appropriate for each piece of equipment specified, including list of equipment to be utilized and their capacities	90	after	Effective Date		No
T06	01500	Copy of Contractor's Safety Plan covering all aspects of heavy haul and heavy lifting included in scope	90	after	Effective Date		No
T07	01500	Detailed list of soil and/or foundation loads to be imposed on specific locations at the site due to heavy haul and/or heavy lift activities.	90	after	Effective Date		No
T08	01500	Contractor's requirements for site preparation in areas of operation onsite of heavy haul/lift equipment	30	before	Initial shipment of first equipment to be transported		No
T09	01500	Copies of approved licenses and permits secured for transport of each specified piece of equipment	14	before	Initial shipment of equipment to be transported		No
T10	01500	Detailed installation procedures, manpower allocation, and schedule (if requested)	30	Before	Start of Installation		No
T11	01500	Data obtained from receiving, storage, and assembly of electrical equipment	14	After	Installation		No
T12	01500	Completed test report forms for on-site testing.	5	After	Completion of the activity covered by the form		Yes
T13	01500	As-built drawings incorporating all red line markup's of Engineers drawings showing startup, calibration, and checkout changes during commissioning.		With	Completed startup/turnover package		Yes
	01500	**Battery Energy Storage Systems (BESS)**			.		
T14	01500	Container outline drawings including overall height, length, width, center of gravity location, and weight.	30	After	Effective Date		No
T15	01500	Bill of material, including quantity, description, and part number for all major components.	30	After	Effective Date		No
T16	01500	Component catalog cut sheets for all major components.	30	After	Effective Date		No
T17	01500	Electrical Schematics, connection and wiring diagrams	60	After	Effective Date		Yes
T18	01500	Time-current characteristic curves for each type of circuit breaker, protective relay, and each type of fuse furnished within each panel.	90	After	Effective Date		No
T19	01500	Manufacturer's catalog sheets showing equipment data including fuse manufacturer's name and model number along with fuse curves when fusible disconnects are furnished.	30	After	Effective Date		No
T20	01500	BESS container equipment arrangement and layout drawings.	60	After	Effective Date		No
T21	01500	Lighting and receptacle layout and wiring drawing.	60	After	Effective Date		No

Item No.	Reference Document	Submittal Item	Submittal Dates				LD's Apply?
			Calendar Days		Event	Due Date	
T22	01500	HVAC shop drawings and diagrams.	45	After	Effective Date		No
T23	01500	Nameplate drawings	45	After	Effective Date		No
T24	01500	Certified as-built versions of all drawings.	30	After	Shipment		Yes
	01500	**Grounding Transformers**					
T25	01500	Manufacturer's catalog sheets showing manufacturer's data including specifications, transformer impedances, noise level in decibels and amount of heat rejected at 50% and 100% load.	30	After	Effective Date		No
T26	01500	Outline drawing including overall height, length, width, center of gravity location, and weight.	30	After	Effective Date		No
	01500	**Microgrid Controllers**					
T27	01500	Manufacturer's catalog sheets showing proposed microgrid controller specifications.	30	After	Effective Date		No
T28	01500	Schematics, wiring, and external connection diagrams.	60	After	Effective Date		No
	16051	**Electrical Design and Equipment**			.		
T29	16051	Certified design data and performance curves	70	Before	Shipment		No
T30	16051	Arrangement and fabrication/ erection drawings	90	After	Effective Date		No
T31	16051	Detailed set of drawings to include arrangement drawings, one-line and three-line diagrams, metering and relaying diagrams, schematics, instrument door details, nameplate schedule, and bill of materials	60	After	Effective Date		No
T32	16051	Final set of above drawings in addition to interconnection wiring diagrams	21	After	Purchaser comments on initial drawings		Yes
T33	16051	Final submittal of as-built drawings	30	After	Shipment		Yes
T34	16051	Relay instruction and service manual including relay curve information	90	After	Effective Date		No
T35	16051	Current transformer ratio correction factor and excitation curves	90	After	Effective Date		No
T36	16051	Time overcurrent curves for each overload, molded case circuit breaker, and solid-state protective device used	30	After	Effective Date		No
T37	16051	I/O database and I/O wiring diagrams		Upon	Shipment		No
T38	16051	Grounding Installation Drawings for equipment with scope with sufficient detail to confirm code requirements	120	After	Effective Date		No
	16510	**Conductors and Accessories**			.		
T39	16510	Certified shop drawing of each cable type, including dimensions	30	After	Effective Date		No
T40	16510	Certified shop drawing of all conductor accessories	30	After	Effective Date		No
T41	16510	Cable manufacturer's approval of splicing and terminating materials	30	After	Effective Date		No

Item No.	Reference Document	Submittal Item	Submittal Dates				LD's Apply?
			Calendar Days		Event	Due Date	
T42	16510	Cable manufacturer's approval of pulling compounds	30	After	Effective Date		No
T43	16510	Cable manufacturer's installation requirements such as maximum pulling tension, maximum sidewall pressure, minimum bending radius, etc.	30	After	Effective Date		No
T44	16510	Production Test Reports	7	Before	Shipment		No
	16925	**Conductors Installation**			.		
T45	16925	As installed circuit installation records.	5	After	Installation		No
	16930	**Grounding Installation**			.		
T46	16930	As installed grounding drawings.	20	After	Installation		No
	19000	**Quality System Requirements**			.		
T47	19000	Certification Letter or Certificate of Authorization (copy), if certified by a registered agency, e.g., ASME Certificate of Authorization, ISO Certificate	30	After	Effective Date		No
T48	19000	Subsupplier listing	5	Before	Issue of Subsupplier Purchase Order		No
T49	19000	Notification of inspection/test (for hold/witness points)	14	Before	Test/Inspection		No
T50	19000	Quality Manual, uncontrolled copy	28	After	Effective Date		No
T51	19000	Inspection and test plan with monthly inspection target dates	28	After	Effective Date and then monthly thereafter		No
	Q400	**General Equipment Requirements**			.		
T52	Q400	Shipment Plan providing details of field assembly work required as described in the Supplier's proposal.	30	After	Effective Date		No
	Q500	**Shop Drawings and Instruction Manuals**			.		
T53	Q500	For instruction manual submittal requirements, refer to Technical Supplemental Q501 and the commercial submittals section.		Upon	Shipment of Equipment		Yes
	633601	Medium Voltage Switchgear					
	633601	For switchgear, MCCs, and SUSs that utilize any type of network communication, add option pricing for field technical service rates to support network communications hardware and configuration.					
T54	633601	Certification Letter or Certificate of Authorization (copy), if certified by a registered agency, e.g., ASME Certificate of Authorization, ISO Certificate	30	After	Effective Date		
T55	633601	Subsupplier listing	5	Before	Issue of Subsupplier Purchase Order		
T56	633601	Notification of inspection/test (for B&V hold/witness points)	14	Before	Test/Inspection		

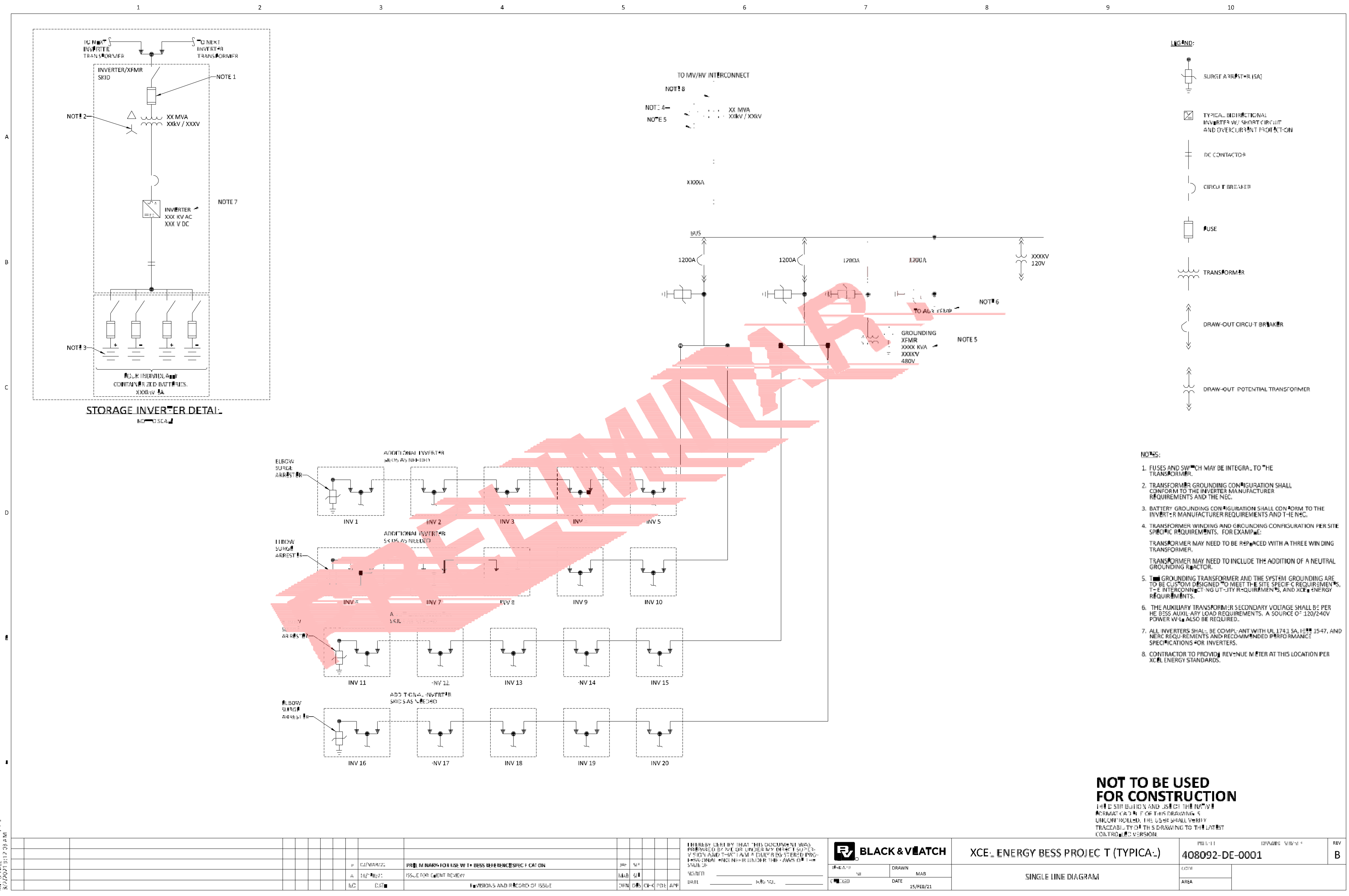
Item No.	Reference Document	Submittal Item	Submittal Dates				LD's Apply?
			Calendar Days		Event	Due Date	
T57	633601	Quality Manual, uncontrolled copy	28	After	Effective Date		
T58	633601	Inspection and test plan with monthly inspection target dates	28	After	Effective Date and then monthly thereafter		
T59	633601	Copies of Certified Test and Inspection Reports	14	After	Test or Inspection		
T60	633601	Electrical/Control Building Plan View Outline - General Arrangement, Center of Gravity Weight, Floor Opening Size and Locations, Mounting Details, and Cable Entry Area and Door Swing Requirements.	30	After	Notice to Proceed		
T61	633601	Electrical/Control Building Elevation outline - General Arrangement in Elevation, Recommended Pier and Tie-Down Locations, and Wall Opening Sizes and Locations.	30	After	Notice to Proceed		
T62	633601	Outline Drawing, including height, length, width, vertical and horizontal center of gravity, weight of each lineup, and nameplates. Mimic Bus Layout Drawings (if required by contract).	30	After	Notice to Proceed		
T63	633601	Typical Elementry & Wiring Diagrams for each MV Breaker, Controller Compartment, Soft Starter, or Assemby Specified.	30	After	Effective Date		
T64	633601	Detailed One-Line and Three-Line Metering and Relaying Diagrams	30	After	Effective Date		
T65	633601	Wiring Diagrams for All Other Wiring Not Included in the Breaker, Controller or Assemby Compartment Wiring Diagrams	60	After	Effective Date		
T66	633601	Non-Segregated Phase Bus Duct Layout Drawing Including Cross Sections and Support Details	60	After	Effective Date		
T67	633601	Network Architecture drawing showing network equipment redundancy.	90	After	Effective Date		
T68	633601	Component Data on All Electrical and Control Devices Being Provided, Including Electrical Ratings.	45	After	Effective Date		
T69	633601	Non-Segregated Phase Bus Duct Catalog Data	45	After	Effective Date		
T70	633601	Final Buswork BOQ for all pieces/parts/fittings furnished as part of the scope of work, broken down by construction work area.	75	After	Effective Date		Yes
T71	633601	Relay Instruction and Service Manual, Including Relay Curve Information	60	After	Notice to Proceed		
T72	633601	Current transformer ratio correction factor and excitation curve with internal resistance (at stated temperature reference) of the CT stated on the secondary exicitation characteristic curve.	90	After	Effective Date		
T73	633601	Current transformer ANSI relaying and metering accuracy	60	After	Effective Date		
T74	633601	Current transformer thermal rating	90	After	Effective Date		

Item No.	Reference Document	Submittal Item	Submittal Dates				LD's Apply?
			Calendar Days		Event	Due Date	
T75	633601	Current transformer secondary resistance at 25° C (77.0° F)	90	After	Effective Date		
T76	633601	Current transformer phase angle correction factor curves	90	After	Effective Date		
T77	633601	List of relays showing firmware revision of each relay furnished		Upon	Installation of Relays in Equipment Assembly		
T78	633601	Communications network point register (16101.2.18.1.6)	90	After	Effective Date		
T79	633601	List showing manufacturer, model number, description, function for each communication device furnished.	90	After	Effective Date		
T80	633601	Certified Air conditioning, Heating, Pressurization design load calculations with considerations of transmission and solar gain, people, lighting, mechanical and electrical equipment, motors, electronic equipment, computers, miscellaneous appliances, infiltration, ventilation or pressurization air.	30	After	Effective Date		No
T81	633601	For HVAC Equipment: Fan curves, motor data, coating data, dimensional data including piping connection sizes and location, weight, performance data, wiring diagrams and sound level data.	60	After	Effective Date		No
T82	633601	For Filters: filter efficiency, airflow resistance, dust holding capacity, media material, thickness, density and dimensional data.	60	After	Effective Date		No
T83	633601	For Dampers: AMCA certified pressure drop and leakage data.	60	After	Effective Date		No
T84	633601	For Terminal Devices: Flow versus pressure drop and flow versus throw.	60	After	Effective Date		No
T85	633601	For Temperature Controls: Wiring diagrams, control and electrical components data sheets, sequence of operations, control system architecture, and temperature control panel layout drawings.	60	After	Effective Date		No
T86	633802	Power Transformers - Unit Auxiliary					
T87	633802	Certification Letter or Certificate of Authorization (copy), if certified by a registered agency, e.g., ASME Certificate of Authorization, ISO Certificate	30	After	Effective Date		
T88	633802	Subsupplier listing	5	Before	Issue of Subsupplier Purchase Order		
T89	633802	Notification of inspection/test (for B&V hold/witness points)	14	Before	Test/Inspection		
T90	633802	Quality Manual, uncontrolled copy	28	After	Effective Date		
T91	633802	Inspection and test plan with monthly inspection target dates	28	After	Effective Date and then monthly thereafter		
T92	633802	Copies of Certified Test and Inspection Reports	14	After	Test or Inspection		
T93	633802	Leak Test Procedure	90	After	Effective Date		No

Item No.	Reference Document	Submittal Item	Submittal Dates: Calendar Days		Submittal Dates: Event	Submittal Dates: Due Date	LD's Apply?
T94	633802	Factory Acceptance Test Procedure	90	Before	Test		
T95	633802	Outline Drawing Containing the Following Information Required for Transformer Foundation Design(Not to Exceed Information as a Minimum) : Weights(Shipping & Oil Filled) Oil Volume. Dimensions of Rad/COPS Tanks for Oil Containment Design. Overall Transformer Dimensions Including all Auxiliary Equipment, Base Dimensions and Top of Oil Tank. Clearance Requirements from Buildings or Fire Walls. Horizontal & Vertical Location of Center of Gravity	30	After	Effective Date		
T96	633802	Detailed Outline Drawing, Including the Following: Location of Major Auxiliary Equipment Iso-Phase Flange Details Non-segarated Bus Duct Interface Details Certified Data for Items listed in Item 510	60	After	Effective Date		
T97	633802	Bushing & Arrester Outline Drawings	60	After	Effective Date		
T98	633802	Wiring Diagrams & Elementary Diagrams	75	After	Effective Date		
T99	633802	Nameplate Drawings	75	After	Effective Date		
T100	633802	Recommended Erection Sequence in Detail	90	Before	Shipment of Equipment		
T101	633802	Andersen Program Input Data	75	After	Effective Date		
T102	633802	Short-Circuit Withstand Type Data			With Proposal (if requested)		

Item No.	Reference Document	Submittal Item	Submittal Dates				LD's Apply?
			Calendar Days		Event	Due Date	
T103	633802	Design Data & Transformer Performance Curves Including: - No Load Overexcitation Capability(% vs. time): No Load Overexcitation Capability shall be furnished as a curve: V/HZ capability as a function of time. There shall be a short-time capability curve with a time scale from 0 to 120 minutes. There shall be a long-time capability curve with a time scale from 2 hours to 30 hours. No Load Overexcitation Capability shall be furnished in a numeric format. The time shall extend from 0 to 120 minutes with a one minute resolution. - Full Load Overexcitation Capability(% vs. time): Full Load Overexcitation Capability shall be furnished as a curve: V/HZ capability as a function of time. There shall be a short-time capability curve with a time scale from 0 to 120 minutes. There shall be a long-time capability curve with a time scale from 2 hours to 30 hours. Full Load Overexcitation Capability shall be furnished in a numeric format. The time shall extend from 0 to 120 minutes with a one minute resolution. - MVA Capability vs. Average Ambient Temperature - I^2t Damage Curves	75	After	Effective Date		
T104	633802	Auxiliary Power requirements	60	After	Effective Date		
T105	633802	Current transformer ratio correction factor and excitation curve with internal resistance (at stated temperature reference) of the CT stated on the secondary excitation characteristic curve.	90	After	Effective Date		
T106	633802	Current transformer ANSI relaying and metering accuracy; thermal rating; secondary resistance at 25 degrees C (77.0 degrees F); phase angle correction factor curves	60	After	Effective Date		
T107	633802	Current transformer thermal rating	90	After	Effective Date		
T108	633802	Current transformer secondary resistance at 25° C (77.0° F)	90	After	Effective Date		
T109	633802	Current transformer phase angle correction factor curves	90	After	Effective Date		

Technical input to 00300.6 Bid Submittals Required with Quotation		
Reference Document	Submittal Item	Yes/No
Bid Submittals		
01500	General outline drawings showing estimated overall size and configuration of each BESS container.	
01500	Description, manufacturer's name, and standard descriptive literature for all major BESS system components and accessories.	
01500	List of components with lead times longer than 30 days that will be ordered and shipped from another manufacturing facility for assembly in the final assembly plant.	
01500	List origin of major components, factory manufactured or assembled.	
01500	Location of factory actually building the BESS container assembly. Manufacturing factories are subject to approval.	
01500	List of recommended spare parts.	
01500	List of special and maintenance tools to be furnished.	
01500	Supplier's previous experience record with proposed equipment.	
01500	List of factory tests.	
01500	Complete description of the extent of shop assembly of components.	
01500	Battery cell data sheets (dimensions, weight, float, and charging voltages, etc.).	
01500	Description of any field assembly work required, including sectional shipments and accessories and appurtenances shipped loose. Include an estimate of man-hours required to complete the field assembly.	
01500	Special Storage Requirements, if Applicable	
01500	Subcontractor List, if Applicable	
01500	Preliminary Milestone Schedule for each project site	
01500	Staggered Shipping Schedule, if Applicable	
01500	Current and Projected Shop Loading and Shop Capacity Curves	


STORAGE INVERTER DETAIL
TO MV/HV INTERCONNECT
XX MVA
BUS
1200A
GROUNDING XFMR
INV 1
INV 2
INV 3
INV 5
INV 9
INV 10
INV 11
INV 13
INV 15
INV 16
INV 18
INV 19
INV 20
LEGEND:
SURGE ARRESTER (SA)
DC CONTACTOR
FUSE
TRANSFORMER
DRAW-OUT CIRCUIT BREAKER
DRAW-OUT POTENTIAL TRANSFORMER
NOTES:
NOT TO BE USED FOR CONSTRUCTION
BLACK & VEATCH
XCEL ENERGY BESS PROJECT (TYPICAL)
408092-DE-0001
SINGLE LINE DIAGRAM
B

Xcel Energy®
RESPONSIBLE BY NATURE™

Minimum Requirements for Wind Generation Projects

Build-Own-Transfer

Revision 1

March 15, 2021

Table of Contents

1. General

The requirements of this section apply in general to all aspects of the wind farm design and construction and are not for one part of the system specifically.

1.1. Project Management

1.1.1. Development

The following information shall be obtained by the Developer before construction commences.

1.1.1.1. ALTA/ACSM Land Title Survey and/or LIDAR

The survey shall be completed with the minimum requirements included in the pre-construction survey drawings

1.1.1.1.1. Address(es) if disclosed in Record Documents, or observed while conducting the survey. (standard option 2)

1.1.1.1.2. Flood zone classification (with proper annotation based on federal Flood Insurance Rate Maps or the state or local equivalent) depicted by scaled map location and graphic plotting only. (standard option 3)

1.1.1.1.3. Location of utilities existing on or serving each surveyed property and within or crossing any public road ROW within the project boundary. (standard option 11b)

1.1.1.1.4. Governmental Agency survey-related requirements as specified by the client, such as for HUD surveys, and surveys for leases on Bureau of Land Management managed lands. (standard option 12)

1.1.1.1.5. Names of adjoining owners of platted lands according to current public records. (standard option 13)

1.1.1.1.6. Proposed changes in street right of way lines, if information is available from the controlling jurisdiction.

1.1.1.1.7. Observed evidence of site use as a solid waste dump, sump or sanitary landfill. (standard option 18)

1.1.1.1.8. Location of wetland areas as delineated by appropriate authorities. (standard option 19)

1.1.1.1.9. Airborne/mobile laser scanning and other similar products, tools or technologies as the basis for showing the location of certain features (excluding boundaries) such as topography or structure location where ground measurements are not otherwise necessary to locate those features to an appropriate and acceptable accuracy relative to a nearby boundary. (standard option 15)

1.1.1.1.10. Vertical relief contour lines having 2 feet intervals and with the source of information (e.g. ground survey or aerial map), contour interval, datum, and originating benchmark identified. (standard option 5)

1.1.1.1.11. Microwave communication beam paths centered within established boundary widths.

1.1.1.1.12. Circle centered on occupied buildings. Circle radius for buffer shall meet permit requirements.

1.1.1.1.13. Identification of participating and non-participating parcels.

1.1.1.1.14. Proposed turbine locations, access roads, crane paths, collection line route, collection substation, O&M building and transmission line route.

1.1.1.1.15. Setback distances from proposed turbine locations to residence, public road ROW and non-participant(s).

1.2. Land acquisition

1.2.1.1. Geotechnical Report(s) and data

1.2.1.2. Environmental concerns such as wetlands

1.2.1.3. Other land uses in the area, such as pipelines, airports, and other conflicts

1.2.1.4. Interconnect agreement

1.2.2. Schedule Requirements

1.2.2.1. Schedule Definitions

1.2.2.1.1. Activity: A separate and distinct part of the Contract that can be identified for planning, scheduling, monitoring, and controlling the Work. Activities shall have a defined start date and finish date. The duration of an activity shall not normally exceed 30 calendar days. Activities shall not normally reflect the work of more than one discipline.

Critical Activities: Activities on the critical path, and have zero or negative total float.

Predecessor Activity: An activity that must start or finish before its successor activity can start or finish.

Successor Activity: An activity that cannot start or finish until its predecessor activity has started or finished.

1.2.2.1.2. Baseline Project Schedule: The original approved Project Schedule.

1.2.2.1.3. Critical Path Method (CPM): A method of planning and scheduling a Project where activities are arranged based on activity relationships and duration of each activity; and network mathematical calculations determine when activities can be performed and the critical path of the Work.

1.2.2.1.4. Critical Path: The longest continuous chain of activities through the network schedule that establishes the minimum overall duration from the Effective Date to Acceptance.

1.2.2.1.5. Milestone: A key or critical point in time for reference or measurement. A milestone has no duration.

1.2.2.1.6. Total float: The amount of time an activity can be delayed without adversely affecting an intermediate deadline or the Contract completion date.

1.2.2.2. Project Schedule

1.2.2.2.1. The Project Schedule shall be based off of meeting milestone dates provided by Owner.

1.2.2.3. General

1.2.2.3.1. Section 1.2.2 sets the requirements for the Project Schedule. Contractor shall use the critical path method (CPM) of scheduling to plan, manage and execute the Work. The Project Schedule will be used to report progress, evaluate changes and to validate payments.

1.2.2.3.2. Contractor shall supply a preliminary Project Schedule to Owner for review and acceptance. Owner shall review and comment on the preliminary Project Schedule to ensure that Contractor's plan meets the Schedule dates and does not conflict with any Owner obligations. Upon agreement with Contractor concerning any necessary revisions, the Project Schedule will be accepted. The accepted Project Schedule shall become the Baseline Project Schedule and shall be binding to Contractor. The Project Schedule will be updated at least once each month to show actual progress compared to the Baseline Project Schedule or as specified in the contract document(s).

1.2.2.4. Project Schedule Requirements

1.2.2.4.1. The Project Schedule shall be developed and maintained in Primavera Project Management Version 8.2 or higher. Certain activity codes for the P6 Schedule may be dictated by Owner to allow for grouping and sorting the schedule. The activity code dictionary shall be structured to allow codes for Phase, Discipline, Unit, Area, System, Component, Submittal Type / Number and Milestone Type / Number.

1.2.2.4.2. It is intended that the Project Schedule reflect Contractor's actual plan for accomplishment of the work.

1.2.2.4.3. The Project Schedule shall represent the entire Scope of Work.

1.2.2.4.4. The Project Schedule shall divide Work into separate detailed activities that define each major portion of Work, with dates activities are expected to start and finish.

1.2.2.4.5. The Project Schedule shall address all phases of the work covered by this Contract including but not limited to engineering, design, procurement, manufacturing, shipment, prefabrication, installation, testing, startup, commissioning, and closeout.

1.2.2.4.6. The Project Schedule shall indicate times when submissions, reviews or approvals by Owner are required.

1.2.2.4.7. The Project Schedule shall include the Guaranteed Mechanical Completion Date.

1.2.2.4.8. The Project Schedule shall be defined in more detail for critical and near critical path activities.

1.2.2.4.9. To the greatest extent practical, predecessors and successors shall be applied to all activities. Adequate consideration shall be given to these logical relationships to represent requirements for design evolution, procurement lead times, construction sequencing, commissioning strategy and overall resource leveling.

1.2.2.4.10. The Procurement/ Production/ Shipping Schedule shall be an integral part of the Construction Schedule. Each line item in the Procurement/Production/Shipping Schedule shall be represented in the Project Schedule. At a minimum, procurement scheduling shall indicate the date each item will be needed at the Site, the time required for delivery, the time required for manufacturing, the date the order is placed and dates for receipt of vendor's drawings.

1.2.2.4.11. The Submittal Schedule shall be an integral part of the Project Schedule. Each line item in the Submittal Schedule shall be represented in the Project Schedule. At a minimum, activities for prepare, submit, review, comment, re-submit and approval shall be represented in the schedule.

1.2.2.4.12. The Project schedule shall include detailed breakdowns for areas, systems, disciplines, and equipment components. The Project Schedule shall clearly indicate the timing of the turnover of areas to Owner and Turbine Supplier for commissioning wind turbine generators (WTGs). These work areas include, but are not limited to, completion of foundations, substation, equipment installation, WTGs, erections, operations and maintenance building, and collection circuits.

1.2.2.4.13. If, at any time during the performance of the Work, certain activities shown on Contractor's schedules fall behind such that any of the milestone or completion dates are in jeopardy, Contractor shall submit for Owner's review a supplementary schedule, showing Contractor's plan for restoring to schedule the activities that are behind. Upon acceptance by Owner of the revised detailed schedule of activities, Contractor will be responsible for maintaining and updating such schedule.

1.2.2.5. Schedule Updates and Reporting

1.2.2.5.1. On the third day of each month, Contractor shall submit to Owner an updated schedule reporting the progress from the previous month. The Baseline Project Schedule and each subsequent update shall be submitted electronically in a format allowing Owner to maintain an integrated master project schedule. The Project Schedule provided by Contractor to Owner shall be the most detailed schedule it has available. Owner may request interim updates (i.e. bi-monthly or weekly).

1.2.2.5.2. Schedule updates shall be furnished to Owner in the form of reports which shall include print outs, in various sorts, so that Owner may easily read and analyze the information. Electronic copies in the Primavera export format shall be included. Schedule reports shall show the Work in a horizontal bar chart or other graphic format suitable for displaying scheduled and actual progress. Schedule reports shall clearly identify actual start and finish dates in direct comparison to baseline dates. In-progress activities shall indicate percentage completion. Schedule reports shall include as a minimum early start, early finish, late start, late finish, original duration, and remaining duration. Narratives of the schedule update identifying problems and proposed solutions shall be included in the Monthly Progress Report.

1.2.2.5.3. Contractor shall develop a three (3) week Look-A-Head schedule. Timing of development shall be mutually agreed to by Contractor and Owner after commencement of field mobilization and shall be in a format specified by Owner. The look-a-head schedule shall be submitted to Owner on a weekly basis as mutually agreed upon by Contractor and Owner.

1.2.2.5.4. Within thirty (30) days after the Effective Date, Contractor shall submit to Owner, commodity "S" curves plotting planned units of production on a monthly basis for the duration of the contract. Thereafter, Contractor shall submit monthly, except as noted, markups of the commodity curves plotting actual production for the month versus planned. Contractor shall submit weekly reports indicating the quantity of commodity materials installed. The report format shall be acceptable to Owner. Reports shall include, but not be limited to: WTG erection, access roads, substation, collection, and transmission.

1.2.2.6. Schedule Changes

1.2.2.6.1. The Baseline Project Schedule may only be modified via a fully executed Change Order. Contractor shall maintain a log documenting the incorporation of approved schedule changes and time extensions.

1.2.3. Management and Coordination

1.2.3.1. General

1.2.3.1.1. Contractor shall be responsible for coordinating, managing, and directing the activities of its Personnel. Contractor shall furnish adequate management, supervision, and technical Personnel to ensure safe, environmentally-sound, expeditious, and competent handling of the Work. At a minimum, Contractor shall provide a construction manager, superintendent, and safety professional onsite at all times Contractor's (or Contractor's Subcontractor's) Personnel are onsite.

1.2.3.1.2. Contractor shall maintain a system that tracks all on-site Personnel that are part of Contractor's Work each Day, including field and office Personnel. This list shall be available for accounting Personnel during an emergency evacuation.

1.2.3.1.3. Owner will not be responsible for the assignment of Personnel, or obtaining materials or supplies or for any other services to Contractor except as specifically set forth in the Agreement Documents.

1.2.3.1.4. Owner shall have the authority to implement procedures, reporting, and Site rules to conduct the safe, orderly, optimized performance of the Project. Contractor shall abide by all such procedures, reporting requirements, and Site rules.

1.2.3.1.5. Contractor's organization shall include an experienced staff of qualified Personnel to handle agreement administration, engineering and technical services, planning/scheduling, environmental safety and inspection requirements, and direction of all Work.

1.2.3.2. Preconstruction Conference

1.2.3.2.1. Owner will schedule a preconstruction conference at the Site prior to commencement of any major work activity by Contractor. Attendance by Owner, Contractor's Project Manager, Contractor's Safety Professional, Contractor's Site Manger and Superintendents, and Contractor's Hazardous Material Manager, as well as Major Subcontractors, will be required. The purpose of the meeting is to ensure that all Parties Personnel understand their responsibilities and the procedures that will be used to ensure safe and efficient completion of the Work.

1.2.3.2.2. Agenda for the Preconstruction Conference will include:

Introduction of Owner and Contractor Personnel representing the Parties Representative and designation of lines of communication and lines of authority.

Project Schedule review.

Critical Work sequencing.

Weekly Contractor Progress Meetings.

Weekly Site Coordination Meetings.

Daily Site Meeting.

QA/QC Plan compliance monitoring and reporting.

Use of Site and Facility including equipment, material Storage, staging areas, and temporary facilities.

Procedures and processing of Field Change Authorizations (FCA's) field decisions, Commercial Deliverables, Submittals, substitutions, drawings, application for payments, proposal requests, Change Orders, Requests For Information (RFI's), Agreement close-out procedures, and Record Documents.

Drawings and Submittals

Testing schedule

Site restrictions

Barricading, fencing, and enclosures

Safety measures

Display of required Permits

Project Schedule updates

Safety Inspections and Reports

Environmental

Permits

Notifications

SWPPP

Water management

SPCC plan

Waste removal and management

Dust Control

1.2.3.3. Weekly Construction Progress Meetings

1.2.3.3.1. The purpose of the progress meetings are to assess the progress of the Work, evaluate the progress schedule, and promote the timely completion of the Project. Contractor shall lead the meetings, prepare meeting minutes, and distribute minutes to all participants. Contractor's Project Manager and Safety Professional shall attend these meetings and shall coordinate and require attendance of other Contractor Personnel and Subcontractors whose work may be in progress at the time or whose presence may be required for any purpose.

1.2.3.3.2. Progress Meeting Agenda

Construction Site safety issues

Administrative issues

Technical/construction issues

Design Issues

QA/QC Plan monitoring and compliance

Project Schedule/progress issues

Resolution of items from previous meeting

Contractor's anticipated activities for upcoming week

1.2.3.4. Daily Site Coordination Meetings

1.2.3.4.1. Contractor's Safety Professional and Contractor and Subcontractor Site Superintendents shall attend daily coordination meetings each morning.

1.2.3.5. Unscheduled Meetings

1.2.3.5.1. Contractor shall make the appropriate Contractor Personnel available to attend other unscheduled meetings which may be reasonably requested by Owner to discuss unanticipated changes in the Work or conditions at the Site and which must be resolved before progression of the Work.

1.2.3.6. Weekly Field Report

1.2.3.6.1. Daily head count of Contractor's Personnel with breakdown by craft, including Subcontractors, and daily equipment usage submitted the first business day of each week for the work performed in the previous week.

1.2.3.6.2. Safety statistics submitted the first business day of each week for the work in the previous week and for the total Work to-date.

1.2.3.6.3. Actual work hours performed each week, including hours of work for each trade or type of equipment Subcontractors, management, engineers, and all Personnel under Contractor's authority submitted the first business day of each week for the work performed in the previous week.

1.2.3.6.4. Safety training report of weekly training and Site orientations submitted the first business day of each week for the work performed in the previous week.

1.2.3.6.5. Major Work activities performed, and progress thereof, including estimated amounts of specialty work, asbestos abatement, lead abatement, waste shipments, excavation, stockpiling, loading, and backfilling work completed.

1.2.3.6.6. Tests and inspections performed and the results of tests and inspections.

1.2.3.6.7. Conditions affecting work submitted the first business day of the week.

1.2.3.6.8. Schedule showing progress to date, future plans, and critical path analysis submitted the first business day of each week.

1.2.3.7. Field Records

1.2.3.7.1. Contractor shall maintain at its Site office, up to date copies of all Project Design Documents (engineer, vendor, shop, or other), specifications, and other Agreement Documents and supplementary data, complete with latest revisions thereto. In addition, Contractor shall maintain a continuous record of all field changes as approved by Owner through the Field Change Authorization process, and at the conclusion of the Work, shall incorporate all such changes in the Design Documents and other engineering records. The record of changes shall include copies of all approved Field Change Authorizations which contain information as to when the change was made, who made the change and who approved the change, with reference to the appropriate transmittal number. Drawing changes shall be recorded in a neat, orderly manner, drawn to scale, and dimensioned as a qualified draftsman would show the revisions. Changes shall be continuously updated such that the working set of Design Documents is never more than forty-eight (48) hours out of date. Drawing Changes shall be coordinated with Owner's working set of Project Design Documents files in Owner office. Contractor is responsible to ensure the changes are on Owner master set.

1.2.3.7.2. Field drafting of these revisions shall be of equal quality and detail as the original Project Design Documents. Additions shall be shown in green, and deletions shall be shown in red. Upon completion of the revisions, two (2) copies shall be submitted to Owner in electronic and hard copy format. Contractor shall develop and maintain field records, such as extent of excavation surveys, required for environmental reporting and compliance documentation.

1.2.3.8. Field Surveys

1.2.3.8.1. Contractor shall develop and maintain accurate record drawings of any remaining underground features, based on field surveys. Prior to backfilling, Contractor's Registered Land Surveyor shall document by survey the locations and elevations of any remaining underground features to a vertical and horizontal tolerance of 0.1 feet. The survey information shall be adequate to define the geometry of items remaining. For items that are polygons in plan, Contractor shall provide a survey point at each corner. For items that are linear, such as strip footings, walls, or collection line, Contractor shall provide survey points at each face at a maximum spacing of 20 feet on center and at all break points in their alignment. All surveys shall use the County Coordinate System (Minnesota or Wisconsin) or State Plane Coordinate System based on (NAD 83) for horizontal coordinates and North American Vertical Datum of 1988 (NAVD 88) for vertical coordinates. Where necessary, Contractor's Surveyor shall resurvey in these datum for verification. Field survey work shall be conducted on an on-going basis to meet the requirements of the Agreement. Data shall be compiled on field survey drawings, which shall be maintained and posted at the Site as required for Contractor's field records.

1.3. Submittals and Documents

1.3.1. Contractor shall provide a schedule of Submittals that includes product data, material specifications, cut sheets, and shop drawings for products used as part of Project construction. The schedule of Submittals must be submitted within ten (10) Business Days of Agreement Award. Thereafter, Contractor shall submit bi-weekly updates of the Submittal Schedule.

1.3.2. The Schedule of Submittals shall be in tabular form listing all Submittals which are required by this Specification and the date on which Contractor will make Submittal. As a minimum, the schedule of Submittals shall consist of the following columns.

1.3.2.1. Submittal Number: Number consecutively.

1.3.2.2. Section Number: Technical Specification section number.

1.3.2.3. Item: Description of item or items to which Submittal pertains.

1.3.2.4. Submittal Type: A letter code indicating what type of Submittal is requested. The type key shall be as follows:

1.3.2.4.1. Information or Documentation

1.3.2.4.2. Review

1.3.2.4.3. Approval

1.3.2.4.4. Alternate Product Supporting Data

1.3.2.4.5. Administrative such as schedules, etc.

1.3.2.5. Exceptions: Manner in which Submittal or proposed alternate product does not meet the requirements of this Specification.

1.3.2.6. Anticipated Submittal Date: Date on which Contractor anticipates Submittal to be delivered to Owner.

1.3.2.7. Response Required: Indicate 'yes' if Contractor anticipates response from Owner and 'no' if no response is anticipated.

1.3.2.8. Submittal Date Requirements: Advance durations for Submittals.

1.3.3. The Schedule of Submittals will be reviewed by Owner and Owner will respond in writing listing deficiencies. The schedule shall include all items for which Contractor proposes to use substitute or "or equal" products. Contractor shall correct deficiencies and resubmit Schedule of Submittals prior to beginning any Work.

1.3.4. Electronic copies shall be provided for all project submittals. Additionally, hard copies shall be provided as requested in this Specification.

1.3.5. Drawings

1.3.5.1. Drawings shall be produced per EEC 7.970W01 Drawing Deliverable Standards.

1.3.5.2. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.3.6. Manufacturer’s Catalog Data

1.3.6.1. Submittals for each manufactured item shall include current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts. Handwritten and typed modifications and other notations not part of the manufacturer's preprinted data will result in the rejection of the submittal. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted.

1.3.7. Manufacturer's Instructions

1.3.7.1. Where installation procedures or part of the installation procedures are required to be in accordance with manufacturer's instructions, submit printed copies of those instructions prior to installation. Installation of the item shall not proceed until manufacturer's instructions are received. Failure to submit manufacturer's instructions shall be cause for rejection of the equipment or material.

1.3.8. Operation and Maintenance Manuals

1.3.8.1. Submit operation and maintenance manuals for electrical works that provide basic data relating to the design, operation, and maintenance of the electrical system. This shall include:

1.3.8.1.1. Single-line diagram of the "as-built" electrical works.

1.3.8.1.2. Schematic diagrams of electrical control system.

1.3.8.1.3. Manufacturers' operating and maintenance manuals on active electrical equipment, as applicable.

1.3.9. Operating Instructions

1.3.9.1. Submit text of proposed operating instructions for each system including O&M building systems.

1.3.10. Within 2 weeks of contract award, contractor shall produce a schedule of submittals to be reviewed by Owner, which shall also be incorporated into the overall project schedule. The submittal schedule shall indicate those submittals whose timing must be before other submittals, the overall number of submittal packages to be delivered, and other typical details.

1.3.10.1. Typical Substation Package Guidelines – Packages shall include, but not be limited to the contents below

1.3.10.1.1. 30% Submittal

Metering & Relaying One-line Diagram

Circuit Diagram with bubbles identifying components and a spreadsheet identifying those specific components by item number

Location Plan

Grading Plan

1.3.10.1.2. 60% Submittal

Updated 30% submittal

Control House Layout and Panel Elevations

Foundation & Steel Plans

AC & DC Schematics

1.3.10.1.3. 90% Submittal

Updated 30% and 60% submittals

Conduit & Cable List

Above and Below Grade Physical Construction

1.3.10.2. Typical Transmission Line Package Guidelines – Packages shall include, but not be limited to the contents below

1.3.10.2.1. 30% Submittal

Route and poles setting

1.3.10.2.2. 60% Submittal

Updated 30% submittal

Material and Assembly

1.3.10.2.3. 90% Submittal

Updated 30% and 60% submittals

Final Route Plan

1.4. Environmental Requirements

1.4.1. SWPPP

1.4.1.1. Contractor shall develop a Storm Water Pollution Prevention Plan (SWPPP) that meets all federal, State and Local requirements. The plan shall detail the requirements necessary to prevent silting and muddying of lakes, ponds, wetlands, and any rivers or tributary streams of creeks which may lie in close proximity of the work. In support of the SWPPP the civil design shall include the following features:

1.4.1.1.1. Areas of exposed erodible soil in the course of earthwork operations shall be shaped to permit storm runoff with minimum erosion.

1.4.1.1.2. Temporary berms, slope drains, diversion mounds and sedimentation basins shall be required where possibilities for water pollution exist and permanent erosion controls are not completed or operative.

1.4.1.1.3. Silt fence or sediment logs shall be required to prevent sediment from entering wetlands or open water.

1.4.1.2. Contractor shall implement all requirements of the SWPPP including, but not limited to, installation, inspection, and repair requirements.

1.4.1.3. SWPPP shall include the maintenance of all temporary spoil piles to prevent weed growth and proliferation.

1.4.2. Spill Prevention, Control, and Countermeasure Plan

1.4.2.1. General

1.4.2.1.1. Contractor shall develop a Spill Prevention Control, and Coutermeasure Plan (SPCC) that meets all federal, state and local requirements. All necessary and appropriate measures shall be taken to prevent any accidental discharges of hazardous chemicals or other pollutants during construction of the project. Pollutants and spillable materials that are most likely to be used during construction of the project are fuels (gasoline and diesel) and lubricants.

1.4.2.2. Prevention

1.4.2.2.1. Fueling of equipment and storage or fuels will not be permitted within 300 feet of any wetland or riparian areas, or any rivers or streams, whether perennial or ephemeral.

1.4.2.2.2. Lubrication of equipment, or changing of lubricants, will not be permitted within 300 feet of any wetland or riparian areas, or any rivers or streams, whether perennial or ephemeral.

1.4.2.2.3. Fuel trucks will only be operated by qualified personnel who are trained in emergency procedures. All fueling will meet the minimum requirements and regulations established by the Department of Transportation.

1.4.2.2.4. All fuels and lubricants will be appropriately stored and handled at all times. No fuels or lubricants will be stored in outside unprotected containers, or in unprotected areas.

1.4.2.2.5. If, during construction of the project, any hazardous chemicals or other pollutants are accidentally discharged, the following measures will be implemented to contain the discharge and immediately begin the cleanup effort.

1.4.2.3. Containment and Cleanup

1.4.2.3.1. If any hazardous chemicals or other pollutants are accidentally discharged, Owner personnel or contractor personnel who notice the release will immediately contact Owner and the construction contractor foreman. All necessary measures shall be immediately undertaken in an effort to contain the spill within the affected area. Owner's Environmental Services Department shall be immediately notified of any non-incidental spill.

1.4.2.3.2. Cleanup of incidental spills of fuel, lubricants where a small quantity is released which does not pose an immediate or long-term safety, or health hazard, shall be coordinated by Contractor. Absorbing compounds shall be available to absorb small amounts of oil or other lubricants that may be accidentally discharged. Any accidental discharges of fuels shall be immediately contained, and any effected soils shall be removed and adequately disposed of. Following containment and cleanup efforts, Owner's Environmental Services Department shall be contacted to determine what additional measures may be required, if any.

1.4.2.3.3. Containment, cleanup and disposal activities associated with non-incidental spills, where a quantity of a hazardous substance or pollutant is released which does pose an immediate or long-term safety or health hazard, will be coordinated by Contractor.

1.4.2.3.4. If an emergency occurs where a spill has reached, or may reach, water, sewers, or otherwise leave the site, immediate measures must be undertaken by trained personnel to prevent additional spill material from entering these areas. Owner's Environmental Services Department shall be immediately notified. Contractor shall coordinate containment and cleanup efforts.

1.4.2.3.5. Owner's Environmental Services Department will make all appropriate notifications to State, Federal and local authorities. Any required reports will be prepared by Contractor and submitted to Owner’s Environmental Services Department for review.

1.4.3. Care of Property of Others-Special Provisions

1.4.3.1. When working within the project site, Contractor's employees and personnel associated with the project shall remove their meal wrappers, waste, garbage, and other combustible wastes. All waste materials shall be hauled away. This shall be done continuously in an effort to keep the project site and adjacent lands free from trash and clutter.

1.4.3.2. Construction plans, methods and practices are extremely important for the success of this project and shall be designed to minimize damage to privately-owned lands involved in this project. All work shall therefore be performed in a manner that will maximize preservation of natural beauty, conservation of natural resources and minimize marring and scarring of the landscape or silting of streams.

1.4.3.3. The methods of construction shall take into account soil stability, the protection of natural habitat for wildlife and appropriate measure for the prevention of silt deposition in watercourses; therefore, the selection of equipment and construction methods and practices is of primary importance to the success of this project.

1.4.3.4. All oil cans, part boxes, repair parts and other waste material in connection with line construction shall be kept picked up from the entire project area. Oil and gas spills along with other types of pollution shall be avoided, particularly while performing work near roads, trails, streams, lakes, and reservoirs. Any oil and/or gas spills shall be cleaned up according to all Federal, State and Local laws and will be at Contractor's expense and reported to Owner.

1.4.3.5. The best environmental planning can be reversed or defeated by uncontrolled or improperly supervised construction activities; therefore, the entire force employed by Contractor shall be advised that all aspects of the construction operation and activity shall be geared to the preservation and enhancement of natural beauty and the conservation of our natural resources. If anyone on the construction force is found to be negligent in this regard, Owner reserves the right to have them removed from the project immediately. This shall include all levels of supervision and working grades employed by Contractor.

1.4.4. Erosion Control

1.4.4.1. The erosion control plan requirements shall be performed and maintained during all phases of the construction.

1.4.4.2. Earthwork shall not start until affected areas such as lakes, ponds, wetlands, rivers, and stream are protected by appropriate and effective control devices.

1.4.4.3. Critical erosion control areas involving public waters or wetlands shall be expeditiously provided with complete final grading, topsoil placement, and turf establishment. At large site developments these operations shall be completed on a drainage area basis in order to provide permanent erosion control as soon as possible.

1.4.4.4. Temporary drainage control items specified herein, or on the grading drawings, which contribute to the control of erosion and sedimentation shall be provided.

1.4.4.5. Contractor shall establish and complete all permanent erosion control features required for the site development. All temporary features shall remain in place to the extent practical, until permanent erosion control features are effective.

1.4.4.6. Contractor shall establish and complete, or rework erosion control items, to the extent necessary to correct conditions which develop during the sequence of work on the site. These efforts shall be maintained until permanent turf establishments, drainage facilities or controls incorporated into the grading drawings are complete and operative.

1.4.4.7. Areas of exposed erodible soil in the course of earthwork operations shall be shaped to permit storm runoff with minimum erosion.

1.4.4.8. Temporary berms, slope drains, diversion mounds and sedimentation basins, as shown on the drawings, shall be required where possibilities for water pollution exist and permanent erosion controls are not completed or operative.

1.4.4.9. Silt fence shall be required to prevent sediment from entering wetlands or open water.

1.5. Construction

1.5.1. Manufacturer’s Specification and Instructions

1.5.1.1. All manufactured materials and equipment shall be installed or applied in accordance with the Manufacturer's instructions, directions or specifications. Said installation or application shall be in accordance with printed instructions furnished by the manufacturer of the material or equipment concerned for use under conditions similar to those at the job site. Installation instructions shall be furnished to Owner for acceptance before work is started.

1.5.1.2. Any deviation from the Manufacturer's printed recommendations shall be explained and acknowledged in writing by the Manufacturer involved as correct for the circumstances. Contractor shall be held responsible for all installations contrary to the Manufacturer's recommendations. If any item of material or equipment is found to be installed not in accordance with the Manufacturer's recommendations, Contractor shall make all changes necessary to achieve such compliance at no cost to Owner.

1.5.1.3. Installation of equipment shall consist of receiving, unloading, reloading (if necessary), storage, placement and field assembling of equipment in accordance with the Manufacturer's installation instructions. All equipment shall be cleaned of dirt, oil, road grime, etc. before installation. Contractor shall give specific attention to rigging, lifting and moving procedures.

1.5.2. Contractor shall furnish at its expense all necessary tools, labor, equipment, transportation, repair materials and materials specified to be furnished by Contractor, necessary to complete the Work with exception to WTG tooling supplied by Turbine Supplier as specified in the associated Turbine Supply Agreement. Contractor shall perform the work in a professional workmanlike manner.

1.5.3. Contractor shall use adequate two-way radio communication for its operations and shall furnish to Owner a radio to monitor each frequency used by Contractor for use in all Owner Vehicles on the project. Portable radios, if requested, shall also be supplied by Contractor for use by Owner. All radios will be returned to Contractor at the completion of the construction.

1.5.4. Site Inspection and Quality Control/Quality Assurance

1.5.4.1. Contractor is responsible for site inspections and QA/QC.

1.5.4.2. All work and materials shall be, at all times, open to the inspection, acceptance or rejection by Owner(s). Contractor shall give Owner reasonable notice of starting new work and shall provide, without extra charge, reasonable and necessary facilities for inspection, even to the extent of taking out portions of the finished work if proper notice was not provided to Owner.

1.5.4.3. Repair work performed by Contractor shall be done so under the direction of Owner and/or Manufacturer’s Representative.

1.5.4.4. In support of Owner’s right to witness, review, audit, etc. Contractor will provide for Owner’s use at the on-site construction office complex a furnished heated/air conditioned doublewide construction trailer with 1) electricity, 2) phone via POTS (provide minimum 10 lines), 3) hardwired fiber optic high-speed internet service, 4) potable water, 5) functional sewer/sanitary facilities within the construction trailer, 6) Outhouse facilities heated per OSHA requirements, 7) designated parking spaces nearest to the Owner’s trailer.

1.5.5. Contractor will be responsible for acquiring all underground utility locates where any earth disturbing activities (excavating, drilling, boring, trenching, or construction necessary for all new structures, guard structures, temporary anchors, culverts, slurry pits, etc.) will be performed.

1.5.6. All gasoline motor operated equipment shall be equipped with spark arresting mufflers. No warming fires will be permitted.

1.5.7. Contractor shall make every effort to notify Owner a minimum of 24 hours prior to any scheduled weekend or holiday work.

1.5.8. Owner shall be notified of any special provisions or commitments agreed upon by Contractor and the Landowner(s).

1.5.9. Contractor shall be responsible for all damage done to existing roads, trails, ditches, culverts, fences, bridges, gates, etc., and shall promptly repair them and leave them in as good a condition as found. All work done in this regard shall be approved by Owner.

1.5.10. All damage claims by landowners or otherwise resulting from Contractor's work along and adjacent to the Project work corridors shall be the responsibility of Contractor.

1.5.11. The design and construction shall meet the Turbine Supplier technical requirements, all engineers' design drawing specifications, manufacturer specifications, applicable codes and standards. Any discrepancy shall be approved by Owner.

1.6. Packaging, Shipping, and Storage

1.6.1. Material shipped shall be delivered to the job-site.

1.6.2. Pre-installation and on-site storage requirements shall be stated, discussed, and agreed to with Owner prior to activities starting.

1.6.3. All equipment and accessories shall be adequately anchored, braced, and packed to prevent damage from vibration, shock or dampness that might reasonably be encountered in transportation and handling. Contractor shall adequately prepare all equipment to withstand any possible damage or loss due to rough handling or exposure to weather during transit. Where required by the nature of the equipment, Contractor shall furnish and install necessary covers to protect the equipment from rain, hail, wind, dust, etc. Flanges and openings shall be adequately sealed and protected during shipment to prevent corrosion, entrance of foreign matter and possible damage from rough handling during transit and storage. Flanged connections shall be provided with suitable flange protectors bolted on before shipment. Screwed outlets shall be provided with plugs.

1.6.4. All exposed machined ferrous metal surfaces shall be coated with a suitable anti- rust compound before shipment.

1.6.5. Preservative coatings used on components shall be suitable for the conditions normally expected during shipping, storage and throughout the erection period. Toxic and hazardous-type preservatives shall not be allowed. Information pertaining to preservatives shall be submitted two months prior to delivery.

1.6.6. When a shipment is to be made, Contractor shall notify Owner giving a description of the articles shipped, the packing list, and any other information necessary for identification, and instructions for assembly and storage including equipment or instruments that should be stored inside or that require special attention to maintenance procedures prior to installation as well as for the period between completion of installation and the time that the equipment is placed in service. The shipping weight and dimensions of each article shall also be given, as well as any information related to unloading or handling equipment or materials, such as pickup points, spreader bar requirements, etc. When a shipment is to be made, Contractor shall provide Owner with the following information included with the shipment:

1.6.6.1. Description of the component and equipment being shipped.

1.6.6.2. A packing list.

1.6.6.3. Identification and instructions for assembly and storage.

1.6.6.4. Identification of what should be stored indoors.

1.6.6.5. Identification of which equipment requires special attention to maintenance procedures prior to installation, as well as for the period between completion of installation and the time that the equipment is placed in service.

1.6.6.6. The shipping weight and dimensions of each component or equipment shall also be given, as well as any information related to unloading or handling equipment or materials, such as pickup points, spreader bar requirements, etc.

1.6.6.7. Any other necessary information.

1.6.7. Contractor shall provide notification to Owner at least 15 days in advance of the expected shipping date. At that time, Owner will advise Contractor of acceptable delivery hours.

1.6.8. Equipment and separately shipped items shall be clearly identified with a securely fastened, weatherproof tag, labeled with Owner's Purchase Order No., Specification No., Equipment No., or Instrument No. (if applicable) and Service information.

1.6.9. Shipping containers, packing lists, bills of material, correspondence, etc., shall be identified with the same above information. Boxes, shipping containers, crates, etc., shall have a packing list firmly attached to the exterior and a duplicate packing slip packed internally.

Example:
P.O. No.___________
[ ] Wind Farm
Equipment No.__________
Service: [Owner to provide project number]
Project Date Shipped:__________

1.6.10. Contractor shall be responsible for its sub-contractor(s) adhering to the above shipping preparations on all equipment and items shipped to Owner by the sub-contractor(s).

1.6.11. Contractor shall provide advance notice of at least 48 hours of each material delivery.

2. Civil Works

2.1. Earthwork

2.1.1. Referenced Codes and Standards - The following codes and standards, amended to date shall govern the work included in these specifications.

2.1.1.1. Colorado Department of Transportation - Standard Specifications for Road and Bridge Construction

2.1.1.2. Michigan Department of Transportation - Standard Specifications for Construction

2.1.1.3. Minnesota Department of Transportation - Standard Specifications for Construction

2.1.1.4. North Dakota Department of Transportation - Standard Specifications for Road and Bridge Construction

2.1.1.5. South Dakota Department of Transportation - Standard Specifications for Roads & Bridges

2.1.1.6. Texas Department of Transportation – Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges.

2.1.1.7. Wisconsin Department of Transportation - Standard Specifications for Highway and Structure Construction

2.1.1.8. Iowa Department of Transportation – Standard Specifications for Construction

2.1.1.9. ASTM C117 Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

2.1.1.10. ASTM C136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

2.1.1.11. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3))

2.1.1.12. ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.1.1.13. ASTM D1140 Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-µm) Sieve

2.1.1.14. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

2.1.1.15. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

2.1.2. Temporary work shall be restored to the original condition before final payment is made to Contractor.

2.1.3. Clearing, Grubbing, and Stripping

2.1.3.1. Perform clearing and grubbing to the limits indicated in the design documents. Brush, trees, stumps, roots, and debris shall be disposed of off-site. Final turbine access road height shall be level with the field.

2.1.3.2. Strip topsoil and organic materials to the limits indicated in the design documents and stockpile in an appropriate area for reuse. This includes excavations for trenching of collection cables.

2.1.3.3. Excavate soils to the limits according to the Design Documents.

2.1.4. Rough Grading

2.1.4.1. Contractor shall complete rough grade to the elevations specified on the drawings. Contractor shall furnish and place topsoil as designated for the areas involved on the drawings. See Section 2.1.6 for topsoil placement requirements.

2.1.5. Final Grading

2.1.5.1. Positive drainage is required to drain water away from all footing or load bearing structures. Drainage shall be directed to natural drainage ways and shall be graded per the Design Documents.

2.1.5.2. Restore the site in accordance with the definitive Project Agreement.

2.1.6. Topsoil Placement

2.1.6.1. Topsoil material shall conform to Section 4.1.2.5.

2.1.6.2. Topsoil shall not be delivered to the site that is in a frozen or muddy condition.

2.1.6.3. Final grading operations, topsoil placement, and stabilization shall be performed to maintain compliance with the SWPPP.

2.1.7. Excavation

2.1.7.1. All work shall be constructed, tested and inspected in compliance with the Project Quality Assurance Plan, this Specification, and as indicated in the design documents.

2.1.7.2. Ensure foundation site is graded in accordance with the Design Documents.

2.1.7.3. Contractor shall perform all excavation as shown on the drawings. Contractor shall be responsible for using excavated materials which meet the requirements of fill material as defined in Section 4.1.2.

2.1.7.4. Excavated material, when determined by Owner to be unacceptable to use as fill and verified by the Engineer of Record, shall be removed and disposed of by Contractor.

2.1.7.5. Contractor shall furnish labor, supervision and equipment to perform excavating in an efficient and timely manner.

2.1.7.6. Blasting will be permitted only when proper precautions are taken for the protection of persons, the work, and public or private property and Contractor has the written approval of Owner. Contractor shall repair any damage done to the work and public or private property. Caps shall in no case be stored, transported or kept in the same place in which dynamite or other explosives are stored, transported or kept. Only electric caps shall be used on the project.

2.1.8. Subgrade

2.1.8.1. Contactor's Engineer of Record shall determine allowable subgrade bearing capacity for all main erection crane bearing pads and critical lifts.

2.1.8.2. Compaction of the sub-grade for roads, crane pads and foundations shall be as required by the Design Documents or to a minimum of 95% of Standard Proctor (AASHTO T99).

2.1.8.3. Prior to further construction (including placing a protective lean concrete surface), a qualified technician shall inspect and approve the sub-grade conditions and record the soil type encountered, groundwater conditions, or other subsurface conditions. Check that observations taken are consistent with the observations contained in the reference geotechnical documents. Any unknown water conditions or soil considered weak shall require the Engineer of Record to be contacted.

2.1.8.4. Upon discovery of any unknown water condition or weak subgrade materials, the Engineer of Record may order additional subcuts or subgrade treatment. Contractor shall perform and install these changes as directed by the Engineer of Record.

2.1.8.5. Subgrade materials determined to be unacceptable by the Engineer of Record shall be excavated and removed to the extent necessary.

2.1.8.6. The subgrade surfaces will be accepted by Owner only after the graded area is clean of mud, debris and weak soil areas have been removed, and surface irregularities are removed to permit drainage of surface water. Contractor shall perform and document all relevant testing as required in the Design Documents and Section 13.1 prior to further construction.

2.1.8.7. To protect the sub-grade for wind turbine foundations, place a lean concrete surface per Section 4.1.3, and fill to the lines and levels indicated on the drawing. It is recommended that the surface be placed as level as possible to facilitate placement of the reinforcing steel and embedment ring.

2.1.9. Fill and Compaction

2.1.9.1. Fill materials shall meet the requirements outlined in Section 4.1.2.

2.1.9.2. Fill slope shall not be steeper than specified in the Geotechnical Report or applicable Design Documents.

2.1.9.3. The existing ground shall be cleared of brush, roots/organic matter, debris and standing water prior to placing structural fill. All unsuitable material shall be placed in non-structural fill areas.

2.1.9.4. All fill materials shall be placed to the lines and grade shown on the drawings. Substitutions of qualified fill materials shall not be made without approval of Owner. Contractor shall state their intent for use of on-site materials before fill placement is allowed to proceed.

2.1.9.5. Fill surfaces shall be maintained level during construction to provide even bearing except where crowns or slopes are required as shown on drawings.

2.1.9.6. Fill shall not be placed on frozen surfaces. Fill placement shall be suspended if wet weather restricts operation of compaction equipment. Frozen material shall not be used for backfill.

2.1.9.7. Fill shall be placed at moisture contents within 2% of optimum moisture content at optimum density. Granular fill shall be placed with suitable moisture to allow compaction, in accordance with ASTM D698.

2.1.9.8. Fill material shall be placed in a maximum of 12 inch loose, 6 inch compacted lifts.

2.1.9.9. All fill shall be compacted to a minimum of 95% maximum density (Standard Proctor) in accordance with ASTM D698 or as specified in the Design Documents. Collection line trench compaction may be 85%. When crossing an access road, over WTG foundation, or over other areas that are needed to support a load; the compaction shall be 95%.

2.1.9.10. Structural fill shall be defined as any fill area receiving permanent loading from an external source, i.e. WTG foundation. Structural fill shall be compacted to a minimum of 95% of the maximum dry density per (modified proctor) ASTM D1557 method or as specified in the Design Documents. Structural fill shall be placed in a maximum of 12 inch loose, 6 inch compacted lifts.

2.1.9.11. Structural fill shall meet the requirements for Select Fill as defined in Section 4.1.2.2 and shall be approved by the Engineer of Record prior to transport. Structural fill shall be placed on undisturbed native soil. Depth of the structural fill and compaction requirements shall be according to drawings and specifications.

2.1.9.12. Fill which is discovered to be unacceptable shall be removed. The subgrade shall be subsequently leveled and compacted prior to placement of the next lift of qualified fill.

2.1.9.13. Contractor shall not place additional fill until acceptable test results are obtained.

2.2. Cement Stabilization

2.2.1. Shall meet the requirements of the Design Documents.

2.2.2. Type I or Type II Portland Cement shall be mixed uniformly with existing soils to a minimum depth of 12 inches. Other stabilization materials (e.g., fly ash or lime) may be used provided Owner approval.

2.2.3. Assume a 16 ft. width (i.e., two passes) for cement stabilization on all turbine access roads with a 16 ft. wide aggregate surface.

2.2.4. Apply cement at an average rate of 5%. The amount of cement may be adjusted based on field conditions, soil type, moisture content, test strip information, and testing data from roads previously constructed for the project.

2.2.5. Compaction shall be performed until the stabilized material “breaks.” Compaction is typically achieved by multiple passes of a pad foot roller until the roller “walks” out of the reclaimed material (space is visible between the drum and the reclaimed material). If a density failure occurs, and additional application of compaction does not improve the density, a one point proctor shall be run to determine whether the material had changed and a new proctor is needed.

2.2.6. The stabilized material shall be continuously wet cured for a minimum of 24 hours (wet cured is identified visually as surface damp). This may require the application of water every 2-3 hours, including at night when no other work is being performed.

2.3. Anchor Bolts and Embedment Plate

2.3.1. Products, execution, and testing are specified to provide durable anchor bolts and embedment plates that will meet the intent of the Design Documents.

2.3.2. All Work shall be constructed, tested, and inspected as described in the Project Quality Assurance Plan, this Specification, and as indicated in the Design Documents.

2.3.3. Anchor Bolt material selection should consider toughness requirements as may be specified by the Wind Turbine Generator System (WTGS) Supplier and/or in consideration of cold temperatures at the project site.

2.3.4. Anchor bolts should be post-tensioned to tension values and sequences specified by the Engineer utilizing calibrated equipment. Unless otherwise specified by the Engineer of record, following completion of tensioning of all bolts for a turbine, a tension check should be performed on a random 10% of the anchor bolts. Tensioning records should be kept for initial tensioning and subsequent verification testing.

2.4. Grout

2.4.1. All Work shall be constructed, tested and inspected as described in the Project Quality Assurance Plan, this Specification, and as indicated in the design documents.

2.4.2. Mix, place, and cure grout in accordance with manufacturer's instructions.

2.4.3. The grout selected must cure to the required strength as specified in the Design Documents. Grout design strength shall exceed design strength of the concrete the grout is placed on.

2.4.4 Grout under the tower base flange should be designed to resist the applied loads with due consideration for fatigue including initial loads (post-tension force) in the anchor bolts. The designer should specify the required permanent strength as well as the strength required during construction (e.g. tower/turbine erection and anchor bolt post-tensioning).

2.4.5 Grout should be designed or detailed in consideration of the interface with the tower base flange and service climatic conditions such as precipitation, freeze/thaw cycling, and use of de-icing chemicals. (Ref. is given to ACI 318, 351.1R and 351.2R.

2.4.4.

2.5. Miscellaneous Concrete Embedments

2.5.1. Verify the location of miscellaneous concrete embedments and ensure they are properly secured to prevent movement during concrete placement.

2.5.2. Anchor bolts and concrete embedments shall not be "wet-set".

2.5.3. Conduit shall be secured to prevent shifting during concrete placement. If applicable, conduit ends shall be secured against the formwork to provide accessibility following concrete placement.

2.5.4. Ground grid shall be secured to prevent shifting during concrete placement.

2.5.5. Embedments shall be installed according to the tolerances detailed in the most recent ACI 117 or as detailed in the Design Documents.

2.5.6. Anchor bolt projection shall meet requirements outlined in Design Documents.

2.5.7. Anchor bolts shall be secured in place with a template to ensure anchor bolt shifting does not occur during concrete placement.

2.6. Concrete Work

2.6.1. Concrete work shall be in compliance with all of the most current applicable codes and specifications including, but not limited to, the following:

2.6.1.1. ACI 318 latest edition, Building Code Requirements for Structural Concrete and Commentary.

2.6.1.2. ACI 117, Specification for Tolerances for Concrete Construction and Materials.

2.6.1.3. ACI 306, Cold Weather Concreting.

2.6.1.4. ACI 305, Hot Weather Concreting.

2.6.1.5. ACI 304, Guide for Measuring, Mixing, Transporting, and Placing Concrete.

2.6.1.6. ACI 301, Standard Specifications for Structural Concrete.

2.6.1.7. ACI 309R Guide for consolidation of concrete placement.

2.6.1.8. ACI 201.2R Guide to Durable concrete

2.6.1.9. ACI 207.1R Guide to Mass Concrete

2.6.1.10. ASTM C 94 Standard Specification for Ready-Mixed Concrete

2.6.1.11. ACI 351.1R Grouting between Foundation and Support of Equipment and Machinery

2.6.1.12. ACI 351.3R Foundation for Dynamic Equipment

2.6.1.13. All Work will be constructed, tested and inspected as described in the Project Quality Assurance Plan, this Specification, and as indicated in the design documents.

2.6.2. All concrete mix designs shall be approved by the Engineer of Record.

2.6.3. Where structures are erected using concrete foundations, structures shall not be erected on foundations until the concrete has reached the design strength specified by the Engineer of Record.

2.6.4. Place reinforcement, anchors, embedments, and concrete in accordance with the final design dimensional tolerances.

2.6.5. Wind turbine foundation reinforcement and concrete shall be placed over a lean concrete working surface clear of debris, ponding of water, standing mud, and organic material.

2.6.6. Reinforcement shall be clean and free of rust, mud, debris and foreign material.

2.6.7. Provide necessary chairs and standees to support rebar and prevent movement or deflection of the reinforcement during placement of concrete.

2.6.8. It shall be Contractor's responsibility to check before, during and after the concrete or backfill is placed to be certain all footings, direct embedment sections, or anchor bolt cages are properly set as to depth, plumb, level, horizontal and vertical dimensions per the Design Documents.

2.6.9. Any footing, direct embedment section, anchor bolt cage found to vary more than the limits of industry standards shall be removed and reset. If, in the opinion of Owner, any component of the foundation being removed is damaged, it shall be replaced rather than reused, at Contractor’s own expense.

2.6.10. Contractor shall arrange for a third party testing representative to obtain all site measurements (slump, air, etc.), prepare, cure, and perform compressive strength tests on all concrete test cylinders. All test results shall be provided to Owner.

2.6.10.1. See Section 13.1.6 for relevant testing requirements.

2.6.11. Concrete shall be placed following the requirements below:

2.6.11.1. Debris shall be removed from the hole prior to placement. Placement of concrete should be continuous to prevent formation of layers. Contractor shall provide an adequate number of vibrators of sufficient capacity to keep up with the maximum rate of concrete placement.

2.6.11.2. Prevent formwork from moving during placement of concrete.

2.6.11.3. Concrete shall be placed to avoid segregation of the materials, to prevent the formation of joints, voids, and honeycombing, and displacement of the reinforcement or anchor bolt cages. Concrete shall not be pumped through aluminum alloy pipe. All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete.

2.6.11.4. Drop height of concrete being placed shall not exceed a height so as to cause separation of ingredients or water to pond on the surface of the newly placed concrete.

2.6.11.5. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting anchor bolts.

2.6.11.6. Finish top of concrete footings and pedestals per Design Documents as approved by Owner.

2.6.11.7. Cure concrete in accordance with ACI 318. If a curing membrane is used, apply curing membrane as soon as bleeding has stopped and free water has disappeared from the surface.

2.6.11.8. Concrete repair methods and procedures shall be approved by the Engineer of Record, with a copy to Owner before beginning repairs. Repairs shall be scheduled such that the repair process can be observed by Owner.

2.7. Security Fencing Details

Security fencing details apply to substation, O&M, and, if required, transmission line fencing.

2.7.1. Fencing Details

2.7.1.1. Substation

Fencing details including, but not limited to, type, wire gage, height and post size and spacing shall meet Owner's minimum specifications. The entrance gate shall be two 8 feet wide gates that latch and lock at the center. A personnel entrance gate of (3) feet wide shall be integrated into one of the entrance gates. The gates shall be designed to withstand wind loads of 60 mph in operation. Other gates: If the site layout is suitable, one personnel gate shall be located opposite of the main entrance gate. Standard fence height is 8 foot high: 7 ft. fabric plus a minimum of 1 ft. vertical height of barbed wire, mounted at 45 degree angle, pointing outward from the substation.

2.7.1.2. O&M

2.7.1.2.1. O&M building entrance gate shall be a vertical pivot AutoGate model VPL-300, 14 ft. wide by 7 ft. high plus 1 ft. barb wire and a manual horizontal swing gate which shall be 8 ft. wide by 7 ft. high plus 1 ft barb wire. The vertical pivot gate shall be remote operable with an exterior pedestal mounted access card reader and phone, an interior buried open loop and photo eye safety close device, and be designed to withstand wind loads of 60 mph in operation. The photo eye opposite the gate operator shall be mounted off the horizontal gate hinge post. Provide one personnel gate within 10 ft. of the entrance gate. Other gates: personnel gates shall be located near any facilities located outside of the fenced area (e.g. metering devices, service cabinets, etc.) and, at a minimum, one opposite of the main entrance gate. The gate shall include:

- Heater for cold weather operation (cold climates only)
- Heated melt away kit for under gate (cold climates only)
- Deep cycle marine AGM batteries
- AutoGate footing, HydroVac'd 4 ft. x 7 ft. by 12 in. with five 12 in. sono tubes to 72 in. deep with #4 rebar ties and setting of latch post in a 12 in. by 72 in. deep sono tube.
- High voltage surge suppressor, 115 vac
- EMX, IRB-MON commercial thru-scan photo-eye with protective hoods per UL325
- LMA-1250-LV vehicle detectors
- Patriot Detection, direct bury loops for outside/inside obstruction and inside auto exit
- Fire department emergency access device

2.7.2. Substation Wildlife Deterrent

2.7.2.1. 18-24 in. wide 26-28 gauge galvanized sheet metal in 8'-10' lengths mounted near the top of the fence to deny climbing animals the toe hold necessary to climb over the fence. Sheet metal shall have rolled edges at top and bottom to improve stability.

2.7.2.2. Additional fence fabric and applied "rubber" belting over gaps around the gate area to deny animals access through these areas.

2.7.3. Security

2.7.3.1. 2 in. diamond chain link fence to deny good toe hold and make climbing over the fence more difficult for the public.

2.7.3.2. 45° outrigger with three stands of barbed wire to make climbing over the fence more difficult for the public and to legally declare the substation fences as security barriers.

2.7.4. Fencing Material and Application

2.7.4.1. Standard fence height is 8 foot high: 7 ft. fabric plus a minimum of 1 ft. vertical height of barbed wire, mounted at 45 degree angle, pointing outward.

2.7.4.2. The fence fabric is a 2 in. diamond mesh chain link style, galvanized or aluminum and coated as follows:

2.7.4.2.1. Galvanized - Maximum of 2 in. mesh Number 11 AWG (American Wire Gauge), galvanized after weaving, Class II, Conforming to ASTM A392, “Zinc-Coated Steel Chain-Link Fence Fabric”.

2.7.4.3. Barbed wire top guards, consisting of 3 or 4 strands of barbed wire, shall be mounted on outriggers directed outward at a 45 degree angle. The barbed wire should be equally spaced about 6” inches apart. Outriggers should be at least 18” or 24” long to insure 1’- 0” vertical height over the top rail of the fence. Wire material to be either galvanized or aluminum coated as follows:

2.7.4.3.1. Galvanized - 12 1/2 gauge with 14 gauge 4 barb, 5-inch spacing, conforming to ASTM A121, Class 3 “Zinc - Coated Steel Barb Wire.”

2.7.4.4. Fence Framework

2.7.4.4.1. Intermediate line posts shall be 2 1/2” galvanized Schedule 40 pipe (2 7/8” O.D.) 5.79 lbs per foot of sufficient length to be driven into the ground a minimum of 4 feet deep.

2.7.4.4.2. Corner and terminal posts shall be 2 1/2” galvanized Schedule 40 pipe (2 7/8” O.D.) standard pipe, 5.79 lbs. per foot. Posts shall be of sufficient length to be set in concrete at a minimum of 5 feet deep.

2.7.4.4.3. Gate posts shall be galvanized standard weight pipe sized as indicated in Table 1 for single swing gates or one leaf of the double gate. Posts shall be of sufficient length to be set in concrete at a minimum of 5 feet of depth.

2.7.4.4.4. Top rail and braces shall be 1 5/8” O.D. 2.27 lbs. per foot.

2.7.4.4.5. All pipe shall be galvanized to conform to ASTM A120 covering “Black and Hot Dipped Zinc-Coated (galvanized) Welded and Seamless Steel Pipe for Ordinary Uses.”

Table 1: Sizing of galvanized standard weight gate posts.

Up to 6' wide	2 7/8" O.D.	5.79 lbs per foot
Over 6'to 13'	4" O.D.	9.11 lbs per foot
Over 13' to 18'	6 5/8" O.D.	18.97 lbs per foot

2.7.4.5. Gates shall be galvanized 1.90 inch O.D. pipe, 2.72 lbs. per foot, complete with hinges, stops, rests, and latching devices of a type to accommodate a padlock.

2.7.4.5.1. Fittings and latches shall be of appropriate specifications for their functions.

2.7.4.5.2. All Pipe shall be galvanized to conform to ASTM A120 covering "Black And Hot Dipped Zinc-Coated (galvanized) Welded And Seamless Steel Pipe For Ordinary Uses."

2.7.4.5.3. Latch for double gate shall allow opening one half of the gate without disturbing anchorage of the second half.

2.7.4.6. Hardware fittings and braces shall be in compliance with applicable industry standards for complete and proper installation of the fence standard. Galvanizing shall conform to ASTM A153 "Zinc- Coating Hot Dip on Iron and Steel Hardware."

2.7.4.7. Each shipment of fence shall be inspected by Contractor and Owner to determine whether or not the galvanizing meets the specifications under which it was purchased.

2.7.5. Installation Chain Link Fencing

2.7.5.1. Installation shall be made in a professional manner by skilled persons experienced in the erection of this type of fence. The fence shall be erected on lines and to grades as provided in the Design Documents. Fence shall follow the ground line unless otherwise specified. Line posts shall be spaced not more than 10 feet apart and shall be driven into the ground, 4 feet minimum, without concrete. All gate, corner and terminal posts shall be set in concrete foundations to a minimum depth of 60 inches. The diameter of the foundation is to be a minimum of 9 inches, except for gate posts, on which the minimum diameter shall be three times the outside diameter of the post. The foundation shall be 3000 PSI concrete.

2.7.5.2. All foundations shall extend to the finished grade and shall slope away from the post to assure proper drainage. The top shall be the same diameter as the remainder of the foundation and shall be neat in appearance. The fabric and the barbed wire shall be stretched to proper tension between the terminal posts and securely fastened to the frame work members as covered in the material specifications. The bottom of the fabric shall be held uniformly to the rough grade elevation. Four inches of crushed rock finished grade shall then be laid up to the fence fabric on both sides to help prevent animal access, erosion, or settlement problems.

3. Electrical Works

3.1. NERC Requirements

(North American Electric Reliability Corporation) Standards and Compliance

3.1.1. Contractor shall provide NERC testing and compliance reports for review by Owner. Reports shall provide NERC related support documentation in a manner that is thorough, well organized, complete, and include explanations that support the conclusions reached. Reports shall be suitable for use in presenting to NERC audit personnel.

Table 2: FAC-008 NERC Standard Requirements.

NERC Standard	FAC-008
NERC Standard Title	Facility Ratings
Requirement	
Standard Summary	Ensure Facility ratings used are determined based on technically sound principles.
Reference	EPR 5.200 Facility Rating and Reporting, EPR-5.220P01 NERC Facility Rating Methodology
Responsible Party	Contractor to develop the report.
Required Evidence	Comprehensive report including equipment and conductor ratings from individual generators to point of interconnection including current transformer ratings. Report to be submitted as part of 90% design documents

Table 3: MOD-025 NERC Standard Requirements.

NERC Standard	MOD-025
NERC Standard Title	Verification and Data Reporting of Generator Real and Reactive Power Capability and Synchronous Condenser Reactive Power Capability
Requirement	
Standard Summary	Ensure accurate information on generator gross and net Real and Reactive Power capability and synchronous condenser Reactive Power capability is available for planning models.
Reference	EPR 5.201S Stability Modeling Data Maintenance and Reporting Requirements
Responsible Party	Contractor to develop test plan and complete the necessary documentation after testing is complete. Owner will conduct the test and collect the data.
Required Evidence	Comprehensive report including test plan and test results for MOD-025 testing Report to be submitted within 60 days following substantial completion.

Table 4: MOD-026 NERC Standard Requirements.

NERC Standard	MOD-026
NERC Standard Title	Verification of Models and Data for Generator Excitation Control System or Plant Volt/VAR Control Functions
Requirement	
Standard Summary	Verify the generator excitation control system or plant volt/var control function model and the model parameters used in dynamic simulations accurately represent the generator excitation control system or plant volt/var control function behavior.
Reference	EPR 5.201S Stability Modeling Data Maintenance and Reporting Requirements
Responsible Party	Contractor to develop a test plan in consultation with the MOD-026 modeling company (*Electric Power Engineers (EPE) or owner approved equal*). The test plan is to be submitted to the Owner for approval. Contractor to coordinate and conduct the test and collect the data required
Required Evidence	Comprehensive report including modeling of the Var/Volt Control and verification testing of the model per MOD-026. Report due within 60 days following substantial completion.

Table 5: MOD-027 NERC Standard Requirements.

NERC Standard	MOD-027
NERC Standard Title	Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions
Requirement	
Standard Summary	Verify the turbine/governor and load control or active power/frequency control model and model parameters used in dynamic simulations accurately represent generator unit real power response to system frequency variations.
Reference	EPR 5.201S Stability Modeling Data Maintenance and Reporting Requirements
Responsible Party	Contractor to develop a test plan in consultation with the MOD-027 modeling company (*Electric Power Engineers (EPE) or owner approved equal*). The test plan is to be submitted to the owner for approval. Contractor to coordinate and conduct the test and collect the data required.
Required Evidence	Comprehensive report including modelling the active power / frequency control and verification testing of the model to meet MOD-027. Report due within 60 days following substantial completion.

Table 6: PRC-005 NERC Standard Requirements.

NERC Standard	PRC-005
NERC Standard Title	Protection System Maintenance
Requirement	R3, R5
Standard Summary	Document and implement programs for the maintenance of all Protection Systems affecting the reliability of the BES so that these Protection Systems are kept in working order.
Reference	EPR 5.704S Battery Maintenance Standard EPR 5.714S Protective Relay Maintenance Standard
Responsible Party	Contractor shall produce all of the necessary documentation.
Required Evidence	• Settings files for all protective relays • Documentation of testing proving functionality of A/D converters in relays and relay inputs and outputs. • Documentation of instrument transformer testing including wiring to relays. Load check of relays when at power to prove proper relay receipt of instrument transformer signal. • Documentation of functional testing of control circuitry from the relay output through the trip coils of actuated circuit breakers. • Documentation of testing of protection system communication systems – lines interconnecting to remote substations. • Completion of initial battery testing. • Completion of monthly, quarterly, annual and battery capacity tests if required. Depends on duration of construction after batteries are commissioned. • Commissioning testing of substation including end to end testing of line relaying. • Written testing procedure to be submitted for review. • All documentation submitted to Owner for review two weeks prior to Commercial Operation Date.

Table 7: PRC-001 NERC Standard Requirements.

NERC Standard	PRC-001
NERC Standard Title	System Protection Coordination
Requirement	R3, R5
Standard Summary	To ensure system protection is coordinated among operating entities.
Reference	EPR 5.202S NERC Protection System Coordination, Relay Setting, and Reporting Requirements

Responsible Party	Contractor and Owner shall document coordination with the transmission Owner. Contractor shall provide relay coordination study.
Required Evidence	Provide a relay coordination study per PRC-001. This study should also include validation of relay setpoints as required to meet PRC-019, "Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection"; PRC-024, "Generator Frequency and Voltage Protective Relay Settings"; and PRC-025, "Generator Relay Loadability". This includes protective relaying associated with aggregating system and step up transformers. PRC-001 portion of relay coordination study to be completed and approved as part of 60% electrical design submittal data.

Table 8: PRC-019 NERC Standard Requirements.

NERC Standard	PRC-019
NERC Standard Title	Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection
Requirement	R1, R2
Standard Summary	Verify coordination of generating unit Facility or synchronous condenser voltage regulating controls, limit functions, equipment capabilities and Protection System settings.
Reference	EPR 5.202S NERC Protection System Coordination, Relay Setting, and Reporting Requirements
Responsible Party	Contractor
Required Evidence	Provide evidence of coordinating the voltage regulating system controls, including in-service limiters and protection functions, with the applicable equipment capabilities and settings of the applicable Protection System devices and functions as specified in Requirement R1. Report to be submitted as part of 60% design documents

Table 9: PRC-024 NERC Standard Requirements.

NERC Standard	PRC-024
NERC Standard Title	Generator Frequency and Voltage Protective Relay Settings
Requirement	
Standard Summary	Ensure that generator protective relays are set such that generating units remain connected during defined frequency and voltage excursions.
Reference	EPR 5.202S NERC Protection System Coordination, Relay Setting, and Reporting Requirements
Responsible Party	Contractor

Required Evidence	Comprehensive report of evidence that relay settings meet PRC-024 voltage and frequency ride through requirements. Report to be submitted as part of 60% design documents

Table 10: PRC-025 NERC Standard Requirements.

NERC Standard	PRC-025
NERC Standard Title	Generator Relay Loadability
Requirement	R1
Standard Summary	Set load-responsive protective relays associated with generation Facilities at a level to prevent unnecessary tripping of generators during a system disturbance for conditions that do not pose a risk of damage to the associated equipment.
Reference	EPR 5.202S NERC Protection System Coordination, Relay Setting, and Reporting Requirements
Responsible Party	Contractor
Required Evidence	Comprehensive report of evidence that relay settings are set per PRC-025 methodology for applicable relay type, application and anticipated loads. Report to be submitted as part of 60% design documents

3.2. Approved Manufacturers

Table 11: Approved manufacturers.

EQUIPMENT	MANUFACTURER
HV Circuit Breaker	Siemens, ABB, GE/Alstom Grid
MV Circuit Breaker	ABB, Siemens, Myers Power Products
Switch MOD	Southern States, Royal
Main Power Transformers	HICO, ABB, SPX, Siemens, Hyundai, SMIT
Insulators	Ohio Brass, Lapp, MacLean
T-line Hardware	Anderson, Fargo, Hubbell, Hughes Brothers
Steel T-line/Substation pole	Meyer-Thomas and Betts, Sabre-Ft. Worth Tower, Valmont Industries
Grip and AGS	Preformed
Electrical Equipment Enclosure	Powell, AZZ, Crown Technical Systems, Trachte
Grounding Transformers	GE Prolec, ABB
Lighting	Crouse Hinds, Lithonia, Holophane, General Electric
Auxiliary Relays	Allen-Bradley, Cutler-Hammer, General Electric, Potter-Brumfield
Protective Relays	SEL, Basler, General Electric, Electroswitch
Relay Panels	SEL, Electrical Power Products (EP2), Systems Control, Western Controls, Keystone
Battery	C&D, GNB, Exide, BAE, Varta
Battery Charger	Exide, Ametek
Terminal Blocks	Allen-Bradley, Cutler-Hammer, General Electric, Potter-Brumfield
600V Cable	American Wire Group, Anixter, BICC/Cablec, General Cable, Houston Wire and Cable, Okonite, Southwire
Panelboards	Cutler-Hammer, General Electric, Square-D, ABB
Cable Tray	B-Line, PW Industries, T&B
35 KV Cable Accessories	Underground Splices; 3M Terminations: Tyco, 3M, Richards, Cooper
Fiber Optic Cable	Commscope, Furukawa, Brugg
PTs and CCVTs	Kuhlman, ABB, Trench, Alstom, Arteche, ITEC
MV Cable	General Cable, Prysmian, Synergy, Southwire, WTEC
Junction Boxes	Nordic, Highline
Capacitor Banks and Cap Switchers	Cooper Power Systems, Southern States, GE and Eaton

3.3. Approved Contractors

Table 12: Approved contractors.

Type	Contractor
Electrical Commissioning Testing	L&S Electric, CE Power, Real Time Utility Engineers, High Voltage Service
Electrical Engineering	Ulteig, Sargent and Lundy, HDR Engineering, P & E Engineering

3.4. General

3.4.1. Electrical connections shall be tightened to torque specifications stated by the equipment manufacturer. Where equipment manufacturer specifications are not provided, torque connections per NETA (International Electrical Testing Association) standards.

3.4.2. Arrange all electrical work in a neat, well-organized manner. Indoor conduit and similar services shall be installed running parallel with the primary lines of the building construction and with a minimum of 7 feet of overhead clearance where possible.

3.4.3. Install permanent labels on all wires, cables, electrical panels, cabinets, disconnects, motor starters, major equipment, or components. More information located in sections 7, 8, and 9.

3.5. Access for Operation and Maintenance

3.5.1. Arrange all electrical work with adequate access for operation and maintenance.

3.6. Field Panels

3.6.1. All field panels shall be mounted at a height such that snow removal is not required to access the panels and personnel can easily reach devices/fuses.

4. Products and Materials

4.1. Civil

4.1.1. Access Roads

4.1.1.1. Road Base and Cap Aggregate

4.1.1.1.1. Shall be as specified in the Design Documents.

4.1.1.1.2. Road base material shall meet the requirements from the state transportation office in which construction is taking place. Typical gradations are MnDOT Class 5Q, CoDOT Class 5 or 6, and TxDOT Class 1 or 2. Final selection of road base material shall be based upon owner approval.

4.1.1.1.3. The aggregate shall have a minimum of 3 fractured faces meeting the State Department of Transportation specification, or an approved alternative acceptable to Owner.

4.1.1.1.4. Aggregate shall have a minimum of 40% crushed material by weight.

4.1.1.2. Geogrid Membrane

4.1.1.2.1. Shall meet the requirements of the Design Documents.

4.1.1.2.2. The engineer of record shall follow the manufacturer's recommendations for aggregate base thickness to be used during construction.

4.1.1.3. Culvert

4.1.1.3.1. Shall be corrugated metal pipe unless specified to be concrete or PVC by Owner or road authority and shall meet the requirements as directed by the State Department of Transportation and/or the County Engineer in which the project is located.

4.1.1.3.2. All approved culverts shall be installed in accordance with Manufacturer's Specifications as well as Section 5.1.8 of this Specification.

4.1.1.4. Low Water Crossing

4.1.1.4.1. Shall be approved by Owner as either Flexamat, cable concrete, or geocell and shall meet the requirements of the Design Documents. Low water crossings shall be located as indicated in the design documents or as identified by Owner during construction. Geofabric shall be installed underneath all low water crossings.

4.1.2. Fill Material

4.1.2.1. Common Fill

4.1.2.1.1. Common fill material shall be free of topsoil, organic matter, and debris. Common fill shall consist of material with cobbles less than 6 inches in size and liquid limit less than 35.

4.1.2.2. Select Fill

4.1.2.2.1. Select fill material shall consist of granular material less than 1 inch in diameter, with less than 40% passing the #40 sieve, and less than 8% passing the #200 sieve. Cohesive materials above 8% passing #200 sieve being considered for use as select backfill shall be specifically approved by design Engineer of Record.

4.1.2.3. Granular Fill

4.1.2.3.1. Granular fill material shall be sand, gravel, or crushed rock and shall be dense, sound and durable material. Granular fill shall be well graded, and shall conform to the specified gradation requirements based on its application as defined in this specification.

GRADATION TYPE "A"

3 1/2"	100% passing (maximum size)
3"	70% to 80% passing
2 1/2"	25% to 60% passing
1 1/2"	0% to 5% passing (minimum size)

GRADATION TYPE "B"

2"	100%
1 1/2"	90% - 100%
1"	30% - 75%
3/4"	0% - 20%
3/8"	0% - 10%
No. 4	0% - 5%

GRADATION TYPE "C"

1"	100%
3/4"	90% - 100%
3/8"	50% - 90%
No. 4	35% - 70%
No. 10	20% - 55%
No. 40	10% - 35%
No. 200	0% - 5%

Standard Transmission Line Gradation

1"	100%
3/4"	100%
1/2"	60% - 90%
No. 4	40% - 60%
No. 8	25% - 50%
No. 16	20% - 40%
No. 200	5% - 15%

Substation “Finish Rock”

1"	100%
3/4"	10% - 20%
1/2"	0% - 5%
3/8”	0%

A minimum of 70% material shall have at least one fractured face.

4.1.2.4. Lean Concrete Backfill

4.1.2.4.1. Lean concrete backfill shall consist of a sand-cement flyash mixture having a 6-7 inch slump when placed, and 200 psi compressive strength at 3 days.

4.1.2.4.2. Flyash shall be a type "C" or "F" per ASTM 618, amended to date, and shall be provided in the mix as a replacement of Portland cement to a limit of 20% by weight. Portland cement shall be a type "I" per ASTM C150.

4.1.2.5. Topsoil

4.1.2.5.1. Natural topsoil stockpiled on site shall be used to the extent it is available and accessible.

4.1.2.5.2. Topsoil shall consist of near surface organic soil, identified as a suitable growing medium and meeting MNDOT 3877 requirements or equivalents in IA, MI, ND, SD, TX & WI.

4.1.2.6. Riprap

4.1.2.6.1. Riprap shall conform to MNDOT 3601-2A2 Random Riprap, Class 1 (or MDOT 916, NDDOT 708.04, SDDOT 830, WIDOT Section 606) and shall be durable, sound, angular in shape, resistant to weathering and free of organic material or debris.

4.1.3. Cast-In-Place Concrete & Steel Reinforcing

4.1.3.1. As specified by Design Documents or as a minimum:

4.1.3.2. WTG Foundation 5,000 PSI in 28 days.

4.1.3.3. Misc. Footings 4,000 psi in 28 days

4.1.3.4. Flat Slabs and sidewalks 3,000 psi in 28 days

4.1.3.5. Lean Concrete Slabs 2000 psi in 28 days

4.1.3.6. All concrete exposed to freeze-thaw effects shall be air entrained.

4.1.4. Anchor Bolts and Embedment Plate

4.1.4.1. As required by Design Documents.

4.1.5. Grout

4.1.5.1. Non-Shrink Grout: Pre-packaged grout conforming to Design Documents.

4.1.6. Miscellaneous Concrete Embedments

4.1.6.1. Electrical Conduit

4.1.6.1.1. In accordance with manufacturer requirements; Code requirements (NEC or NESC or local jurisdiction); Design Documents.

4.1.6.2. Grounding Grid

4.1.6.2.1. In accordance with manufacturer requirements; Code requirements (NEC or NESC or local jurisdiction); Design Documents.

4.2. Electrical

Except as otherwise indicated; provide new electrical products free of defects and harmful deterioration at the time of installation. Provide each product complete with trim, accessories, finish, guards, safety devices and similar components specified or recognized as integral parts of the product, or required by governing regulations. Unless otherwise indicated by the plans or specifications or approved in writing, the materials and equipment furnished under these specifications shall be the standard products of manufacturers regularly engaged in the production of such equipment, and shall be the manufacturers' standard design.

All products shall be capable of compliance with all OSHA lockout requirements.

4.2.1. Collection Cable

All materials, equipment, and workmanship shall conform to the applicable chapters of the National Electrical Code (NEC), the National Electrical Safety Code (NESC), and other Authorities having lawful jurisdiction pertaining to the Work required.

Underground cable shall be as required by final design. Provide all cable termination and splice materials.

Where multiple units of a product are required for the electrical work, provide identical products by the same manufacturer without variations.

4.2.1.1. Cable Construction

4.2.1.1.1. 35 kV UD Cable, suitable for use in wet or dry locations, direct burial, underground ducts, and exposure to sunlight.

4.2.1.1.2. Manufactured to the latest edition of the following specifications:

ANSI/ICEA S-94-649

AEIC CS-8

ASTM B 231

4.2.1.1.3. Stranded Aluminum with copper concentric neutral. Conductor and concentric neutral is to be sized based upon the calculated current requirements and thermal damage limits that the cable can withstand under full load and short circuit conditions. Short circuit thermal damage limit calculations shall assume a minimum of a 5 cycle delay on relay trip signal, and an additional 1 cycle of margin being added to the breaker interrupt time. For the conductor, it is assumed that 100% of the fault current is carried by the conductor. For the concentric neutral it is assumed that 70% of the fault current is carried by the concentric neutral (30% of fault current is through earth, bare copper conductor (collection system grounding conductor), or other phase cables concentric neutral.

4.2.1.1.4. Tree-Retardant Cross-Linked Polyethylene (TRXLPE) Insulation.

4.2.1.1.5. Moisture Blocked, Class B Stranded conductor system that is designed to prevent longitudinal migration of water along stranded conductors. Water blocking tapes installed between conductor layers are not allowed as a water blocking system.

4.2.1.1.6. Water-Blocked completed cable construction must pass longitudinal water penetration resistance test in accordance with ANSI/ICEA T-34-664.

4.2.1.1.7. Evenly spaced concentric neutral wires per standards.

4.2.1.1.8. Water-blocked concentric neutrals / jackets.

4.2.1.1.9. Extruded cable core dimensions per ANSI/ICEA, AEIC and CSA standards.

4.2.1.1.10. Certified test reports to be provided by the manufacturer for each shipping reel.

4.2.1.2. Cable Ampacity

Cable ampacity shall be calculated using a cable ampacity software package that models the cable using the Neher McGrath, IEC 60287 and

IEC 60949 standards. Ampacity calculations must consider operational conditions including:

4.2.1.2.1. Ground temperature

4.2.1.2.2. Air temperature

4.2.1.2.3. Maximum conductor temperature ratings

4.2.1.2.4. Critical soil interface temperature

4.2.1.2.5. Measured maximum soil temperature

4.2.1.2.6. Measured native in-situ soil thermal resistivity

4.2.1.2.7. Native soil dried-out thermal resistivity

4.2.1.2.8. Load factor

4.2.1.2.9. Burial depth of the conductors

4.2.1.2.10. Ampacity on concentric neutrals

4.2.1.2.11. Measured historical minimum soil moisture content

4.2.1.3. Grounding

4.2.1.3.1. An appropriately sized (assume 30% of fault current is carried by the conductor) , but not less than 1/0, bare, copper grounding conductor or equivelantly sized copper clad steel rated for the available fault current shall be routed with the collection system feeder cables, and installed with the collection circuits.

4.2.2. Junction Boxes

4.2.2.1. Junction box medium voltage terminations shall utilize “T-body” type connectors that will allow for the easy installation or relocation of surge arrestors along the collection circuits.

4.2.2.2. Junction boxes shall be pad mounted.

4.2.2.3. Junction boxes within 500 ft. of wind turbines shall be of steel construction.

4.2.2.4. Distance between junction boxes or a junction box and termination at the collection sub or a junction box and wind tower termination shall be no greater than 8000 feet to allow for off-line partial discharge testing of cables.

4.2.3. Padmount Transformers

4.2.3.1. Shall be provided for collection circuit feeder grounding transformers. Unit substation transformers may be substituted for padmount transformers. Transformers shall include:

4.2.3.1.1. KVA Rating as required for effective grounding of collection circuits. All grounding transformers to have the same KVA rating, etc. and be interchangeable.

4.2.3.1.2. 34,500V Grounded Wye primary with +/- 2, 2 ½% tapswith 150 KV BIL Rating. Note that when the grounding transformer is located within the collection substation, and the collection substation voltage is maintained at 34,500V by the main power transformers on-load tap changer, the +/-2, 2 ½% grounding transformer taps are not required. Deadfront primary construction, no fuse protection on primary winding. Externally clamped, 600A non-load break epoxy bushing wells.

4.2.3.1.3. 480V Delta Secondary voltage with 30 KV BIL Rating.

4.2.3.1.4. 65 Deg. C temperature rise above 30 Deg. C ambient temperature.

4.2.3.1.5. Mineral Oil fluid.

4.2.3.1.6. Tank ground pads in HV & LV compartments.

4.2.3.1.7. ANSI 61 Gray.

4.2.3.1.8. Cover Mounted pressure relief device with semaphore.

4.2.3.1.9. Liquid level gauge

4.2.3.1.10. Drain valve and sampling device.

4.2.3.1.11. Electrostatic shielded and grounded core.

4.2.3.1.12. Locking hasp for all external devices and ports.

4.2.3.1.13. Low Voltage Bushings with ANSI Spades

Cover un-used ANSI spades with an insulating, pliable, high dielectric strength (500 Volts/Mil) plastic molded boot that can be easily removed and re-installed. Boots shall be manufactured by Insulboot, Eger Products, or Owner approved equivalent.

4.2.3.2. Pedestals for padmount transformers, if any, shall be fiberglass, pre-cast, or poured concrete.

4.2.4. Grounding System

4.2.4.1. All above and below-grade grounding conductors shall be soft-drawn, bare, uncoated, stranded copper, meeting the requirements of ASTM B3 and ASTM B8.

4.2.4.2. Grounding connections shall utilize an Owner approved exothermic-welding process. Connection types other than exothermic shall be used only where indicated on the Design Documents.

4.2.4.3. Sectional-type, copper-clad ground rods of the diameter and length shown on the Design Documents shall be used.

4.2.4.4. On collection strings only, copper clad steel sized appropriately for the available fault current is allowed.

4.2.5. Bus System

4.2.5.1. Bus Conductor

4.2.5.1.1. All tubular bus shall be extruded aluminum tubular-bus conductor, ANSI Schedule 40 SPS (standard pipe size) pipe, 6063-T6 alloy. All channel bus shall be aluminum integral web channel bus (IWCB) conductor, No. 2EC-T61 alloy.

4.2.5.1.2. Contractor shall unpack, clean and check aluminum bus for damage and/or staining immediately upon receipt from the carrier. Contractor shall remove all materials which might damage the bus finish and store the bus in such a manner that the finish will be protected. Contact with the ground or other abrasive surfaces shall be prevented. Any remedial action regarding handling of the bus will be at Owners direction and at no cost to Owner.

4.2.5.2. Shielding Gas

Contractor shall utilize either the Tungsten Inert-Gas (TIG) arc or the Metal Inert-Gas (MIG) arc for all aluminum welding. The shielding gas used for all aluminum welding shall be commercially prepared and shall be certified as being welding grade and purity. The gas shall be one hundred percent (100%) argon, or a mixture of seventy-five percent (75%) helium and twenty-five percent (25%) argon for MIG and one hundred percent (100%) argon for TIG.

4.2.5.3. Filler Metal

Type ER4043 filler metal shall be used for all aluminum welding, except for those isolated cases where the base metal is other than types (356, 6061, or 6063) normally used in the electrical power industry. The following handling requirements shall be observed:

4.2.5.3.1. Filler metal shall be stored in a dry, warm, uniform-temperature storage area. Original cartons shall not be opened until the filler metal is actually needed for welding.

4.2.5.3.2. Rod for the TIG process shall be kept in a closed container except during rod removal.

4.2.5.3.3. Wire for the MIG process shall be uniform in diameter, suitable temper, free from slivers, scratches, inclusions, kinks, waves and sharp bends and spooled so that it is free to unwind without restriction. Proper pitch and cast shall also be maintained to prevent wandering of the wire as it emerges from the electrode gun. Wire left on the machine overnight shall be sealed tightly to prevent contamination. Wire left on the machine that is not scheduled for use in less than twenty-four (24) hours shall be returned to its original carton and tightly sealed.

4.2.5.3.4. Filler metal which, in the judgment of Owner, is unsuitable for the work shall be immediately removed from the job.

4.2.6. Wiring Systems (600V and Below)

4.2.6.1. All control and power wires and cables to be routed in the cable tray, or conduit runs shall be flame resistant, tray-rated cable, conforming to the standards listed above and the Design Documents.

4.2.6.2. All control and power wires and cables to be routed in the concrete trench shall be flame resistant, tray-rated cable, suitable for direct burial and wet/dry locations conforming to the standards listed above and the Design Documents.

4.2.6.3. All wire sizes shall be determined as specified on the Design Documents. All wiring colors, sizes and types shall conform to that shown on the Design Documents and in this Section, regardless of what is supplied by the wire manufacturer.

4.2.6.4. Wiring devices shall be installed where shown on the Design Documents and shall meet UL requirements for the ratings specified.

4.2.6.5. Wall switches shall be equal to the following:

4.2.6.5.1. Single-pole - Hubbell #1221

4.2.6.5.2. Three-way - Hubbell #1223

4.2.6.6. Receptacles shall be equal to the following:

4.2.6.6.1. Duplex (125 volt, 20 amp, NEMA 5-20) - Hubbell #5362

4.2.6.6.2. Single (250 volt, 50 amp, NEMA 6-50) - Hubbell #9367 (suitable for a transformer oil-filter pump)

4.2.7. Outdoor Voltage / Potential transformers (PT's)

4.2.7.1. Outdoor potential transformers (PT's) connected to the collection system bus must be suitable for use on renewable applications including the ability to withstand frequent reactive power switching events (turning capacitor or reactor banks on and off) causing transient overvoltage conditions.

4.2.7.2. PT's shall meet or exceed the following standards:

a. IEEE C57.13-2016 – IEEE Standard Requirements for Instrument Transformers

b. IEC 61869-3, Clause 7.2.3 – IEC standard – Instrument transformers – Part 3: Additional requirement for inductive voltage transformers

c. CAN/CSA 411.1, Clause 6.6 – CSA standard for AC suspension insulators, clause 6.6 - requirements for basic impulse and fast impulse transient withstand.

4.2.7.3. Approved PT's are ABB type VOG-20BR or Owner approved equal.

4.3. Transmission Hardware

4.3.1. Bolts & Nuts

Bolts and nuts with yield strengths less than 100,000 psi shall be hot-dip galvanized per ASTM A153 and A143 or mechanically coated with zinc in accordance with ASTM B454, Class 50. Bolting materials with yield strengths in excess of 100,000 psi shall not be hot-dip galvanized. Instead, they shall be painted with zinc enriched paint or mechanically coated with zinc per ASTM B454, Class 50.

4.3.2. Approved Manufacturers

See section 3.1 Table 11 for approved Transmission manufacturers. Additional manufacturers may be used upon approval by Owner.

5. Access Roads

5.1. Design

5.1.1. Access road design and construction shall meet the Turbine Supplier's standards and requirements.

5.1.2. Approaches shall be located to meet state and county setback and sight requirements.

5.1.3. Access roads shall have an orthogonal orientation and be installed along existing fence lines, section lines, or property lines, etc., wherever possible.

5.1.4. To establish the proper road base, access roads shall be designed and constructed in a manner to allow all delivery and construction vehicles access to the turbine sites under their own power without being assisted by another tow vehicle.

5.1.5. Access roads shall be designed and constructed such that all uses during construction produce a maximum rut depth of 3 inches. Roadways shall also be maintained by Contractor in acceptable condition for a standard 2-wheel drive ½ ton class truck to safely navigate the entire road to perform site inspections.

5.1.6. Road design and construction shall consider water runoff patterns that will exist after construction is complete such that road material will not wash into fields or block, restrict, or divert water flow during heavy rains. Low water crossings shall be installed where drainage patterns cause focused water to flow over the road. The turbine access roads shall match existing grades.

5.1.6.1. Contractor shall address locations where access road washouts are observed during construction by regrading or installing an approved water crossing. The option to regrade or install a water crossing shall be done with Owner approval with the intent to meet the requirements in Section 5.1.6 and this Specification.

5.1.6.2. See Section 4.1.1.4 for acceptable low water crossing material.

5.1.7. Low water crossings shall be used in lieu of permanent culverts wherever possible. Permanent culverts shall only be installed upon Owner approval.

5.1.8. Permanent culverts shall be installed per the manufactures recommendations. The area where culverts are to be installed shall be cleared and grubbed. Organic materials shall be removed and replaced with recommended bed material. Culverts shall not be placed on frozen material. Fit, match, and lay the pipe to form a smooth, uniform conduit. Culverts shall be installed at the flow line and have a minimum cover over culverts of 12 inches.

5.1.9. Access road placement shall consider construction activities such as foundation excavations. In the event that construction activities damage access road base or subgrade, the road shall be replaced to a like-new condition meeting all applicable access road construction and testing requirements in the design documents and this Specification.

5.2. Civil/Grading

5.2.1. All grading shall conform to county grading ordinances, storm water permit requirements and other Applicable Laws and Applicable Standards pertaining thereof.

5.2.2. Contractor shall perform the grading work, including the exercise of sufficient supervisory control during construction, to ensure compliance with all plans, specifications, and codes.

5.2.3. Contractor shall meet or exceed all recommendations in the Geotechnical report.

5.2.4. Top soil shall be stripped to a depth equal to the final road thickness, including cap material, such that the final road and field elevations are equal.

5.2.5. Tree branches overhanging the drive zone of the access road shall be trimmed back to the edge of the access road.

5.2.6. Contractor shall utilize cement stabilization for all access roads with silty or clay subgrades. Alternate road design based on the recommendations of the site specific Geotechnical Report may be used upon Owner approval. The road base coarse material thickness shall be adjusted to accommodate construction traffic and to meet all other requirements as specified in the Agreement.

5.2.6.1. Cement stabilization shall be installed according to design documents, manufacturer's recommendations, and Section 2.2 of this Specification as required.

5.2.7. Roadway locations shown on maps may be altered to avoid sensitive vegetation. As-built drawings conforming to Section 1.3 shall be provided upon completion to reflect road and turbine pad modifications made during construction.

On-site access roads shall be restricted from use by the general public. Signs at all entrances shall indicate "NO TRESPASSING, AUTHORIZED PERSONNEL ONLY. DANGER - WIND TURBINES". Sign size, content, location, etc. shall be approved by Owner prior to installation. The signs shall have metal posts and the integrity of the sign shall be designed to withstand all seasonal and earthly elements including but not limited to sun, wind, snow, ice, rain, acidic soils, etc. The sign shown in Figure 1 is as an example of a sign meeting the aforementioned requirements.

Figure 1: On-site access road sign example (post to be changed to metal).

5.2.8. Turbine access roads shall extend to the tower access door. The road surface area shall be sufficient for a maintenance truck to complete a 3-point turn or provide the maintenance truck a path to travel completely around the wind turbine.

5.2.9. A rock ring shall be installed around the base of each turbine to create a smooth drivable surface; the depth shall be a minimum of 6 inches. Rock ring material shall be equivalent to that used for the access roads or Owner approved alternative. A layer of geogrid or geotextile must be placed underneath the 6 inches of aggregate. Upon Owner approval, geogrid or geotextile use can be omitted if the subgrade is sufficiently adequate that the desired performance can be achieved without its use.

5.2.10. The rock ring shall extend a minimum 20 ft. from the pedestal face.

5.2.11. The rock ring shall extend beyond all ground mounted equipment associated with the turbine and be wide enough to allow a 1-ton, 4-door, long box utility truck to drive on the rock ring around the turbine.

5.2.12. See Section 2 for additional civil construction requirements.

5.3. Structural

This section is intentionally left blank.

5.4. Electrical

This section is intentionally left blank.

5.5. Submittals

5.5.1. Contractor shall submit to Owner all QA/QC plan records, all testing and inspection results, compaction test results for road base material, including location, dry density and moisture content.

5.5.2. Contractor shall submit to Owner grain size analysis test results for road base material, including location and moisture content.

5.5.3. Contractor shall submit to Owner copies of all completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan, the Design Documents and in Section 13.1.

5.5.4. See Section 1.3 for more submittals information.

6. Wind Turbine Generator Foundations

6.1. Design

6.1.1. Foundations shall be designed by a Professional Engineer experienced with wind turbine generator foundation design.

6.1.2. Foundation design shall accommodate all requirements outlined by the Turbine Supplier.

6.1.3 Foundation design shall be supplemented by Certification Agency Guidelines and other international codes deemed better suited for a particular design aspect.

6.1.4 Foundations shall be designed or evaluated for ultimate limit states, serviceability and fatigue limit states.

6.2. Civil/Grading

6.2.1. Foundations shall be positioned within the vertical and horizontal tolerances identified in the Design Documents and all relevant construction codes and standards, permits, and offset requirements.

6.2.2. See Section 2 for additional civil construction requirements.

6.3. Structural

6.3.1. All fill shall meet requirements outlined in Section 2.1.9.

6.3.2. Wind Turbine Foundation Anchor Bolts and Embedment Plate

6.3.2.1. The final engineered dimensional tolerances shall be adhered to for all installations.

6.3.2.2. Use a template ring to set anchor bolt plumbness and position. Ensure the template ring is set in accordance with the specified construction tolerances or within industry standard tolerances.

6.3.2.3. Place and level the embedment ring in accordance with the specified tolerances or within industry standard tolerances. Insure the embedment ring is properly anchored to prevent movement.

6.3.2.4. After placement of concrete and at the final elevation, seal the space between the anchor bolt and the anchor bolt sleeve to prevent water from entering the sleeve annulus prior to setting of tower and grouting of baseplate.

6.3.2.5. After setting of the lower tower section and grouting the baseplate anchor bolts shall be tensioned according to the specified tensioning procedure to a force as specified in the final design. The tensioning device for the anchor bolts should be calibrated in accordance with the approved procedure described in the Project Quality Assurance Plan on a regular basis to insure required tensions are achieved.

6.3.3. See Section 2 for additional civil construction requirements.

6.3.4. See Section 2.6 for additional concrete work details.

6.4. Electrical

6.4.1. Foundation grounding and conduit layout shall meet all Turbine Supplier requirements.

6.5. Submittals

6.5.1. Documentation from the Structural Engineer of record confirming that they have reviewed the testing and inspection records and that the work was performed in conformance and compliance with the Design Documents. The review does not relieve the Contractor of the work due to errors contained in those documents.

6.5.2. Excavation, Backfill & Compaction

6.5.2.1. Grain size analysis, natural moisture content and modified proctor maximum dry density test data for common fill soil materials.

6.5.2.2. Compaction test results indicating location of test, dry density and moisture content of placed fill.

6.5.2.3. Copies of all completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan and the Design Documents.

6.5.3. Cast-In-Place Concrete & Steel Reinforcing

6.5.3.1. Final mix design shall meet the concrete specification certified by the professional engineer of record.

6.5.3.2. Aggregates used for concrete shall be tested to determine the potential for deleterious alkali-aggregate reaction (ASR).

6.5.3.3. Product data for admixtures including aggregates, cements and other additives in the concrete mix. Curing of concrete shall be per the latest ACI standards of practice/recommendations.

6.5.3.4. Mill certification reports for the reinforcing steel confirming the grade and strength of the reinforcing steel used on the Project is as specified in the Design Documents.

6.5.3.5. Quality control field tests of air content, slump, and concrete cylinder strength test results.

6.5.3.6. All completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan and the Design Documents.

6.5.4. Anchor Bolts and Embedment Plate

6.5.4.1. Product data for anchors and hardware.

6.5.4.2. Mill certificates for anchors indicating the yield strength.

6.5.4.3. Mill certificates for the embedment ring indicating the material meets the minimum strength requirements.

6.5.4.4. Tension test data for anchor bolts that are tested indicating bolt location and tension value.

6.5.4.5. Copies of all completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan and the Design Documents.

6.5.5. Grout

6.5.5.1. Manufacturers' product data for grout.

6.5.5.2. Grout cube strength test results.

6.5.5.3. All completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan and the Design Documents.

6.5.6. Miscellaneous Concrete Embedments

6.5.6.1. Documentation stating that electrical conduit and grounding grid have been installed in accordance with the turbine manufacturer requirements.

6.5.6.2. All completed forms and documentation of all tests and inspections described in the Project Quality Assurance Plan and the Design Documents.

6.5.7. See Section 1.3 for more submittals information.

7. Collection

7.1. Design

7.1.1. This section is intentionally left blank.

7.2. Civil/Grading

7.2.1. Grading

7.2.1.1. See requirements detailed in Section 2 of this Specification.

7.2.2. Underground Power Cable Installation

7.2.2.1. Medium voltage cables shall be pulled into the project substation and tied off to the termination structure with a Kellems grip, or equivalent.

7.2.2.2. Contractor shall use a minimum cable insulation rated 100% (345 mil).

7.2.2.3. Contractor shall obtain all necessary permits for road bores or trench crossings.

7.2.2.4. Preparation

7.2.2.4.1. The minimum bending radius of primary cable is twelve (12) times the overall diameter of the cable. The minimum bending radius of secondary and service cable is eight (8) times the overall diameter of the cable. In all cases the minimum radius specified is measured to the surface of the cable on the inside of the bend. No cable bend shall be made within six (6) inches of a terminal base. In all cases the bending radius of a cable shall not be less than the manufacturer's recommendation.

7.2.2.4.2. All exposed ends of conduit shall be plugged during construction to prevent the entrance of foreign matter and moisture into the conduit. Burrs or sharp projections, which might damage the cable, shall be removed. Riser shield or conduit shall extend at least eighteen (18) inches below grade at all riser poles or as shown on the drawings. If full round conduit is used as a riser shield, an end bell shall be installed on the lower end to prevent damage to the cable.

7.2.2.4.3. Each cable in a switch, sectionalizing cabinet, transformer, etc. shall be identified by circuit number, phase and location of the opposite end with permanent plastic or corrosion resistant metal tags. Close to each cable termination, Contractor shall also mark the cable termination phase designation on the cabinet.

7.2.2.4.4. At each junction box or turbine pad mount transformer, a minimum of 10 feet of slack cable shall be coiled in the transformer vault or buried as close as possible if a vault is not used.

7.2.2.5. Direct Burial Installation of Cables

7.2.2.5.1. No trench shall be left open overnight.

7.2.2.5.2. Cable burial depth shall meet the more stringent of the design requirements or Conditional Use Permit requirements. Communication cable shall be buried at the same depth as the power cable, except in the case when the turbine manufacturer requires that ground cable be buried above power cable. In that case, the communication cable shall be buried at the same level as the ground cable.

7.2.2.5.3. A minimum bend radius of twelve (12) times the outside diameter of the cable shall be followed.

7.2.2.5.4. Cable separation distance shall be maintained at all times as specified by the product documentation and the Design Documents.

7.2.2.5.5. Sufficient slack shall be left at all risers, transformer pads, pedestals, splices and terminal points so that movement of cable after backfilling will not cause damaging strain on the cable or terminals. Cable slack length at splices shall be of sufficient length that a failed splice can be repaired.

7.2.2.5.6. All debris including sharp objects, rocks larger than 6 in., and organics shall be removed from the fill before placing it back in the trench. Prior to trenching, organic topsoil shall be removed / scraped away. Removed, non-organic soils shall be installed back into the trench first. Organic soils are to be placed on the top of the trench only over the non-organic soil. Care must be taken to avoid contaminating the non-organic soils with the organic topsoil or the cable ampacity calculations may be invalid. Trench backfill shall be compacted to a minimum of 85% compaction to ensure soil achieves designed thermal resistivity values. Cable trenches shall be mechanically compacted six (6) feet minimum from all riser poles, pads, pedestals and terminal points. All disturbed area shall be restored as to not cause ground settling greater than 1” below the undisturbed elevation.

7.2.2.5.7. In the event Contractor chooses to plow, starting and terminating points of the plowing operation shall be installed properly to reduce possible cable damage and to assure sufficient burial depth.

7.2.2.5.8. During the plowing operation, care is to be exercised to feed the cable or wire into the ground through the plow loosely and at minimum tension. Besides using proper equipment and construction methods, supervision shall be furnished at all times at the site of plowing operations to assure compliance with these specifications and the Design Documents.

7.2.2.5.9. Plowing or trenching though any public roads is not allowed.

7.2.2.5.10. If, during the plowing operation, the plow should strike a buried object or rock that would stop the equipment and necessitate removal of the plow from the ground, the plow shall be removed from the ground carefully and, if practical, without backing the plow. If it should be necessary to back the plow to remove it from the ground, the cable shall be uncovered a sufficient distance back for inspection to determine whether the cable or wire has been damaged.

7.2.2.5.11. The cable shall be inspected carefully as it is laid out from the reel to be certain that it is free from visible defects. Every instance of damaged cable observed at any time, whether prior to installation, during installation, or when discovered by test or observation subsequent to installation in plant, shall be immediately called to the attention of Owner. The location of any such repair shall be recorded on the As-Built Drawings and Documentation, along with clear photographs.

7.2.2.5.12. Cable Jacket integrity testing shall be performed on all cable sections to confirm a jacket defect free installation.

7.2.2.6. Splices/Terminations/Connections

7.2.2.6.1. Splices

Cable splices shall be of the pre-molded rubber, cold-shrink type, of the correct voltage rating and shall be installed in accordance with the splice manufacturer’s instructions. Splices that depend solely on tape for a moisture barrier shall not be used.

Electrical Works design shall minimize the number of splices required.

No bends shall be permitted within twenty four (24) inches of the end of a splice.

The cable or circuit numbers and the exact location of all splices shall be noted on the As-Built Drawings and Documentation shall include GPS locations of each splice.

Splicing in ducts is not allowed.

The location of each splice shall be marked with single or stacked locating marker balls.

A marker ball detection device compatible with the marking balls installed shall be provided.

All fibers within a cable shall be splices when completing fiber cable splices.

Cable slack length at splices shall be of sufficient length that a failed splice can be repaired in the future.

7.2.2.6.2. Primary Cable Terminations and Stress Cones

Prefabricated stress cones or terminations shall be installed in accordance with the manufacturer's instructions at all primary cable terminals. They shall be suitable for the size and type of cable that they are used with and for the environment in which they will operate. Any indication of misfit, such as a loose or exceptionally tight fit, shall be called to the attention of Owner. The outer conductive surface of the termination shall be bonded to the system neutral. A heat-shrink or cold-shrink sleeve shall be installed to seal between the body if the termination and the cable jacket.

7.2.2.6.3. Special Precautions for Cable Splices and Terminations

A portable covering or shelter shall be used when splices or terminations are being prepared and when prefabricated terminations are being switched. Since cleanliness is essential in the preparation and installation of primary cable fittings, care shall be exercised to prevent the transfer of conducting particles from the hands to insulating surfaces. Mating surfaces shall be wiped with a solvent such as denatured alcohol to remove any possible accumulation of dirt, moisture or other conducting materials. A silicone grease or similar lubricant shall be applied afterwards in accordance with the manufacturer's recommendations. Whenever prefabricated cable devices are opened, the un-energized mating surfaces shall be lubricated with silicone grease before the fittings are reconnected.

Where cable splices are made, additional cable length (sufficient cable slack) shall be provided to allow for future replacement of failed cable splices. Where cables terminate at padmounted equipment (such as at junction boxes or transformers) with a wiring compartment underneath, a full coil of cable shall be installed before the cable is terminated. This coil (cable slack) will allow for some equipment movement due to frost heave without stressing the cables or the terminations. Additional cable slack shall also be provided where cables terminate at 34.5 KV breakers on the collection system or in the base of the wind tower.

7.2.2.6.4. Secondary and Service Connections

A suitable inhibiting compound shall be used with all secondary and service connections.

All secondary cable connections located below grade or in secondary pedestals shall be made with pre-insulated secondary connector blocks. Diving bells with open terminals, insulating boots or moisture barriers that depend solely on tape are not acceptable.

If the secondary phase terminals are threaded studs, the connection shall be made with a pre-insulated secondary transformer connection block. If the transformer secondary phase terminals are insulated cable leads, connection shall be made with a pre-insulated secondary connector block or with a secondary prefabricated splice when the transformer leads continue directly to the service.

The secondary connections and insulation shall have accommodations for all future and existing service as shown on the plans and specifications.

7.2.2.7. Fault Indicators

7.2.2.7.1. To assist in locating electrical faults during operation, resettable fault indicators shall be installed strategically along each collector circuit, including at each collector circuit branch and junction box, except for 2-way junction boxes. Fault indicators located at junction boxes shall have exterior indication.

7.2.2.8. Tunneling/Boring

7.2.2.8.1. Horizontal boring or jacking for conduits shall be used for crossings under roads, streets, etc. where required. Augers or pneumatic or hydraulic jacks shall be used to install a conduit through an area that may not be trenched (such as a paved road or paved area). The diameter of the hole shall not exceed the diameter of the conduit by more than one (1) inch. Where a gap between the conduit and hole exceeds 1" a thermally conductive, flow-able material shall be added to fill the void around the conduit. Boring a hole utilizing water pressure and washing is not acceptable. PE or HDPE type conduit shall be installed for all tunneling/boring.

7.2.2.9. Cleanup, Disposal and Restoration

7.2.2.9.1. All excess excavated material debris, such as boulders, broken concrete, trees, shrubs, roots, lumber, and any other items resulting from the construction operation, shall be removed and the site restored to its original appearance.

7.2.2.9.2. All areas in which trenching takes place shall be restored to the original condition. This includes gravel, concrete and asphalt surfaces.

7.2.2.9.3. Construction areas shall be de-compacted to a workable condition for farming to the extent practicable and vegetation cover re- established where disturbed by the Work.

7.2.3. Other Collection System Installation

7.2.3.1. Junctions Boxes

7.2.3.1.1. Shall be located near towers, along fence lines, along field edges, along wind farm access roads, near but outside of public road ROW or as approved by Owner. In all cases junction box placement must be accessible to wind farm maintenance personnel via public roadway or access road.

7.2.3.1.2. Shall not be located in wet areas.

7.2.3.1.3. Junction boxes shall be installed level and square to roads.

7.2.3.1.4. Junction boxes shall be installed frequent enough that partial discharge testing of the cables may be performed. The maximum distance between junction boxes or a junction box and other termination shall be 8000 feet.

7.2.3.2. Equipment Pads

7.2.3.2.1. The site for the pad shall be adjacent to but not over the trench. The site shall be cleared of all debris and excavated to the specified depth. Cohesionless soils shall be added to the site and thoroughly compacted. The pad shall be installed level at the specified elevation.

7.2.3.3. Transformers

7.2.3.3.1. Transformers shall be handled carefully to avoid internal damage to the transformer or damage to the finish and shall be positioned in accordance with the plans and specifications. Only qualified and experienced personnel shall be allowed to make connections and cable terminations.

7.2.3.4. Grounding

7.2.3.4.1. All neutral conductors, ground electrodes, and groundable parts of equipment shall be interconnected. All interconnections shall be made as shown in the Design Documents. Ground rods shall be installed at all equipment locations as shown in the Design Documents. All underground ground connections shall be exothermically welded. Clamps shall not be used to make underground ground connections. All grounding shall be copper. Copper clad steel is not allowed without written approval from Owner.

7.2.3.5. Equipment Enclosures

7.2.3.5.1. Excavations for sleeve-type sectionalizing cabinet pads and other below-grade enclosures shall be made so as to disturb the surrounding earth as little as practical. Enclosures shall be installed with side walls plumb and without any panel distortion. When installation is complete, the cover of the enclosure shall not be lower than and not more than two (2) inches higher than specified grade. Soil in the immediate vicinity shall be tamped and sloped away from the enclosure. The excess soil shall be spread evenly over the surface of the ground to the design requirements.

7.2.3.6. Warning Signs

7.2.3.6.1. Each equipment enclosure or junction box shall display a “Caution” sign placed so that it is visible to anyone attempting entry to the enclosure. Also, the equipment inside the enclosure shall display a “Danger” sign so that it is visible when the enclosure is open.

7.2.3.6.2. Cable markers which indicate the presence of underground electrical facilities shall be installed at all road crossing locations. Cable markers shall be fireproof and have the wind farm name, state, and the locating service telephone number clearly written on it.

7.2.3.7. Labeling

7.2.3.7.1. Boxes to be labeled with 4 inch tall reflective letters. Fault indicator displays to be labeled according to what branch of the circuit they are connected to.

7.3. Structural

This section is intentionally left blank.

7.4. Electrical

7.4.1. Design Criteria

7.4.1.1. The collection system shall be designed using data derived from studies required in section 7.5.6.

7.4.1.2. The electrical system shall be designed for a 2.25% maximum calculated power loss at nameplate generation measured from the down tower turbine switchgear to the substation 34.5kV breaker, this equates to an average annual energy loss of less than 2%. Calculations shall be performed and provided to Owner for review of the calculated power loss.

7.4.1.3. The latest adopted edition of the National Electrical Safety Code (NESC), ANSI C2-2017 shall be followed except where Owner standards and/or local regulations are more stringent, in which case the most stringent requirement shall govern.

7.4.1.4. Oil Containment for Oil Filled Transformers

7.4.1.4.1. Transformers shall be placed such that in the event of a leak, the transformer fluid does not flow into an adjacent ditch or waterway. Modify the grading as required so that a transformer fluid leak does not flow into a ditch or waterway. Should these spill control measures not be available, then a containment system shall be provided. The containment system should be a passive system designed to contain 110% of the transformer fluid, and a 25 year rain -24hr event. The containment shall be designed to allow for water to flow through the containment (not accumulate), but contain the oil.

7.4.2. Feeder Capacity

7.4.2.1. Wind farms shall adhere to approximately 25MW per feeder cable, two feeder cables per breaker (unless state/local jurisdiction is more stringent), up to 8 feeders. This requirement can accommodate 200MW which is approximately the typical maximum for a substation transformer. Where more than one feeder is on a breaker, each feeder shall be on its own disconnect (to allow isolation of each feeder from the collection bus).

7.4.3. Feeder Grounding

7.4.3.1. Grounding breakers are not an acceptable form of grounding a feeder following disconnection of the feeder from the substation (feeder breaker opening) and shall not be used.

7.4.3.2. Grounding transformers shall be sized to keep the collection feeder voltage rise during a fault to an acceptable level as determined in the Collection System Transient Temporary Overvoltage study. Standard grounding transformer ratings are 2500 KVA, 34,500V Wye Primary, 480V Delta secondary, 3.57% impedance. Alternate ratings to be approved by Owner.

7.4.3.3. An analysis of the maximum transient overvoltage along the feeder collection circuits under a fault shall be performed to determine the appropriate ratings and placement of the grounding transformers on the collection circuits. The collection circuit cable side of each breaker shall contain at least one grounding transformer, and each grounding transformer shall be interchangeable with another. The analysis shall be provided to Owner for review.

7.4.3.4. The preferred grounding transformer location is within the fenced area of the substation.

7.4.3.5. Single line to ground fault current sourced from the substation main power transformer may be limited by placing a neutral grounding reactor between neutral and ground on the 34.5 KV side of the main power transformer that steps the voltage in the substation from the collection system voltage of 34,500V to the transmission level voltage.

7.4.3.6. Station class arrestors shall be placed on each feeder at the substation, and along the collection circuit at the end of each string, and as needed between to limit the voltage rise during fault conditions, or other events that can cause transient overvoltages.

7.4.4. Power Factor Compensation Equipment

7.4.4.1. Power factor compensation equipment shall be utilized if studies indicate it is needed to meet the interconnect agreement. The means of power factor compensation and its control shall be reviewed and approved by Owner.

7.4.4.2. The preferred location of power factor compensation equipment is on the low voltage side of the main power transformer, unless otherwise required by the Interconnection Agreement.

7.4.5. Turbine Grounding

7.4.5.1. The turbine grounding grid shall be designed to comply with the requirements of the Turbine Manufacturer, the NEC (National Electrical Code), NESC (National Electrical Safety Code), and IEEE/ANSI standards.

7.4.5.2. The ground grid shall be of copper construction. Equidistant rings shall be interconnected a minimum of every 90 degrees.

7.4.5.3. All ground grid interconnections shall be exothermic weld-type connections, unless otherwise specified by the Turbine Supplier and approved by the owner. The ground rings shall include multiple connections to the rebar in the foundation, and the steel on the tower of the turbine.

7.4.6. SCADA

7.4.6.1. Contractor shall install and terminate the communication cable and SCADA equipment for the Project as per the Turbine Supplier's specifications and drawings.

7.4.6.1.1. All fiber optic cable fibers shall be terminated.

7.5. Submittals

7.5.1. Collection System One-Line

7.5.1.1. Drawing depicting turbines connected via the collection cable system, showing placement of fault indicators, step up transformers, feeder breaker, feeder cable lengths, feeder cable sizes, trench or plow designation for each feeder cable segment, and junction box locations.

7.5.2. Layout and Section Views

7.5.2.1. Topographic layout showing land route of cable and feeder designation, junction boxes, substation location, turbine names/numbers, transmission line, and other geographic features such as street names or wetlands. Background image shall be provided. Section Views shall show similar features but at a close up view such as a square mile.

7.5.3. Cable Installation Details

7.5.3.1. Typical Trench showing placement of fiber, ground, and triplex 35kV cable.

7.5.3.2. Cable MV Splice and Junction Box with associated materials.

7.5.3.3. Directional bore due to utility, pipeline, or wetland crossing.

7.5.4. Wind Turbine Conduit and Grounding

7.5.4.1. Show route and conduit placement of conduit between step up transformer into wind turbine through anchor bolts.

7.5.4.2. Show ground rings and connections to tower, foundation steel, and transformer.

7.5.5. Equipment Details

7.5.5.1. Additional equipment such as fiber splice boxes, bollards, etc.

7.5.6. Collection Studies

7.5.6.1. Medium Voltage Cable Ampacity – The purpose of the cable ampacity study is to confirm that the calculated cable ampacity is greater than the load on any given cable in the collection system. Study must include thermal modeling of the cable in the soil, developed using CYME CYMCAP. Factors to consider in the study include but are not limited to:

- Historical Ambient Soil temperature data
- Historical Soil Moisture content data
- Air temperature data
- Maximum rated conductor temperature
- Critical soil interface temperature
- Measured maximum soil temperature
- Measured native in-situ thermal resistivity
- Native soil dried-out thermal resistivity
- Laboratory determined compacted soil thermal resistivity
- Compacted soil dried out thermal resistivity
- Load factor
- Conductor installation arrangement (Trefoil, etc.)
- Conductor burial / bore depth
- Concentric Neutral conductor ampacity
- Number and spacing of adjacent cables
- Heating effect from adjacent cables

Testing of the soil to determine its thermal resistivity characteristics shall be performed using the methods defined in IEEE standard 442 (IEEE Guide for Soil Thermal Resistivity Measurements). Sufficient soil sample locations shall be taken to account for variation in soils encountered at a site. Statistical analysis of the samples may be performed and statistical outliers eliminated from the population of soil samples. No laboratory adjustment of the soil moisture content is allowed to maximize the dry density of compacted soil in the laboratory. Soil samples shall be taken at depths that are representative of the installed depth of the soil and at depths between the installed depth and grade.

Soil moisture content assumptions in Cymcap shall be based upon:

- Available historical soil water content data.

- Soil water content measurements determined in the laboratory during testing of the soil thermal resistivity characteristics.
- Soil water content data used in Cymcap shall account for seasonal variation in soil moisture and drought conditions.

When cables are installed using trenching methods, the 85% or greater compacted soil that is placed above the cables in the trench area is assumed to have thermal resistivity characteristics (heat transfer capabililties) that are no better than the native soil. Where soil thermal resistivity testing shows the compacted soil has worse heat transfer properties than the native soil, the laboratory test heat transfer results shall be used for the soil in the trench areas in modeling the compacted soil using Cymcap.

Thermal modeling of the cable in the soil shall account for dryout of the soil in the vicinity of the cable and the associated decrease in the ability of the soil to dissipate the heat that is generated by the cable.

The CYMCAP calculated cable ampacity shall be derated to account for installation variation of the placement of the cables into the soil. Installation variation increases the circulating currents that flow in the concentric neutrals. Ampacity derate factors shall be as follows:

- Trefoil installation, 1000 KCMIL or greater 0.95 derate (5% reduction in CYMCAP calculated cable ampacity).
- Trefoil installation, 750 KCMIL, 0.98 Derate (2% reduction in CYMCAP calculated cable ampacity).

Note that the organic top soil is required to be removed prior to trenching and must be kept separate and not mixed with the organic free native soils. The organic free native soils are to be placed into the trench first followed by the organic top soils placed into the trench last. If the organic soils are mixed with the non-organic soils, additional derating of the cables is required, and the installation may be rejected by the owner.

7.5.6.2. Reactive Power Control analysis – The purpose of the reactive power control analysis is to develop the logic for use by the wind turbine manufacturer to signal when each reactive power source (switched capacitor, switched reactor, or static var compensation) should be turned on or off in coordination with the reactive power supplied by the wind turbine generators. Information used in determining the logic include items such as:

- The voltage schedule letter.
- The voltage flicker limitations identified in the Reactive Power study.
- Generation Interconnect agreement and FERC 827 power factor requirements.

- Reactive power capability curves for the wind turbine generators.
- Dynamic model of the system if needed to model the impact of reactive power switching.

The end results of the study are the parameters / inputs required for the wind turbine manufacturer and it's controller to coordinate with the other available reactive power sources (switched capacitors, switched reactors, static var compensation). Parameters supplied from the study typically include (Vestas in example below):

- Voltage Droop profiles (% Droop; % Deadband; QMax; Qmin)
- Reactive Power Switching Parameters (Switch in %; Switch Out %)
- Reactive Power Switching time delay (Switch in delay; Switch out delay)
- POI Power Factor limits (Leading PF limit; Lagging PF limit)

7.5.6.3. Insulation coordination study – The purpose of the insulation coordination study is to ensure the insulation coordination requirements have been met per IEEE Std. C62.22-2009.

7.5.6.4. Power Loss Study– The purpose of the Power Loss Study is to calculate the power loss of the collection system, substation, and transmission line as a percentage of the total wind turbine production. The Collection system power loss calculations include the nacelle transformers and down tower power cable, to the 34.5 kV bus at the wind farm substation/switching station. Shall be developed in Easypower or owner approved equal. The study results should confirm that the collection system power losses at 100% output are less than 2.25% at 100% wind turbine production.

7.5.6.5. Short Circuit – The purpose of the fault current analysis and coordination study is to determine the maximum fault current on each section of cable or conductor in the collection system and determine the maximum amount of time the conductor can withstand the fault before the cable is damaged. The study shall be developed in Easypower.

7.5.6.6. Collection System Transient Temporary Overvoltage. The collection system transient temporary overvoltage study is developed with a digital simulation program that models transient voltages and currents on the wind farm collection system. Study is develop using EMTP (Electromagnetic and Electromechanical Transients Program by EMTP Alliance) or similar.

a. The purpose of the transient temporary overvoltage study is to determine the minimum KVA rating of the grounding transformer needed to limit the temporary overvoltage on the 34.5 KV collection system following the substation feeder breaker opening during a single line to ground fault on a substation feeder. The study shall verify the ratings of the Xcel typical grounding transformer rating (2500 KVA, 3.57% Impedance) as suitable for the system
b. The study shall also be used to select the MCOV (Maximum Continuous Operating Voltage) rating for the surge arresters installed on the collection system. When selecting the arrester MCOV (Maximum Continuous Operating Voltage) rating, both the highest transient overvoltage and the highest temporary overvoltages shall be considered. The system model shall determine the highest voltage that occur on the un-faulted phases for a single line to ground fault along the collection system.
c. The highest transient overvoltage typically occurs within 3 cycles of either the fault occurring or the substation feeder breaker opening to clear the fault. Minimum MCOV rating = Peak Transient Overvoltage / (1.53 x 1.4142). See IEEE standard C62.22-2009 Figure 12: .02 second overvoltage duration requirement for metal oxide surge arresters on AC systems).

7.5.6.6.1. The arrester shall also be capable of withstanding the temporary overvoltage (voltage following the transient overvoltage while the wind turbine inverters continue to provide power). Minimum MCOV rating = Peak Temporary Overvoltage / (1.30 x 1.4142) (see IEEE standard C62.22-2009 Figure 12: 10 second overvoltage duration requirement for metal oxide surge arresters on AC systems). The transient power simulation study shall be performed using EMTP Power system analysis software and shall confirm that the temporary overvoltage on the collection system due to a fault are acceptable and that any arrestors that operate as a result of a fault are not damaged or overdutied.

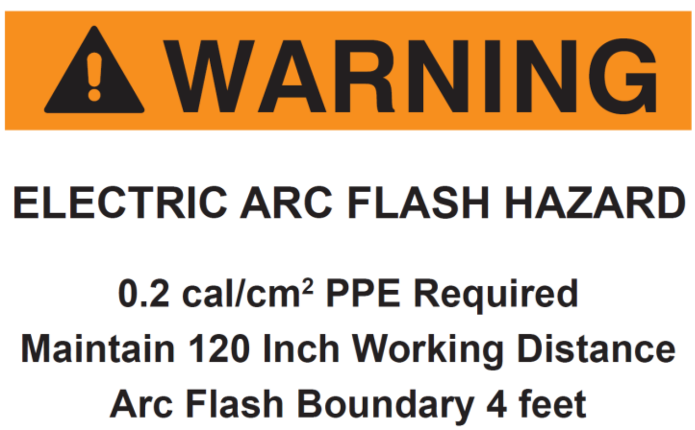
7.5.6.7. Reactive Power Flow – The purpose of the reactive power flow study is to calculate the power factor over a range of plant outputs to ensure the power factor of the wind farm meets the Generator Interconnection Agreement required power factor range while staying within the power factor limitations of the wind turbine. Study shall include the main power transformer On-load Tap Changer settings, and the tap settings required for the wind turbine generator transformers. Developed in an application such as PSSE.

7.5.6.8. Wind turbine Ground Grid – The purpose of the ground grid analysis study is to calculate the touch and step potential and certify that the proposed ground grid will meet or exceed IEEE Std. 80 safety requirements and the Wind Turbine Generators manufactures touch potential requirements. Developed in an application such as CDEGS.

7.5.6.9. Arc Flash – The purpose of the arc flash hazard assessment is to calculate the arc flash incident energy at various points of the wind farm, switchyard and wind turbine under all operating configurations to ensure the worst possible set of results is captured at each location. Applicable standards include current versions of IEEE C2, (National Electric Safety Code), IEEE 1584, and OSHA 1910.269.

7.5.6.9.1. Contractor shall provide the arc flash study for the project. Study shall include the input data, one line model, and study results both in a pdf report form, and also provide the software files for the project (for Owner use in updating the arc flash study in the future). It is preferred that the study be performed used ESA Easy Power software for voltages up to 15 KV. Above 15 KV, ARCPRO software is required.

7.5.6.9.2. Contractor shall supply and install arc flash labels on all applicable equipment enclosures from the substation up through the wind turbines. Outdoor labels shall be weatherproof. Typical label is below:



7.5.6.9.3. For calculations above 15 KV, ARCPRO calculation results must be adjusted to account for three phase arcs in open air or in an enclosure, as required in OSHA 1910.269 Appendix E, Table 3 Notes.

7.5.6.9.4. Working distances used in the arc flash study are indicated in Table 13.

Table 13: Arc flash study working distances.

Class of equipment Working Distance (WD)
480V MCC and Panels - 18”
480V Switchgear – 24”
5KV Switchgear – 36”
15 KV Switchgear – 36”
16 – 36 KV Equipment (enclosed) – 48”
15 KV Equipment (outdoor) – 36”
16-46 KV Equipment -outdoor – 48”
47-72.5 KV Equipment - outdoor -72”
73-169KV Equipment - outdoor - 84”
170-362KV Equipment - outdoor - 120”

7.5.6.10. Harmonic – The purpose of this report is to confirm the wind farm will meet the Generation Interconnect Agreement interconnection harmonic requirements under all configurations of the wind farm and interconnection substation. Upon completion of the wind farm, harmonic measurements shall be made at both the point of interconnection, and the 34.5 KV substation bus to confirm that Generator Interconnection Agreement interconnection power quality requirements and industry standard requirements such as IEEE 519 are met. Harmonic measurements made, and the harmonic report that are prepared are to be per Owner “Guideline for Wind Farm Power Quality Measurement and Report - Rev. B”.

7.5.6.11. Steady State System Analysis – the purpose of this assessment is to determine the load flow and voltage profile along the collection circuit. The load flow at various loads can be used to determine the annual energy loss on the collection circuit. The voltage profile is used to determine that the voltage extremes along the collector circuit are acceptable, and accounted for in modeling by extremes in voltage variation at the point of interconnection, and extremes in Real and Reactive outputs of the turbines.

7.5.6.12. Concentric Shield Wire Induced Voltage Analysis – The purpose of the assessment is to determine the maximum voltage difference between ground and the cable shield. The collection system cables shall have their shields (concentric neutral) grounded on each end of the cable and the maximum shield voltage shall not exceed 25 volts when referenced to ground. An equipment ground conductor (bare copper) shall be routed with each collection system cable.

7.5.7. See Section 1.3 for more submittals information.

8. Transmission

See list of approved manufacturers in Table 11 in Section 3.1.

8.1. Design

8.1.1. Cable Tension Criteria – Cables shall be tensioned to the limits of Table 14:

Table 14: Cable Tension Limits based on NESC Rule 261.H.1.

Weather Parameters						Tension Limits (RBS)		
Case	Wire Temp (°F)	Wind (mph)	Wind (psf)	Ice (in)	Final/ Initial	NESC Limit	XEL Limit AC-SR	XEL Limit AC-SS
NESC Rule 250B	*[SEE FIG 1 & Table 17 FOR VALUES]*				I	60%	40%	50%
NESC Rule 250C	60	90	20.7	0	I	80%	80%	80%
NESC Rule 250D	15	50	6.4	1	I	80%	80%	80%
NESC – Rule 261.H.1.b – Initial	NESC 250 B	0	0	0	I	35%	35%	35%
NESC – Rule 261.H.1.b – Final	NESC 250 B	0	0	0	F	25%	25%	25%

8.1.2. Special loading areas exist throughout the United States and Owner service area, examples such as the higher wind speed areas in southwest Minnesota and along the Colorado foothills may require design limits in excess of those listed in the table.

While the base cases shown in Table 14 account for the majority of these variables, it is the responsibility of the design engineer to intelligently apply and adjust these rules as required by the conditions specific to their project location.

These tension requirements apply equally to both phase conductors and shield wires, both OHGW and OPGW.
Damper Requirements – Stockbridge type dampers are used on conductors that are 0.75·in in diameter and larger. Spiral Vibration Dampers should be used on shield wires and conductors that are 0.75·in in diameter and smaller. The same recommendation applies to OPGW. Stockbridge type dampers are placement sensitive and need to be installed at the optimum position recommended by the manufacturer. The following criteria shall be used to calculate damper need/placement:

8.1.2.1. Terrain Category: Category 1/Open Terrain

8.1.2.2. Direction of Line: Use the direction between dead-ends for each ruling section.

8.1.2.3. Average Annual Minimum Temperature: -20°F for PSCo and NSP Regions and 0°F in the SPS Region.

8.1.3. Bird Diverter Requirements – The Department of Natural Resources (DNR) or the United States Fish and Wildlife Service, in areas of heavy bird traffic, sometimes request installations of bird-diverters to increase the visibility of the wires to the birds. Many varieties of bird-diverters exist; in the absence of a specific permitting requirement, Owner uses a spiral-type bird-diverter, similar to the spiral vibration dampers in design and installation. The additional weight of the bird-diverters shall be considered in the sag-tension calculations.

8.1.4. The FAA or Army Corp of Engineers may require spherical markers to be attached to the top wire of a transmission line to increase visibility of the wire. Markers are installed in spans crossing navigable rivers and where aircraft operate close to the ground. The added weight of the markers must be taken into account in the design of the transmission line.

8.1.5. Spacer Requirements – Spacers shall be used on all horizontal 2-bundle conductor configurations, and in spans of vertical 2-bundle configurations where needed. Spacers shall be placed in intervals recommended by the spacer manufacturer.

8.1.6. Structure Loading Criteria

8.1.6.1. Weather Cases – Table 15 summarizes various weather cases used for design. This table is for use in PLS-CADD. Special projects may need additional weather cases.

Table 15: Weather cases used for structural design.

Notes: Wind pressure, $Q = 0.00256 \cdot V^2$, with Q in psf, and V in mph. Ice density is 57 lbs/ft^3.

Case	Case Description	Wind Velocity (mph)	Wind Pressure (psf)	Wire Ice Thickness (in)	Wire Temp. (deg F)	Wire Wind Height Adjust Model	Wire Gust Response Factor	Final/ Initial
1	NESC Rule 250B	*See Figure 2: NESC Rule 250 B Loading Zones*				None	1	I
2	NESC Rule 250C	*See Figure 3: NESC Rule 250C extreme wind map.*				NESC 2012	NESC 2007	I
3	NESC Rule 250D	*See Figure 4: NESC Rule 250D combined ice and wind map.*				None	1	I
4	Stringing	28	2		See § 3.6	None	1	I
5	Uplift	0	0		See § 3.7	None	1	I
6	Deflection	0	0		See § 3.8	None	1	F
7	Worker Load	750 lb at each wire attachment point (2 workers)						

8.1.6.2. Structure Load Factors – Table 16 summarizes the load cases for new construction at Owner, with the appropriate weather case, structure load factors, and the structure types to which they apply. Additional load cases may be required on a project-by-project basis. These cases may be required for reliability or the performance of the line. Identify any additional load cases in the project design guide.

Table 16: Application of load cases to various structure types.
[1]For PLS-CAD, assume structure weight load factor and wind area load factor are 1.0.
[2]If stringing from a tangent location, the engineer must consider the load case.

Load Case	Case Description	Weather Case	Load Factors[1]			Structure Type			
			Vertical	Transverse	Longitudinal	Tangent Single Pole	Tangent H-Frame	Running Angle (2-45°)	Dead-End Structure (any angle)
1	NESC Rule 250B	1	1.5	2.5	1.65	X	X	X	X
2	NESC Rule 250C	2	1.0	1.0	1.0	X	X	X	X
3	NESC Rule 250D	3	1.0	1.0	1.0	X	X	X	X
4	Anti-Cascading	Greatest of 1, 2, or 3	1.1	1.1	1.1				X
5	Construction	6 and 8	1.0	1.0	1.0	[2]	[2]	X	
6	Uplift	7	1.0	1.0	1.0		X	X	X
7	Deflection	5	1.0	1.0	1.0			X	X

8.1.6.1. Load Cases

8.1.6.1.1. Load Case 1 – NESC Rule 250B

Owner territory is currently located in the NESC Heavy and Medium loading zones. For loading maps, use Figure 2 and Table 17. Apply loading based on the zone the line is located. If a line is located within more than one zone, the project team must agree to appropriate loading at the beginning of the project.

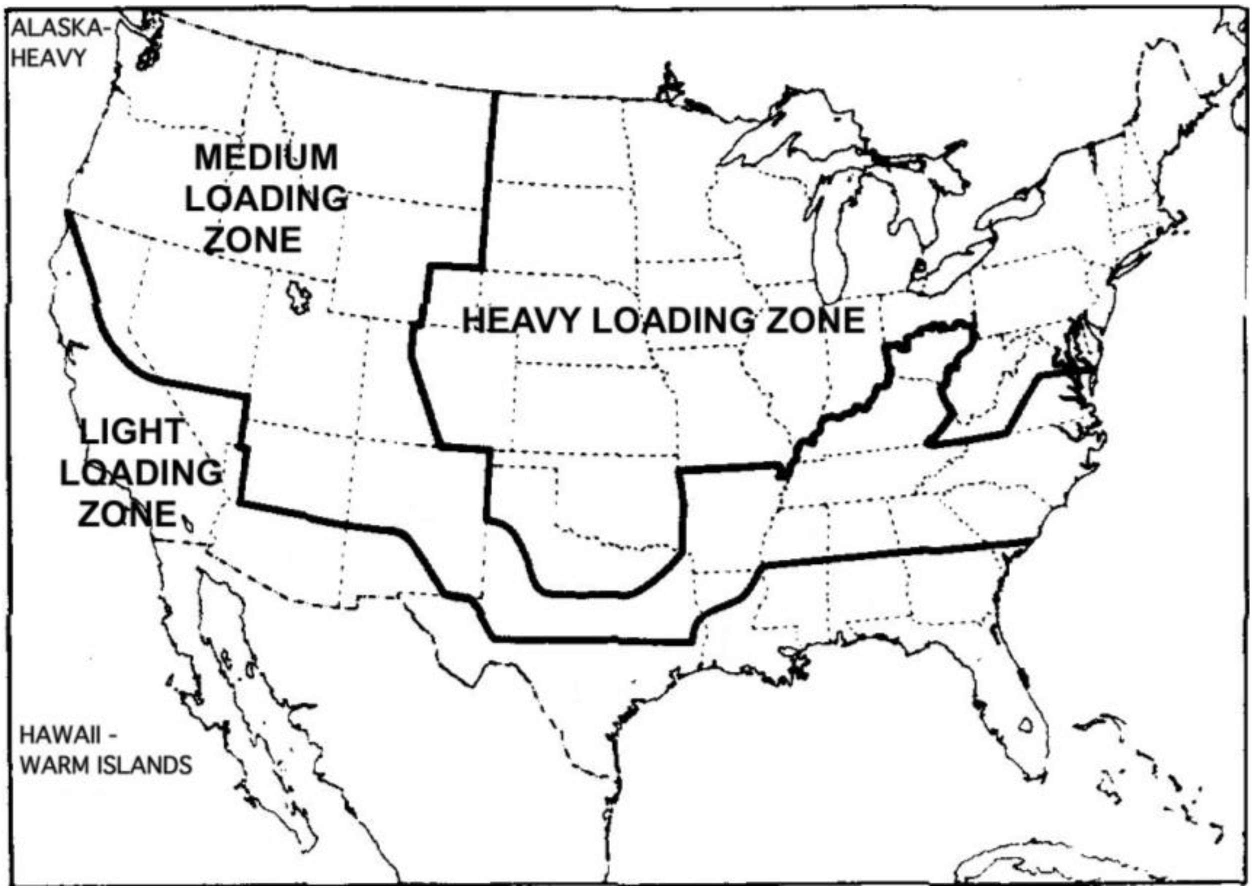


Figure 2: NESC Rule 250 B Loading Zones

Table 17: Weather parameters for use with NESC Rule 250B Loading

	Heavy	Medium	Light
Radial thickness of ice (in.)	0.5	0.25	0
Horizontal wind pressure (lb/ft^2)	4	4	9
Temperature (°F)	0	+15	+30
"k-factor" (lb/ft)	0.30	0.20	0.05

8.1.6.1.1. Load Case 2 – NESC Rule 250C

This load case is for an extreme wind case. For wind maps, see Figure 3. If a line is located in more than one zone, the project team must agree to appropriate loading at the beginning of the project.

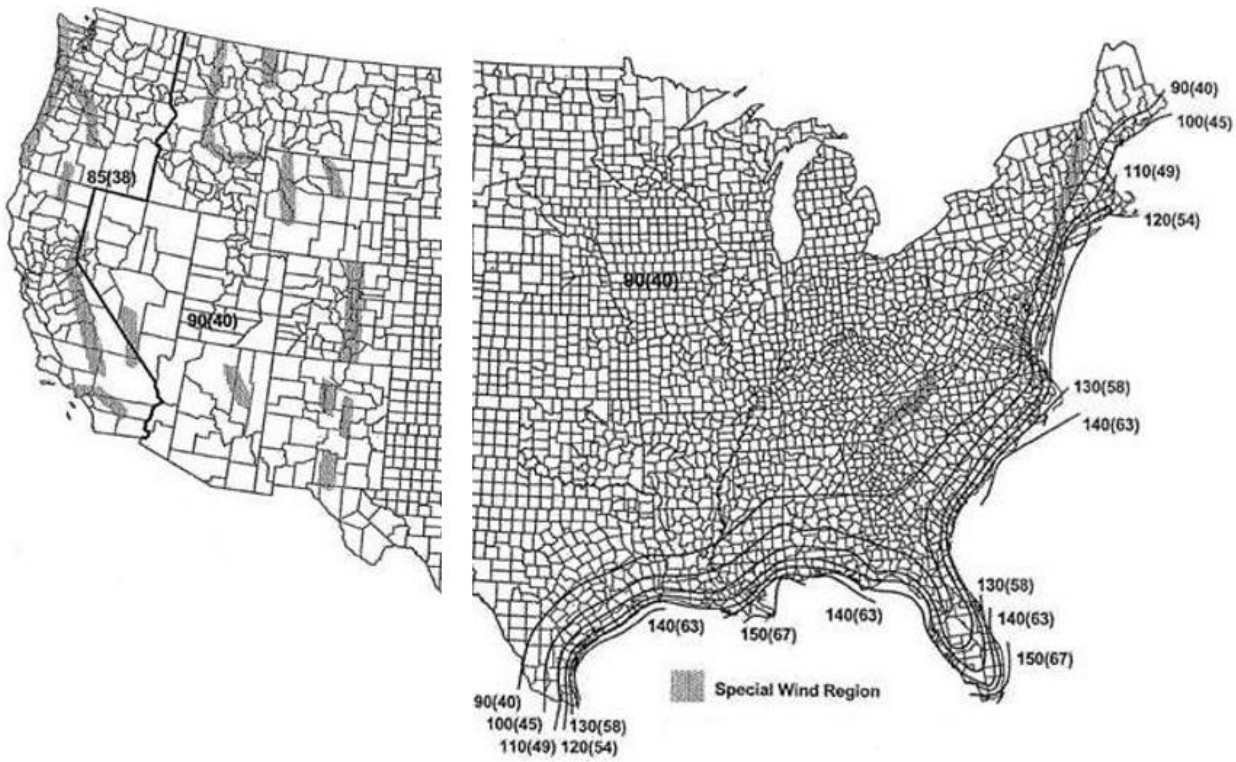


Figure 3: NESC Rule 250C extreme wind map.

8.1.6.1.2. Load Case 3 – NESC Rule 250D

The wind and ice conditions of NESC Rule 250D vary greatly across Owner territory. For ice and wind maps, see Figure 4. The project team at the beginning of the project must agree to the design values.

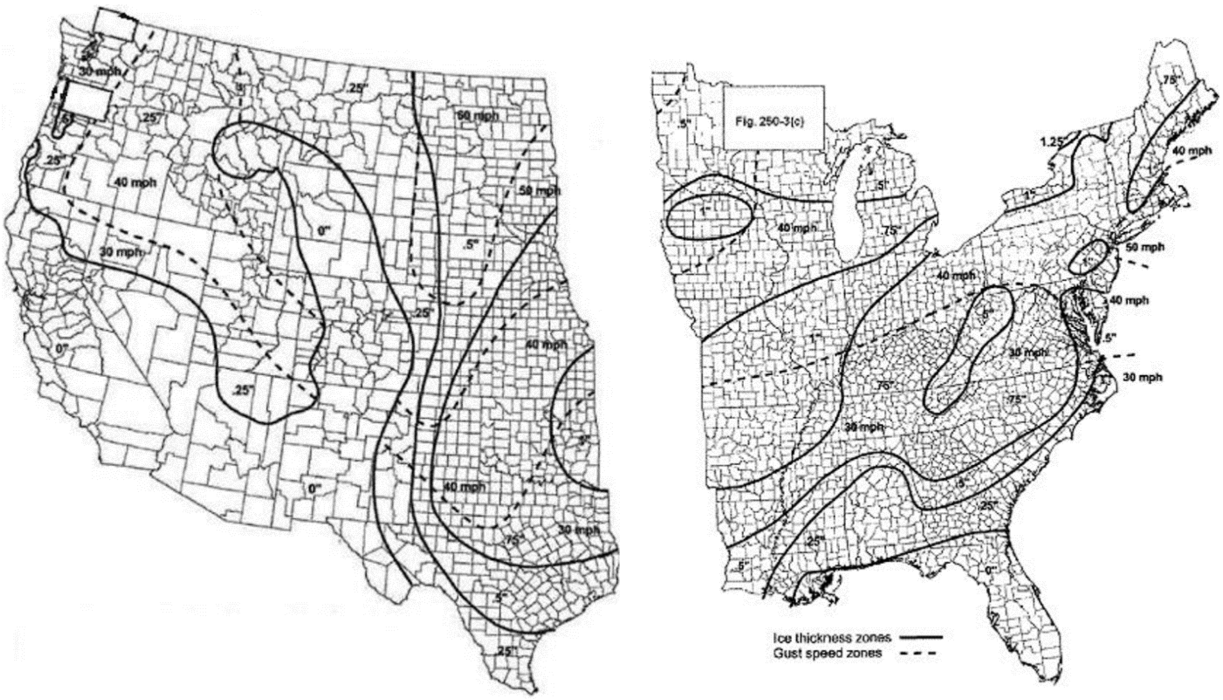


Figure 4: NESC Rule 250D combined ice and wind map.

8.1.6.1.3. Load Case 4 – Anti-Cascading

The design engineer shall check all terminal dead-ends for terminal loading. Terminal loading consists of all wires removed in the ahead or back direction. The loading condition is NESC Rule 250B, with all appropriate load factors. To limit cascade damage, the line segment between terminal dead-ends or anti-cascading dead-ends shall not exceed 5 miles.

8.1.6.1.4. Load Case 5 – Construction Loads

The design engineer must determine where the conductor will enter a puller, or where conductor will enter a tensioner, and where construction will snub a conductor to anchors. (See IEEE 524 for more discussion of the stringing process.) When this is determined, the engineer must ensure that the structure can take the additional vertical load.

The conductor tension must be the highest expected to be seen during stringing operations -20·°F with a 2psf wind. The design engineer shall assume construction will apply the conductor tension at a 1:1 slope. Snub loads shall be applied to sub-conductors of a phase simultaneously.

8.1.6.1.5. Load Case 6 – Uplift

All suspension attachment hardware shall be designed with no net uplift, including line posts and braced line posts.

A minimum positive vertical loading of 50 pounds per attachment is required. The temperature for uplift analysis is defined as -20°F. Uplift is allowed for strain attachments (non-terminal dead-ends) and line posts with clamp top connections.

8.1.6.1.6. Load Case 7 – Deflection

The design engineer shall use annual average temperature with no wind to determine deflection. The temperature for deflection analysis is defined as 60°F. For tangent structures (angle < 2°), there is no deflection limit, for angle structures, and dead-end structures the deflection limit is 2% of pole height at pole top, poles may be cambered to fall within the limit. Deflection loading does not apply to round wood pole or guyed structures. These requirements are aesthetic only.

The design engineer must maintain adequate clearance to the right-of-way edge while including structure deflection. For initial span and right-of-way determinations prior to selection and modeling of structures, consider the following for estimating purposes:

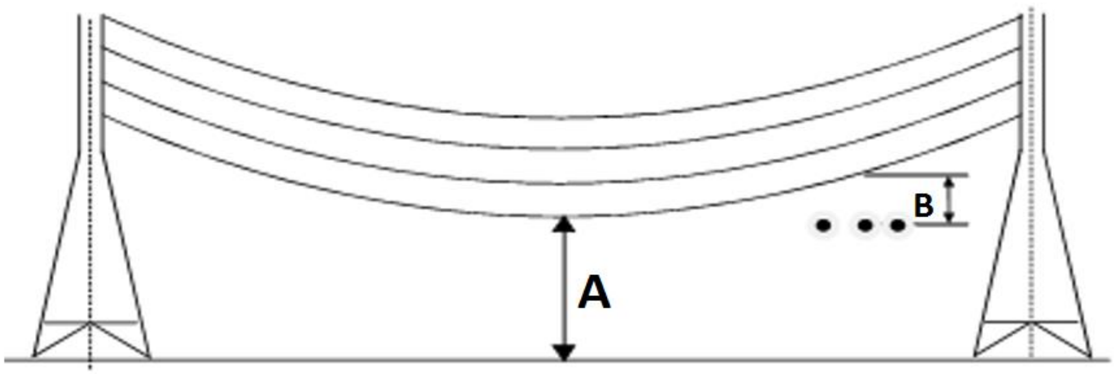
Under NESC Rule 250C (special wind zone regions apply), and conductors at final sag, the structure deflection should be limited to 8% of the structure height, assumed linear for conductor attachments below the top of pole.

Under NESC Blowout, structure deflection should be limited to 4% of the structure height, assumed linear for conductor attachments below the top of pole.

Once the design engineer selects the final structures, the engineer must check clearances including structure deflection to the edge of the right of way while including structure deflection.

Switch structures are limited to a maximum of 1% deflection under NESC 250B weather conditions without load factors.

8.1.7. Vertical and Horizontal Wire Clearance Requirements – Elevation adders per NESC 232-C1(b) shall be added for elevations above 3,300 feet above mean sea level. See Figure 5 through Figure 9. *Add in language to point to what height to use, NESC or Xcel standard.* .



DIM	NATURE OF SURFACE UNDERNEATH WIRE, CONDUCTORS OR CABLES	MINIMUM DESIGN CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR NUMBERS IN (##) ARE NESC CODE VALUES (Section 232)								
		NEUTRAL & COMM	**34.5kV & Below**	**69kV**	**88kV**	**115kV**	**161kV**	**230kV**	**345kV**	**500kV**
A	Track rails of railroads (except electrified railroads using overhead trolley conductors) *NOTE: Check with RR owners*	23’-6” (23’-6”)	31’-6” (26’-6”)	32’-3” (27’-3”)	31’ (27’-6”)	31’ (28’-1”)	32’ (29’-0”)	33’ (30’-5”)	36’ (32’-9”)	39’ (35’-11”)
A	Roads, Streets, driveways, parking lots, alleys and all other land traversed by vehicles, such as agricultural and forests	18’-0” (15’-6”)	23’-6” (18’-6”)	24’ (19’-3”)	25’ (19’-6”)	25’ (20’-1”)	26’ (21’-0”)	27’-7” (22’-5”)	30’ (24’-9”)	33’-8” (27’-11”)
A	Spaces and ways subject to pedestrian or restricted traffic less than 8ft high	9’-6” (9’-6”)	19’-6” (14’-6”)	20’-2” (15’-3”)	25’ (15’-6”)	21’-2" (16’-1”)	22’-1” (17’-0”)	23’-6” (18’-5”)	26’ (20’-9”)	29’-7” (23’-11”)
A	Water areas not suitable for sail boating or where sail boating is prohibited	14’-0” (14’-0”)	22’ (17’-0”)	22’-7” (17’-9”)	25’ (18’-0”)	23’-7” (19’-1”)	24’-6” (19’-6”)	23’-7” (20’-11”)	28’ (23’-3”)	32’-2” (26’-5”)
Water areas suitable for sail boating including lakes, ponds, reservoirs, rivers, streams and canals with unobstructed surface area as follows (Water Level shall be a 10-year normal flood level or as directed by the Corp of Eng).		**NEUTRAL & COMM**	**34.5kV & Below**	**69kV**	**88kV**	**115kV**	**161kV**	**230kV**	**345kV**	**500kV**
A	a. Less than 20 acres	17’-6” (17’-6”)	25’-6” (20’-6”)	26’-2” (21’-3”)	25’ (21’-6”)	25’ (22’-1”)	26’ (23’-0”)	30’ (24’-5”)	32’ (26’-9”)	35’-8” (29’-11”)
A	b. 20 to 200 acres	25’-6” (25’-6”)	33’-6” (28’-6”)	34’-2” (29’-3”)	31’ (29’-6”)	31’ (31’-0”)	31’ (31’-0”)	33’ (32’-5”)	35’ (34’-9”)	38’ (37’-11”)
A	c. 200 to 2000 acres	31’-6” (31’-6”)	39’-6” (34’-6”)	40’-2" (35’-3”)	37’ (35’-6”)	37’ (26’-1”)	37’ (37’-0”)	39’ (38’-5”)	41’ (40’-9”)	44’ (43’-11”)
A	d. Over 2000 acres	37’-6” (37’-6”)	45’-6” (40’-6”)	46’-2” (41’-3”)	43’ (41’-6”)	43’ (42’-1”)	43’ (43’-0”)	45’ (44’-5”)	47’ (46’-9”)	50’ (49’-11”)

DIM	NATURE OF SURFACE UNDERNEATH WIRE, CONDUCTORS OR CABLES	MINIMUM DESIGN CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR NUMBERS IN (##) ARE NESC CODE VALUES								
	All values below for public or private land and water areas posted for rigging or launching sailboats (NESC Section 232)	NEUTRAL & COMM	34.5kV & Below	69kV	88kV	115kV	161kV	230kV	345kV	500kV
A	a. Less than 20 acres	22'-6" (22'-6")	30'-6" (25'-6")	31'-2" (26'-3")	28' (26'-6")	28' (27'-1")	28' (28'-0")	30' (29'-5")	32' (31'-9")	35' (34'-11")
A	b. 20 to 200 acres	30'-6" (30'-6")	38'-6" (33'-6")	39'-2" (34'-3")	36' (34'-6")	36' (35'-1")	36' (36'-0")	38' (37'-5")	40' (39'-9")	43' (42'-11")
A	c. 200 to 2000 acres	36'-6" (31'-6")	44'-6" (39'-6")	45'-2" (40'-3")	42' (40'-6")	42' (41'-1")	42' (42'-0")	44' (43'-5")	46' (45'-9")	49' (48'-11")
A	d. Over 2000 acres	42'-6" (42'-6")	50'-6" (45'-6")	51'-2" (46'-3")	48' (46'-6")	48' (47'-1")	48' (48'-0")	50' (49'-5")	52' (51'-9")	55' (49'-11")

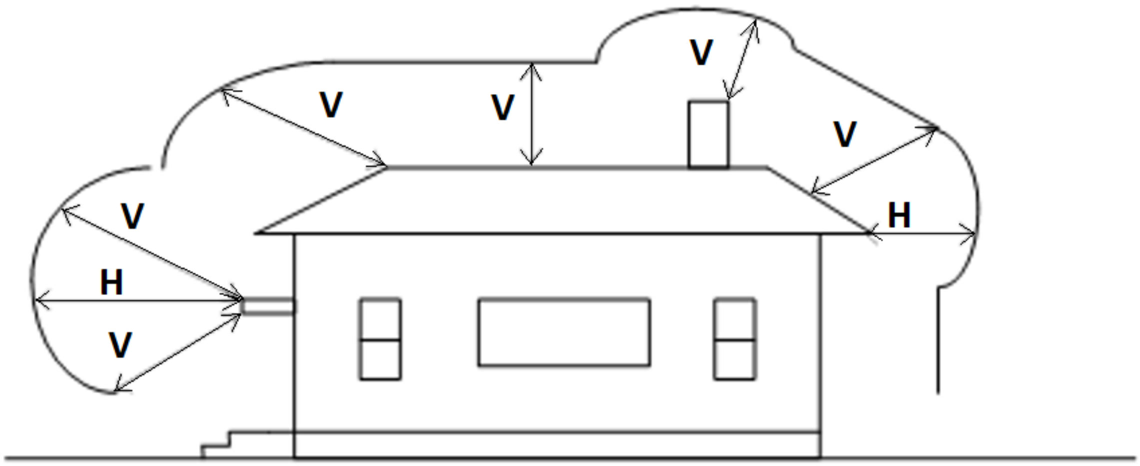
		KV	34.5kV	69kV	88kV	115kV	161kV	230kV	345kV	500kV
B	**The clearance between two different circuit crossings (NESC Section 233)**	34.5kV	4'-0" (2'-0")	4'-0" (2'-8")	5'-0" (3'-1")	5'-0" (3'-7")	6'-0" (4'-6")	7'-0" (5'-11")	10'-0" (8'-3")	13'-0" (11'-4")
		69kV		5'-0" (3'-4")	5'-0" (3'-9")	6'-0" (4'-3")	7'-0" (5'-2")	8'-0" (6'-7")	10'-0" (8'-11")	13'-0" (12'-0")
		88kV			6'-0" (4'-1")	6'-0" (4'-8")	7'-0" (5'-7")	9'-0" (7'-0")	11'-0" (9'-3")	14'-0" (12'-5")
		115kV				7'-0" (5'-2")	8'-0" (6'-1")	9'-0" (7'-6")	11'-0" (9'-3")	14'-0" (12'-11")
		161kV					9'-0" (7'-1")	10'-0" (8'-5")	12'-0" (10'-9")	15'-0" (13'-11")
		230kV						11'-0" (9'-10")	14'-0" (12'-2")	17'-0" (15'-3")
		345kV							16'-0" (14'-6")	19'-0" (17'-7")
		500kV								22'-0" (20'-6")

NATURE OF SURFACE UNDERNEATH WIRE, CONDUCTORS OR CABLES	WORKING CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR								
(These clearances apply to working near energized lines)	NEUTRAL & COMM	34.5kV & Below	69kV	88kV	115kV	161kV	230kV	345kV	500kV

Working clearances to lines for cranes and booms		15'-0"	15'-0"	15'-0"	20'-0"	20'-0"	25'-0"	25'-0"	30'-0"
OSHA Clearance between lines and cranes and booms and their loads (NESC Sec. 1926.550(a)(15))		10'-0"	10'-8"		12'-2"	13'-9"	16'-0"	19'-10"	25'-0"
OSHA Clearance to lines from scaffolds and any conductive materials handled on scaffolds (NESC Sec. 1926.451(f)(6))		10'-0"	10'-8"		12'-2"	13'-9"	16'-0"	19'-10"	25'-0"
Clearance (approach boundary) for Unqualified Workers (NFPA 70E) [1]		10'-0"	10'-0"		10'-8"	11'-8"	13'-0"	15'-4"	19'-0"
Clearance (approach boundary) for Unqualified Workers (NFPA 70E) [2]		2'-7"	3'-2"		3'-3"	4'-0"	5'-3"	8'-6"	11'-3"
Safety Manual (Notes 3 & 4 Below)		2'-7"	3'-0"		3'-2"	4'-0"	5'-3"	8'-6"	11'-3"
NESC Live work minimum approach distance (NESC Table 441-1 & 441-2)		2'-9"	3'-4"		3'-10"	5'-8"	9'-2"	11'-10"	15'-11"

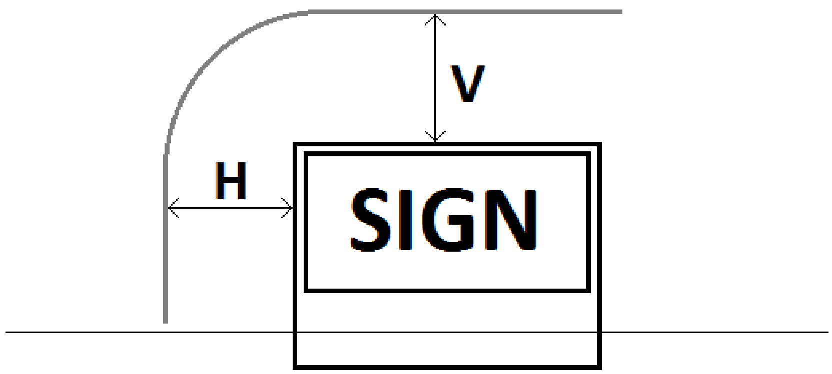
NOTES
1. Clearances are from NFPA 70E, Table 130.2(C), "Approach boundaries to live parts for shock protection"
2. Qualified workers have skills and knowledge related to the construction and operation of the electrical equipment and installations and have received safety training on the hazards involved.
3. Clearances are phase to ground
4. Voltages include 5% overvoltage

Figure 5: Transmission line clearance.



DIM	NATURE OF SURFACE UNDERNEATH WIRE, CONDUCTORS OR CABLES	MINIMUM DESIGN CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR NUMBERS IN (##) ARE NESC CODE VALUES (Sec. 234C)								
		NEUTRAL & COMM	34.5kV & Below	69kV	88kV	115kV	161kV	230kV	345kV	500kV
BUILDINGS – HORIZONTAL To walls, projections, windows, balconies and areas accessible to pedestrians										
H	Minimum with conductor blowout at 120 DEG F	4'-6" (4'-6")	8'-3"	8'-3"	9'-1"	9'-1"	10'-0"	11'-5"	13'-9"	16'-11"
H	Conductor **at rest** code value		(7'-6")	(8'-3")	(8'-6")	(9'-1")	(10'-0")	(11'-5")	(13'-9")	(16'-11")
H	Conductor **wind displaced** code value		(4'-6")	(5'-3")	(5'-6")	(6'-1")	(7'-0")	(8'-5")	(10'-9")	(13'-11")
BUILDINGS – VERTICAL To walls, projections, windows, balconies and areas accessible to pedestrians										
V	Over roofs or projections not accessible to pedestrians	8'-0" (8'-0")	16' (12'-6")	16' (13'-3")	17' (13'-6")	17' (14'-1")	17' (15'-0")	19' (16'-6")	21' (18'-9")	24' (21'-11")
V	Over roofs or balconies readily accessible to pedestrians	10'-6" (10'-6")	17' (13'-6")	17' (14'-3")	18' (14'-6")	18' (15'-1")	18' (16'-0")	20' (17'-6")	22' (19'-9")	25' (22'-11")
V	Over roofs accessible to vehicles but not subject to truck traffic 8ft high	10'-6" (10'-6")	17' (13'-6")	17' (14'-3")	18' (14'-6")	18' (15'-1")	18' (16'-0")	19' (17'-6")	21' (19'-9")	24' (22'-11")
V	Over roofs accessible to truck traffic	15'-6" (15'-6")	22' (18'-6")	22' (19'-3")	23' (19'-6")	23' (20'-1")	23' (21'-0")	25' (22'-6")	27' (24'-9")	30' (27'-11")

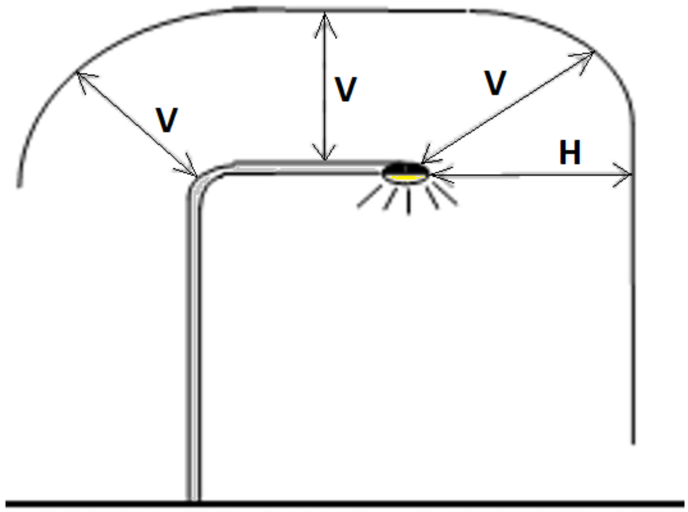
Figure 6: Building clearance.



DIM	NATURE OF SURFACE UNDERNEATH WIRE, CONDUCTORS OR CABLES	MINIMUM DESIGN CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR NUMBERS IN (##) ARE NESC CODE VALUES								
		NEUTRAL & COMM	34.5kV & Below	69kV	88kV	115kV	161kV	230kV	345kV	500kV
SIGNS, Chimneys, billboards, radio and television antennas, tanks and other installations not classified as buildings or bridges (NESC Sec. 234C)										
H	Horizontal clearance. min with conductor blowout at 120 DEG F	3’-0” (3’-0”)	8’-3” (7’-6”)	8’-3” (8’-3”)	9’-1” (8’-6”)	9’-1” (9’-1”)	10’-0” (10’-0”)	11’-5” (11’-5”)	13’-9” (13’-9”)	16’-11” (16’-11”)
V	Vertical clearance	3’-0” (3’-0”)	10’-0” (8’-0”)	10’-0” (8’-9”)	11’-0” (9’-0”)	11’-0” (9’-7”)	12’-0” (10’-6”)	13’-0” (11’-11”)	16’-0” (14’-3”)	19’-0” (17’-5”)
BRIDGES (NESC Sec. 234D)										
H	Horizontal clearance. min with conductor blowout at 120 DEG F	5’-0”	8’-3”	8’-3”	9’-1”	9’-1”	10’-0”	11’-5”	13’-9”	16’-11”
H	Conductor at rest code value		(7’-6”)	(8’-3”)	(8’-6”)	(9’-1”)	(10’-0”)	(11’-5”)	(13’-9”)	(16’-11”)
H	Conductor wind displaced code value		(4’-6”)	(5’-3”)	(5’-6”)	(6’-1”)	(7’-0”)	(8’-5”)	(10’-9”)	(13’-11”)

V	Vertical clearance	10’ (10’-0”)	14’ (12’-6”)	14’ (13’-3”)	15’ (13’-6”)	15’ (14’-1”)	15’ (15’-0”)	17’ (16’-5”)	19’ (18’-9”)	22’ (21’-11”)
NOTE: During installation and maintenance of signs, billboards etc., compliance with the working clearances for booms cranes and workers listed on Figure 6 of this document is required, unless the line can be de-energized.										

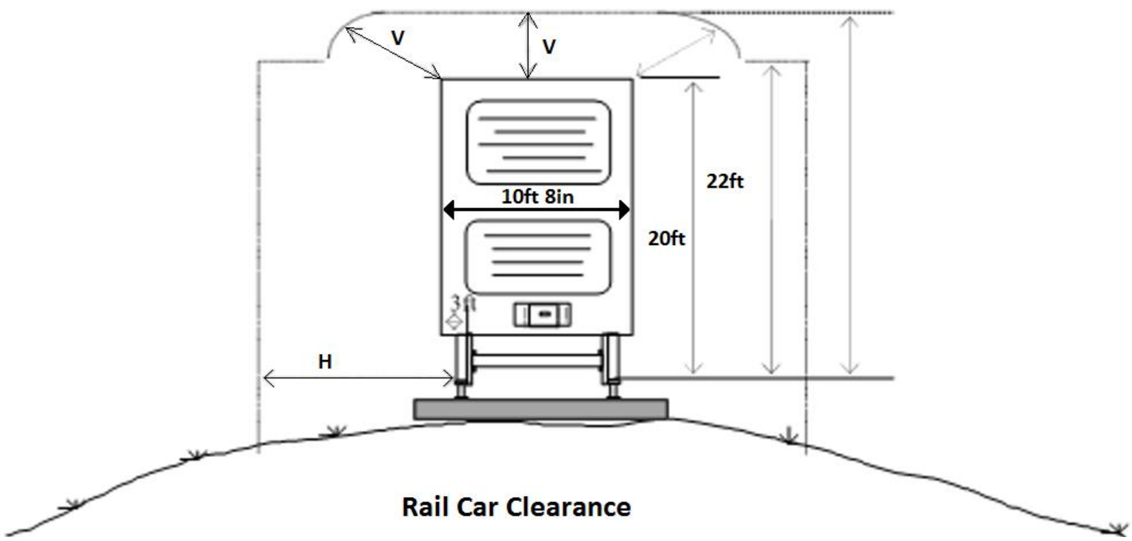
Figure 7: Signage clearance.



DIM	NATURE OF SURFACE UNDERNEATH WIRE, CONDUCTORS OR CABLES	MINIMUM DESIGN CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR NUMBERS IN (##) ARE NESC CODE VALUES								
	Lighting and lighting supports, traffic signals and supports, or supporting structures of a second line (NESC Sec. 234B)	**NEUTRAL & COMM**	**34.5kV & Below**	**69kV**	**88kV**	**115kV**	**161kV**	**230kV**	**345kV**	**500kV**
H	**Horizontal** –minimum with conductor blowout at 120 DEG F	4'-6"	4'-6"	5'-2"	5'-7"	6'-2"	7'-1"	8'-5"	10'-9"	13'-10"
H	Conductor **at rest** code value	(5'-0")	(5'-0")	(5'-0")	(5'-2")	(5'-8")	(6'-7")	(8'-0")	(10'-4")	(13'-5")
H	Conductor **wind displaced** code value	(4'-6")	(4'-6")	(5'-2")	(5'-7")	(6'-2")	(7'-1")	(8'-5")	(10'-9")	(13'-10")
V	**Vertical** clearance	4'-6" (4'-6")	7' (4'-6")	7' (5'-6")	8' (5'-7")	8' (6'-2")	9' (7'-1")	10' (8'-6")	12' (10'-10")	15' (13'-11")

NOTE: During installation and maintenance of signs, billboards etc., compliance with the working clearances for booms cranes and workers listed on Figure 6 of this document is required, unless the line can be de-energized.

Figure 8: Lighting and traffic signal clearance.



DIM	NATURE OF SURFACE UNDERNEATH WIRE, CONDUCTORS OR CABLES	MINIMUM DESIGN CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR. NUMBERS IN (##) ARE NESC CODE VALUES								
		NEUTRAL & COMM	**34.5kV & Below**	**69kV**	**88kV**	**115kV**	**161kV**	**230kV**	**345kV**	**500kV**
V	RAIL CAR CLEARANCE	3’-6”	10’ (6’-6”)	11’ (7’-3”)	11’ (7’-6”)	11’ (8’-1”)	12’ (9-0”)	13’ (10’-5”)	16’ (12’-9”)	19’ (15’-11”)
H		8’-6”	15’ (11’-6”)	15’ (11’-6”)	16’ (12’-6”)	16’ (12’-1”)	17’ (14’-0”)	18’ (15’-5”)	21’ (17’-9”)	37’ (20’-11”)

Figure 9: Rail car clearance.

8.1.8. Galloping Design Requirements – An elliptical analysis shall be performed to estimate the extent of conductor galloping ellipses possible. A single loop calculation shall be used for spans of 700 feet or less. A double loop calculation shall be used for spans greater than 700 feet.

The conductor ellipses shall have minimum separation as indicated in Table 18:

Table 18: Conductor ellipse minimum separation*

34.5kV to 115kV	1 ft.	*Ellipse separation may be reduced where variable cross-section, motion resistant conductor (such as T2) is used. Reductions must be approved by Owner or their designated representative.
161kV to 230kV	2 ft.	
Over 230kV	3 ft.	

8.1.9. Grounding Requirements – All steel and wood poles shall be grounded in a manner consistent with current practices. A copper ground wire shall be used on wood poles to bond the static shield wire to the ground rod(s) at the base of the structure. Only rare circumstances allow the omission of this connection. The shield wire shall be bonded to a ground pad installed on steel structures at each shield wire attachment location. Each steel structure shall have provisions to maintain a continuous ground path from the shield wire to the ground rod(s) at the base of the structure including across all shaft joints, and flanges. One or more ground rods shall be connected to a ground pad installed at the bottom of each structure. All grounding details shall be in accordance with Owner standards. The number of ground rods to be installed shall be sufficient to reduce the total ground resistance of all interconnected rods to less than 25 ohms.

8.1.10. Lightning Performance – Spacing between phases and the static line required by NESC shall be maintained. A shielding angle between phase and static less than or equal to the maximum allowable angle shall be maintained. All new structures shall be designed to a minimum angle of 30 degrees, which complies with RUS Bulletin 1724E-200. Note that a reduction in shield angle may be required as the circuit voltage and/or height increases, or in geographic locations where there is unusually high exposure to lightning. It is considered good practice to maintain a minimum of 2 feet horizontal separation between the static wire and the phase conductors below.

8.1.11. Colorado EMF and Noise - For high voltage transmission and substation facilities (100kV and above) the developer shall meet all Colorado Public Utilities Commission requirements that are part of a normal CPCN process. The most notable requirements are the audible noise and EMF limits at or near the edge of the right of way or property.

8.1.12. Foundation Requirement – Analysis and design of drilled pier foundations shall utilize methods and procedures that consider the structure and soil stiffness to determine foundation shear, bending moment, deflection, rotation, and the soil response to the loads.

8.1.13. Foundations utilizing reinforced concrete shall follow the requirements of ACI 318. Concrete drilled piers shall have a minimum vertical reinforcing steel ratio of $200/F_y$ or at least 1/3 greater than that required by analysis. Lateral ties shall be provided per the minimum shear reinforcement requirements when the factored shear force exceeds one-half the concrete shear strength. Lateral ties may be provided at column spacing requirements when the factored shear force is less than one-half the concrete shear strength.

8.1.14. Foundations shall limit deflection and rotation to the following:

8.1.14.1. The total lateral deflection at grade is limited to 3 inches.

8.1.14.2. Total foundation rotation is limited to 1.5 degrees.

8.1.14.3. Both limits shall be met under all NESC load cases including the NESC overload factors on applied loads.

8.1.15. The foundation designer shall, at a minimum, neglect the soil resistance of the upper soil profile or utilize reduced lateral resistance parameters as specified in the project's geotechnical report. Designer shall use engineering judgment to determine whether neglecting deeper soil resistance is warranted.

8.1.16. Insulation Requirements – All new construction shall use polymer insulators on tangent poles. Dead end structures shall utilize glass bell insulators. See Section 3.1 for a list of approved manufacturers.

8.2. Civil/Grading

8.2.1. Care of Property of Others

8.2.1.1. Contractor shall supply temporary culverts, bridges and gates, where required. Contractor shall repair promptly any bridges, culverts, fences, gates, phone lines, or ditches damaged during construction, and shall leave ditches, roads, fences, gates, culverts, phone lines, and bridges in as good a condition as found. Contractor shall operate in such a manner as to keep property and crop damage to a minimum.

8.2.1.2. Where it becomes necessary for Contractor to make openings in fences to gain access to fields, pastures, etc., Contractor shall immediately install a permanent gate, and shall insure that the said gate is closed at all times. Before the Contract is considered as complete, Contractor shall repair all fences damaged in any way to the satisfaction of Owner.

8.2.1.3. The cost of repairs due to damage done by Contractor to gates, posts, bridges, culverts and fences in the process of construction of this line, shall be borne by Contractor.

8.2.1.4. All crates, boxes, metal bands, reels, lagging, wrappings, conductor and shield wire pieces, guy wire ends, and other material, equipment refuse of every kind shall be cleaned up and disposed of during and following construction of this line. This cleanup work will be done to the satisfaction of Owner before the Contract is considered complete.

8.2.1.5. Contractor shall adequately protect all open holes, where necessary, until structures are set and the holes backfilled. Hole covers shall be furnished by Contractor.

8.2.2. Permanent Gates

8.2.2.1. Refer to Section 2.7 for applicable requirements. The gates shall be grounded in accordance with the standard grounding drawings.

8.2.2.2. The aggregate layer shall be thoroughly compacted by pneumatic tamping. The above-mentioned rules concerning backfilling shall also apply to aggregate backfill.

8.2.2.3. On sloping ground, the depth of the hole shall be the average depth of high and low side of each pole hole. In pole hole conditions of solid rock, aggregate backfill shall also be used. The engineer of record shall determine backfill for each structure hole and list the backfill material on the structure spotting list and /or design drawings.

8.2.2.4. Accumulated water shall be removed from the hole prior to setting the pole. In no case shall the depth of the hole be such that the entire corrosion treated area of any pole is below or above the ground line.

8.3. Structural

8.3.1. Steel Pole Structures

8.3.1.1. Material

Computed unit stresses under the full design load shall be less than the minimum specified material properties as stated in the applicable ASTM specifications. Allowed grades of steel for galvanized structures are limited to ASTM A350, ASTM A572, ASTM A633 and ASTM A871. Allowed grades of steel for weathering structures are limited to ASTM A871, ASTM A588 and ASTM A1066. The Vendor shall design pole shaft and arm components with a minimum wall thickness of 3/16 in.

8.3.1.2. Pole Shaft Joints

The Vendor shall design pole shaft with as few pieces as practical for shipping and field assembly. Pole shaft joints for Contractor to assemble in the field shall be slip joints or bolted flange joints. All switch poles shall have flanged joints. All other pole shaft joints shall be slip joints unless otherwise indicated per Owner standards.

8.3.1.3. Deflection

Deflection at the top of the structure shall not exceed 2% of the structure height under the deflection load case unless otherwise indicated per Owner standards.

8.3.1.4. Camber

The Vendor shall camber the pole if deflection of the top of the pole shaft under the camper load case is greater than one-half of the pole top diameter. The camber shall be the calculated deflection plus the tolerances specified below.
When fully assembled, structures shall meet the following tolerances;

· Straightness or camber in 10ft: + 1/8in, -1/8in
· Total straightness or camber: +3in, -0in.

8.3.1.5. Tolerances

The phase-to-phase and phase-to-ground dimensions per Owner standards are minimums. The Vendor shall account for the cumulative fabrication and installation tolerances from the foundation, pole shaft, joint slip, connections, and arms to maintain these design dimensions. Tolerances on loads shall be as indicated in Owner standards.

8.3.1.6. Coating for Embedded Pole Portion

8.3.2. Poles for direct embedment shall have a coating applied that is resistant to abrasion and ultraviolet light. The coating shall extend from the butt of the structure to the top of the corrosion collar. After fabrication and prior to coating, the Vendor shall clean the portion of the structure to be coated of oil, scale, in accordance with The Society of Protective Coatings (SSPC) reference number SP-10.

8.3.3. The Vendor shall use Chemline Chemthane 2260 or equivalent. The Vendor may change the coating type, application method, and inspection procedure with prior approval by Owner.The coatings shall have adhesion to substrate of at least 2000psi per ASTM D4541. Further The Vendor shall ensure that the controlling state is inter-coating failure.
Direct embedment coatings showing sags, checks, teardrops or fat edges are not acceptable. The Vendor shall check product preparation and coating thickness to ensure minimum dry film thickness requirements. The dry film thickness shall be a minimum of 15mils. The Vendor shall perform visual inspection to detect pinholes, cracking, and other undesirable characteristics. The Vendor shall remove and re-coat poles with defects of size larger than 0.75in. Defects of size smaller than 0.75in may be touched up. Wood Pole Structures

8.3.3.1. Manufacturing

Unless otherwise noted on purchase order, all poles shall be undrilled. All drilling, if specified on purchase order, shall be done prior to preservative treatment. All pole tops shall have a flat roof only.
To mitigate top splits during treatment, Anti-Splitting Devices (ASD's) such as the Star Lock or equivalent shall be placed on pole tops in all Douglas Fir and Western Red Cedar species poles in excess of 50ft in length prior to treatment at the discretion of the pole supplier (the device is not to be used to repair split tops).

8.3.3.2. Incising & Through-Boring

Western Red Cedar poles shall be incised to a depth of no less than 0.75in and the area shall be 3ft above to 3ft below the specified groundline.
Douglas fir poles 40ft in length and longer shall be through-bored prior to treatment at 2ft above to 4ft below the ground line in accordance with the approved manufacturer's standard procedure.
If sapwood thickness is less than 7/8in thickness measured near the brand location, the pole shall be full length incised above the through-bored zone.

8.3.3.3. Pole Marking

All poles shall have two non-corrosive tags stamped with the following information: pole length, class, species code, treatment code, treatment date and suppliers name and plant location. All code lettering of the tag shall comply with the latest revision of the AWPA standard M6. One pole tag shall be placed on the butt of the pole and the other on the face of the pole at a point 6ft +/- 2in above the standard groundline as defined by ANSI O5.1 or otherwise specified in the purchase order.

8.3.3.4. Seasoning

8.3.3.4.1. Seasoning of the poles shall be per ANSI O5.1.2008, except as noted below.

8.3.3.4.2. Air Drying of Poles is permitted provided:

- To prevent the formation of blue stain and decay, the supplier shall, as appropriate, completely saturate the outer surface of poles with a chemical solution as soon as possible after debarking.
- Poles are stacked so as to allow the free circulation of air around individual poles.

8.3.3.4.3. Southern Yellow Pine poles shall not be air seasoned for more than three (3) months and other pine species shall not be air seasoned for more than ten (10) months. Southern Yellow Pine and Red Pine poles shall be tested randomly prior to treatment to ensure that the moisture content at the mid-point and at the three-inch depth does not exceed 35%.

8.3.3.4.4. A combination of Boulton drying, air seasoning, and kiln drying of Douglas Fir is acceptable provided that the air seasoned poles are subjected to a heating period sufficient to continuously raise the temperature of the pith center of the largest pole in the charge to a minimum of 160°F for a minimum of 75 minutes.

8.3.3.5. Preservative Treatment

8.3.3.5.1. An empty cell process shall be used to treat the material. Treatment shall be in accordance with the requirements of AWPA Standards U1 for Category 4B, and T1-07, except as modified or changed by this specification.

8.3.3.5.2. Upon request, the supplier shall furnish to Owner and/or its representative one copy of the treating report or reports. When a kiln drying is used a copy of the kiln chart or schedule shall be supplied.

8.3.3.5.3. Acceptable Preservatives

<u>Pentachlorophenol</u> (Penta) which shall meet the requirements of AWPA Standard P-8. It shall be dissolved in hydrocarbon solvent Type A complying with the requirements of AWPA P-9.

<u>Creosote</u> which shall meet the requirements of AWPA Standards P1/P13

8.3.3.5.4. Treatment Results

Penetration

Penetration and retention shall be determined from increment borer cores, taken approximately one (1) foot below the brand.

Net Retention

The net retention of Pentachlorophenol shall be determined in the appropriate assay zone by the lime-ignition method of chemical analysis as indicated in AWPA Standard A5 Section 5, or by x-ray spectroscopy according to AWPA Standard A9. All treatment shall be in accordance with Use Category 4B in sections U1-07 and T1-07. See Table 19 below for minimum requirements. Poles that do not conform to the above requirements for retention shall be rejected.

Table 19: Penetration and retention requirements for treatment of poles.

CATEGORY	Southern Yellow Pine	
Penetration	3.0" or 90% of sapwood	
Retention Assay Zone	0.5"-2.0"	
Retention (lbs/cubic ft of wood)		
Creosote	7.5	

Pentachlorophenol	0.38	

*Douglas Fir Through Boring Note: In the through boring zone, there will be 100% penetration to pith center. Core may reveal only one annual ring skip in the 4" to pith center zone. Cores must be to the pith center or at least a minimum of 10in long for poles larger than 20in in diameter.

8.3.3.6. After Treatment Moisture Content

The average moisture content after treatment for Douglas Fir poles, using a moisture meter fitted with insulated probes inserted to a depth of 2 inches at the mid-point of the pole, shall not exceed 22%. Poles shall be tested randomly after treatment to ensure compliance.

8.3.3.7. Retreatment

Rejected poles may be retreated one time provided the temperature and pressure limits applying to the original treatment apply to retreatment and do not exceed maximums allowed in AWPA. Retreated material shall be inspected the same as when material was originally treated.

8.3.3.8. Pole Appearance

8.3.3.8.1. When creosote, creosote solutions, or oil borne preservatives are used, material should be supplied reasonably free of exudates and surface deposits. The surface appearance can be inspected using the BMP (Best Management Program) Quality Assurance Inspection Program. The exudates may evaporate, remain liquid and greasy, or harden into a semisolid or solid state.

8.3.3.8.2. The preservative solution and the process for Pentachlorophenol treatment shall be such that the surface of all poles shall be reasonably clean, dry, and free from blooming (crystallized penta on the pole surface). Poles exhibiting evidence of bleeding or otherwise out of compliance with the appearance requirements shall be rejected.

8.3.3.9. Cleaning

At the supplier's option, the poles rejected for cleanliness may be offered for inspection after they have been cleaned. To be accepted, poles must comply with the requirements of Section 8.3.3.8

8.3.3.10. Inspection

Plant inspection by the supplier of 100% of the poles in the white wood stage and after treatment to ensure compliance with the above requirements is mandatory. Evidence of these inspections should be maintained by the supplier for review.

At Owner’s discretion, poles may be inspected at the supplier’s yard by Owner or its designated representative. Inspection shall be performed in accordance with AWPA Standard M-2 except where modified or amended by this specification. Inspectors shall stamp their mark on the top of the pole for material approval and on the butt for approval of treatment. Test borings in all respects shall be made in accordance with this specification. Borings shall be furnished to Owner and/or its representative when requested.

8.3.4. Pole Holes

8.3.4.1. Pole holes shall be considered any hole drilled or dug for installing a direct embedment type pole. Pole holes shall be excavated at the locations and to the required depths as shown on the structure spotting list and/or design drawings.

8.3.4.2. Poles shall be set and backfilled as soon as practical with the backfill as described on the structure spotting list and/or design drawings; if pole holes are to be left overnight, covers shall be placed over the open holes. Contractor shall furnish covers. Open holes shall be protected from flooding.

8.3.4.3. All pole hole diameters shall be as specified on the design drawings and/or a minimum of eight inches (8”) larger than the butt of the pole or pole bearing plate to permit proper tamping. The bottom of the excavation shall be clean so that the end bearing of the foundation shall be on firm soil. The pole butt shall be placed as close as practical to the center of the hole such that a tamper can traverse the entire circumference of the pole. Tamping of backfill shall be accomplished only by pneumatic, mechanical tamps. Generally, there shall be a ratio of three (3) workers operating tamps to one (1) worker shoveling backfill material. Pole backfilling material shall be compatible with the surrounding soil and suitable for providing a dense, supportive soil mass, which is free of voids. Tamping shall proceed from the bottom of the hole to ground level. Surplus earth shall be placed around the pole butt at least one foot (1’) in depth, in a conical shape and packed tightly to permit water to drain away from the pole. Any excess auger spoil shall be evenly distributed over the surrounding terrain if permitted by the landowner; otherwise, Contractor shall remove the excess to an acceptable disposal site. The area shall be left in a neat and clean condition and any reseeding shall be done as soon as practical.

8.3.4.4. In lakebeds and certain locations where soil is deemed poor for satisfactory pole footings, aggregate backfill shall be specified. Contractor shall submit the backfill gradation to the engineer of record for approval.

8.3.4.5. A commonly used gradation for aggregate backfill is specified in Section 0.

8.3.5. Foundations

8.3.5.1. General

8.3.5.1.1. Foundation holes shall be considered any hole excavated for the purpose of installing a footing, direct embedment, pre-cast, stub angle or anchor bolt foundation. Foundations shall be excavated at the locations specified and as detailed on the structure spotting list and/or design drawings and as described in this specification.

8.3.5.1.2. In the event caving occurs or inflow of water into the excavation cannot be properly controlled, casing or slurry shall be provided by Contractor to prevent such caving or water inflow.

8.3.5.1.3. Where the foundation excavation is in close proximity to underground obstructions (sewer, water, etc.) Contractor shall install temporary steel casing or shoring in order to maintain the excavation and prevent damage to the obstruction.

8.3.5.1.4. Excavated materials, including slurry, at each site shall be hauled off and disposed of by Contractor. Contractor shall provide equipment to remove excavated material from around the excavation. Every effort shall be made by Contractor to limit the impact of construction activities. The area shall be left in a neat and clean condition and reseeding shall be done as soon as practical.

8.3.5.1.5. Foundations shall be set and poured or backfilled as soon as practical. If holes are to be left overnight, covers shall be placed over the open holes. Contractor shall furnish foundation covers. Open holes shall be protected from flooding. Accumulated water shall be removed from the hole prior to setting the foundation.

8.3.5.2. Direct Embedment, Steel Pole Foundation

8.3.5.2.1. On steel pole foundations with concrete backfill, drilled caisson foundation excavations will be utilized. The steel poles shall be checked for square with the centerline and plumb on both the longitudinal and transverse faces.

8.3.5.2.2. On steel pole foundations with dirt backfill, the embedment depth may vary ± nine inches (9”) to level the footing. Footings shall be level within ± six (6) inches and the horizontal dimension shall be within ± six (6) inches. The footing hole shall be backfilled and tamped thoroughly. Only mechanical tamping is acceptable. When a mechanical tamping device is used, only one person shoveling per three workers tamping will be allowed. The earth shall not be thrown into the hole to a depth greater than six (6) inches without being tamped hard before the next layer is thrown in.

8.3.5.2.3. Suitable templates or other means prior to the placement of the backfill material shall support steel poles, and it shall be Contractor's responsibility to furnish such templates.

8.3.5.2.4. When corrosion sleeves are provided on steel pole bases, the final grade of the backfill shall be between nine inches (9") and fifteen inches (15") from the top of the corrosion sleeve. Excessive excavated material or backfill shall be removed.

8.3.5.3. Anchor Bolt, Steel Pole Foundations

8.3.5.3.1. Drilled caisson foundation excavations will be utilized. Steel anchor bolt rebar cages shall be supported by suitable templates and other means prior to placement of concrete. A bolt pattern template shall be used. Additional supporting templates or bracing materials shall be used as necessary to maintain design locations, clearances, and straightness of foundation components.

8.3.5.3.2. The anchor bolts shall be level within 0.01 feet, shall be checked for square with the line, and shall be properly positioned such that all horizontal measurements are within + or – one-half inch (1/2”) prior to placement of concrete.

8.3.5.3.3. Contractor shall pay special attention to the anchor bolt projection to assure that after the foundations are poured, there shall be no more than 4-1/2” inches between the top concrete and the bottom of the base plate, and there shall be a minimum of ¼ (one-fourth) inch projection of the anchor bolts above the top nut.

8.3.5.3.4. Any damage to the bolt pattern template or anchor bolts caused by mishandling or assembly of the anchor bolt cage which prevents properly aligned, plumbed and level anchor bolts, shall be corrected.

8.3.5.3.5. The concrete cap shall be square or round in shape and large enough so the base plate of the steel pole does not overhang the cap.

8.3.6. Concrete

8.3.6.1. Placement of Concrete by Water or Slurry Displacement

8.3.6.1.1. If water is encountered, the hole shall be pumped as dry as possible, as specified by the Engineer of Record. Where the water level cannot be lowered sufficiently, underwater placement will be acceptable.

8.3.6.1.2. Concrete should not be placed in water having a temperature below 35°F nor at a concrete temperature of less than 60°F or more than 90°F.

8.3.6.1.3. The concrete slurry mixture shall contain at least 650 lb of cementitious material per cubic yard. The mixture should be plastic so that it will flow readily into place without puddling, but should not be so wet as to segregate. The slump shall between seven (7) and nine (9) inches. The slump will be checked prior to pouring any concrete. Concrete in place should be disturbed as little as possible. Placement of concrete should be continuous to prevent formation of layers.

8.3.6.1.4. A tremie or concrete pump shall be used and kept charged at all times while concrete is being placed, and its lower end shall be well embedded in the concrete so that the concrete will not be dropped through water, but will flow outward and upward from the end of the pipe. If the charge is lost, the tremie should be withdrawn and refilled.

8.3.6.2. Extreme Weather Concreting for Caisson Foundations

8.3.6.2.1. Concrete poured in cold weather, below 40°F, shall follow the recommendations of ACI 306R - Guide to Cold Weather Concreting.

8.3.6.2.2. Protection must be provided immediately after concrete placement to prevent freezing of the exposed concrete surface. The type of protective covering to be used shall be approved by the Engineer of Record. This protective covering shall remain on the exposed concrete for a minimum of 48 hours or as required by the cold weather concrete curing plan.

8.3.6.2.3. The maximum temperature of mixed concrete, prior to and during placement, shall be 90°F. On hot, dry days, prevent loss of moisture by evaporation during finishing. Follow the recommendations of ACI 305R - Guide to Hot Weather Concreting.

8.3.7. Anchor Holes, Anchor and Guying and Special Provisions

8.3.7.1. Anchor holes shall be dug in accordance with the specifications. All transmission structure guys will be a minimum of ½” EHS galvanized steel strand with a minimum length of 10 feet; rods will vary in length to gain sufficient ground cover as shown in specification drawings. Conductor and static guys shall be installed insulated according to the staking sheets. All overhead guys shall be installed un-insulated according to the staking sheets. All anchors are to be set in accordance with specifications and design drawings. If possible, anchors shall be thoroughly rocked in before backfilling is started. Anchors are to be thoroughly compacted with a mechanical tamper. Only one person shoveling per tamping machine will be allowed. The earth shall not be thrown into the hole to a depth greater than six (6) inches without being tamped hard before the next layer is thrown in. Where solid rock conditions exist, expanding rock anchors shall be installed per the specifications and design drawings.

8.3.7.2. Anchor rod slot or rod hole is to be aligned and dug before the disc is placed in the hole, and dug deep enough that the anchor rod remains straight when guy is pulled. In cases where slots or trenches are dug, they shall be properly backfilled and tamped. Where holes are drilled, every attempt shall be made to fill and tamp them. The eye of the rod at no time shall be struck to drive the rod in to meet the specification.

8.3.7.3. A minimum of 1 anchor shall be test pulled at each guyed anchor grouping to no less than 20,000 pounds for 30 seconds before the conductor is strung. They shall be in line with the strain and shall be so installed that no more than eight (8) inches or less than four (4) inches of the rod shall remain out of the ground after test pulling. Contractor shall submit to Owner for review methods and devices used for test pulling anchors. Extra backfill shall not be mounded up around the rod so that the earth is in contact with the guy strand or guy grip at the rod eye. Where two grips are used on one rod, care shall be taken that the grips are properly seated in the rod eyes and that they do not cross. In other words, both grips shall not occupy the same eye. Additional guy anchors may be tested upon the request of Owner or their designated representative.

8.3.7.4. Preformed guy grips shall be used on all guys at the structure attachment; guy rollers or thimble clevises shall be used in all cases. Guy grips shall be installed with the end of the guy strand extending a minimum of one (1) inch and a maximum of three (3) inches into the eye of the grip. Guy attachment at anchor rods shall also be preformed guy grips.

8.3.7.5. One (1) guy guard shall be installed on the top guy at each anchor rod.

8.3.7.6. Guy wires must be cut to proper length. No guy wire scrap ends are to be left on the property when the line is completed.

8.3.7.7. Contractor, using material supplied by Contractor at Contractor’s expense shall install any temporary guys and anchors necessary for stringing.

8.3.7.8. Screw Anchors

8.3.7.8.1. In most Power Installed Screw Anchor applications, the limiting factor is the holding strength of the soil. Only when the anchor is properly installed will the full holding strength of the soil be realized. The importance of the installing equipment, the technique, and in particular, the skill of the equipment operator, cannot be over-emphasized.

8.3.7.8.2. In general, the most important objectives to be remembered for a good anchor installation include:

a) Disturb the soil as little as possible.
b) Avoid damage to anchor and to equipment.
c) Maintain alignment during anchor installation (centerline of anchor coincident with guy inclination).

8.4. Electrical

8.4.1. Grounding

8.4.1.1. These Specifications establish the number and types of permanent deep-driven ground rod systems to be installed as part of construction. This grounding system is to be bonded to the structures per the grounding standards, structure assembly drawings, or as otherwise specified. In addition to permanent grounds called for, all necessary temporary or construction grounds shall be provided by Contractor.

8.4.1.2. There is some hazard to workers installing grounds or grounding systems and this particularly applies to making a connection to the structure. Due caution must be exercised.

8.4.1.3. Approved steps shall be taken to ensure that each pulling cable and the conductor are properly grounded during stringing operations. Ground connections shall be made to temporary or permanent grounds.

8.4.1.4. Contractor shall install all necessary temporary grounds, including moving grounds, and shall mark such grounds with approved “Day-Glo” or “Radiant Red” reflector material. All temporary grounds and markers shall be removed prior to energizing conductors.

8.4.1.5. Temporary shorting and grounding connections shall be installed between all phase conductors and shield wire and the structure grounding system, on structures selected at intervals of not more than one (1) mile. Not less than one (1) set of shorting and grounding connections shall be installed on each dead-end section of line.

8.4.1.6. Contractor shall advise Owner in writing of the structure numbers on which the shorting and grounding connections have been installed and the date of their installation.

8.4.1.7. In addition, Contractor shall provide and maintain all other safety grounding facilities required for transmission line installation including equipment and reel grounding.

8.4.1.8. Grounding equipment used by Contractor shall be designed and installed so that conductors, conductor accessories, and hardware will not be damaged. As the shorting and grounding connections are removed, Contractor shall inspect the conductors and conductor accessories for damage and shall remove any nicks, roughness, or abrasions.

8.4.1.9. Driven grounds shall consist of a system of 5/8 inch by 8 foot ground rods. If driving becomes too difficult, move over 16 feet. Locate ground rods so that the top is at least 2 feet below grade. If the ground rods are located in cultivated land, ground rods should be buried greater than 4 feet deep to avoid being disturbed by farm activity. The closest ground rod to the pole shall not be less than 8 feet from the base of each pole.

8.4.1.10. All driven grounds shall be tested by Biddle Ground “Megger”, and a record of ground resistance obtained. Tests shall be conducted by Contractor following the specific instruction of the “Megger” manufacturer. Test equipment and personnel to conduct the tests shall be furnished as Work of the Contract. All ground resistance readings shall be furnished in writing to the Engineer of Record and Owner upon completion of testing.

8.4.1.11. The quantity and quality of the grounding shall be reported on a Structure Grounding Installation Record Form worksheet. These forms are to be completed for each structure and submitted to the Engineer of Record and Owner upon completion of the project. The Engineer of Record shall determine if the grounding connections are acceptable.

8.4.1.12. During installations, the resistance of the structure grounding is to be checked by Contractor with a Megger tester. A ground resistance reading of 25 ohms or less is required. Contractor shall install additional ground rods until the 25 ohms resistance is obtained.

8.4.1.13. Switch structures are to be grounded in accordance with the standard structure switch drawings and as listed above.

8.4.1.14. Proper grounding of switch structures is important to provide maximum safety for operating personnel. Care shall be taken to ensure that all connections are clean, tight and the entire ground path provides the minimum resistance specified.

8.4.1.15. All fences and gates are to be grounded in accordance with TGA-55 of Owner’s pole grounding standards.

8.4.1.16. Crossing Fence Grounding Requirements:

8.4.1.16.1. On each side of the transmission line right-of-way;

8.4.1.16.2. On each side of gates or gaps; and

8.4.1.16.3. Maximum distance between adjacent grounds will not exceed 2,640 feet.

8.4.1.17. Parallel Fence Grounding Requirements:

8.4.1.17.1. Fences that parallel the right-of-way within 75 foot of transmission centerline will be grounded every 2,640 feet of parallel distance and on each side of all gates and gaps.

8.4.1.18. Gates:

8.4.1.18.1. Ground each strand on both sides of the gate;

8.4.1.18.2. Install a flexible grounding strap between gate and fence such that the gate will swing both ways;

8.4.1.18.3. Bond fence wire and flexible strap to ground rod clamps; and

8.4.1.18.4. For new gate installation in existing fence, temporarily ground fence on both sides of gate location prior to cutting fence wire.

8.4.2. Conductor and Overhead Ground Wire-General

8.4.2.1. Handling and Installation

8.4.2.1.1. Shall be in accordance with IEEE 524 and best industry practice.

8.4.2.2. Armor Rods

8.4.2.2.1. Preformed aluminum alloy armor rods shall be installed at all phase conductor suspension points.

8.4.2.2.2. The armor rods shall be centered in each suspension clamp such that the variation between centerline of the suspension clamp and midpoint of the armor rods is not more than two (2) inches and the variation between ends of the armor rods is not more than one (1) inch. Water pump type pliers (channel locks) shall not be used to rotate armor rods on the conductor at any stage of installation. Due caution shall be exercised in seating the last rod or last few rods of an armor rod set so that the conductor surface is not damaged. Under no condition shall the rods be cut off to even up the ends.

8.4.2.3. Splices

8.4.2.3.1. Conductor tension splices will be one-piece compression sleeves with two core grips and jumper splices will be one-piece compression sleeves.

8.4.2.3.2. Sleeves shall be installed with a hydraulic compression tool using the dies recommended by the manufacturer. The aluminum compression sleeve shall be installed after the aluminum stranding has been thoroughly scrubbed with a wire or nylon brush. The compression sleeves shall be pre-filled or filled with inhibitor and compressed in accordance with manufacturer recommendations. All burrs and sharp edges shall be filed and sanded from the splice. Any excess inhibitor, which has been forced out of the sleeve during compression, shall be thoroughly cleaned from the conductor. The overhead ground wire splices shall use a one piece sleeve. The sleeve shall be installed in accordance with manufacturer's recommendations.

8.4.2.3.3. No straightening of sleeves will be allowed. Tension sleeves or compression DE's bowed more than ½ (one half) conductor diameter shall be cut out and replaced at Contractor's expense.

8.4.2.3.4. The sleeves shall be measured and conductors marked before compressing. This will ensure that the core grips are placed properly on the core wire and thence the conductor is inserted into the sleeves the proper distance.

8.4.2.3.5. There shall be no splices located in any spans crossing railroads, main highways, major phone lines or electric lines of over 13.8kV. No splice shall be located within 100 feet of any structure or in any dead-end span. Sleeves pulled through any traveler, is not allowed.

8.4.3. Fiber Optic Ground Wire (OPGW)

8.4.3.1. Handling and Installation

8.4.3.1.1. The stringing operation shall be prosecuted with due regard to the safety of personnel and to the avoidance of overstraining or damaging conductors, structures or structure parts. Shall be in accordance with IEEE 524 and best industry practice.

8.4.3.1.2. The OPGW wire testing is described in Section 13.2.2.3.

8.4.4. Insulator and Hardware-General

8.4.4.1. Insulators

8.4.4.1.1. Care shall be exercised in handling, erecting and lowering insulators to prevent damage. Improper handling techniques may cause damage to the insulators. All insulators shall be transported to the structure sites in their original shipping crates.

8.4.4.1.2. To assure cleanliness and to prevent damage, insulators shall not be laid directly on the ground. If insulators are set with the structures, great care shall be taken to assure that the insulators are not drug along the ground during structure installation.

8.4.4.2. Toughened Glass Insulators

8.4.4.2.1. If the insulators are erected with the structure, they shall be tied to the arm or structure in a method approved by Owner. Toughened glass insulators shall be supported at least every fifth unit with rope, strap or sling. In no case, shall these supporting ropes, straps or slings be cut to allow the insulators to fall or drop freely into the final position. When these straps, slings or ropes are cut or removed, the insulators shall be lowered carefully to the final position. Insulators that show damage of any type shall not be erected.

8.4.4.2.2. Damage to insulators includes, but is not limited to, breaks, scratches, chips or cracks in the glass, bent or deformed pins, nicks, cuts or undue roughness in either caps or pins. Installed damaged insulators shall be replaced by Contractor at Contractor's expense. All insulators shall be wiped clean at the time of erection. When raising long strings of insulators, other than mentioned above, straps, slings or ropes shall be attached in such a manner that no more than two (2) or three (3) units will be above the point of support. All ropes, slings, straps, etc., must be removed prior to the time the conductor is strung.

8.4.4.3. Polymer Insulators

8.4.4.3.1. Great care shall be taken in the handling of polymer insulators. When transporting, polymer insulators shall be laid flat to prevent cantilever loads and damage to the polymer sheds. Polymer insulators shall be handled in a manner such that no contact is made with the ground. If polymer insulators are hoisted into position using ropes, straps, or slings, these attachments shall be to the metal end fittings only. Under no circumstances shall attachments to the polymer coated insulator rod or sheds be allowed. If the insulators are erected with the structure, they shall be tied to the arm or structure, by the metal end fittings only, in such a manner that no twisting or cantilever loads are applied to the polymer insulators as a result of binding in any part of the assembly. The method for installing insulators shall be approved by Owner. No attachments shall be made to any part of the insulator during the dead-ending or clipping in process or at any other time. Attachments shall be made to the arm or structure in such a manner to prevent damage to the polymer insulators.

8.4.4.3.2. Contractor shall use construction methods to assure all polymer insulators are not subjected to torsion, such methods shall include working swivels when pulling conductor, clipping, adjusting turn buckles and dead ending.

8.4.4.3.3. Contractor shall inspect all insulators prior to installation to assure there is no damage to polymer coating exposing the fiberglass rod.

8.4.4.3.4. If corona rings are used, Contractor shall use great care to follow the manufacturer’s installation instructions. The openings on corona rings shall all face the same direction with the smooth side of ring facing the sheds on the insulator.

8.4.4.4. Hardware

8.4.4.4.1. When installing insulators and hardware, all in line bolts/pins shall face the same direction on all structures on the project. The nuts/pins on all side-to-side bolts/pins shall face the pole (except in a V-String where the outside nut/pin shall face out/down).

8.4.4.4.2. All conductor hardware shall be inspected before installation for rough surfaces, burrs, or other damage. Any damaged hardware installed, shall be replaced by Contractor at Contractor's expense.

8.4.4.4.3. Nuts on all suspension and dead-end clamps shall be tightened in accordance with the torque specified by the manufacturer of the clamp. Necessary torque wrenches shall be supplied by Contractor. It shall be Contractor's responsibility, after the initial tightening of the U bolts on the dead-end clamps, to re torque these bolts before leaving the tower. The interval between the initial tightening and the re tightening should be a minimum of 10 minutes.

8.4.5. Dampers

8.4.5.1. General

Care shall be exercised in the handling and installation of dampers to prevent ground or dirt contact or any other contamination in the clamping area, which later may cause corona trouble. Damper clamp bolts shall be tightened in accordance with the torque specified by the manufacturer of the damper. Necessary torque wrenches shall be supplied by Contractor. Dampers shall be installed per manufacturers' recommendations. Dampers should be installed immediately after clipping.

8.4.5.2. Static Dampers

Static dampers shall be preformed spiral dampers, and shall be installed per the damper drawings. Recommended placement of spiral dampers is one hand’s length from the end of the armor rod or other hardware.

8.4.5.3. Conductor Dampers

Dampers should be installed immediately after clipping. Dampers shall be installed per the damper drawings.

8.5. Submittals

8.5.1. Plan and Profile Drawings

8.5.2. PLS-CADD .cri and .pps files

8.5.3. As-built LiDAR survey data into the existing IFC PLS-CADD model and update model as necessary.

8.5.4. See Section 1.3 for more submittals information.

9. Substation

See list of approved manufacturers in Table 11 in Section 3.1.

See list of approved contractors in Table 12 in Section 3.3.

9.1. Design

All work and materials shall be in accordance with the Project Schedule, Design Documents, all the Transmission Owner requirements and all the Transmission Provider requirements. The Collector Substation shall include, but not be limited to: foundations, breakers, protective relays, RTU, ground grid, surge protectors, Electrical Equipment Enclosure (EEE), buss bar and communications circuits to meet all host utility requirements, including any requirements imposed by the Transmission Owner, Transmission Provider and applicable NERC and FERC standards.

See **WIND FARM EEE AND PANEL ELEVATIONS** and **WIND FARM ONE LINE METERING AND RELAYING** for additional information.

9.1.1. Civil/Structural Design

9.1.1.1. The substation civil/structural design shall be in accordance with **XEL-STD-CRITERIA FOR ENG & DESIGN OF CIVIL & STRUCTURAL PERFORMANCE**.

9.1.1.2. Drilled pier foundations shall include details to resist frost heave such as installing sonotube around the pier perimeter throughout the frost zone depth.

9.1.1.3. Any engineer wishing to deviate from this standard must submit exception to Owner for approval.

9.1.2. Step-Up Transformer

9.1.2.1. Refer to Wind MPT Specification Rev 3 and WIND FARM ONE LINE METERING AND RELAYING for design requirements.

9.1.2.2. Shall have an in-tank, on-load tap changer.

9.1.3. Site Layout Criteria

9.1.3.1. All substations designs shall be in accordance with this specification and accepted industry standards and practices. The National Electric Safety Code (ANSI C2) shall be followed in all cases. The National Electric Code (NFPA 70) shall be followed to the extent that is possible and practical. In certain jurisdictions, the National Electric Code is part of the law and must be followed.

9.1.3.2. Number of feeders shall be determined by the collection system. For feeder and switch designation naming see Table 20

9.1.3.3. A cold storage unit shall be installed as a separate unit. The unit shall provide approximately 200 square feet of storage.

Table 20: Feeder and switch designation naming.

34.5 KV Feeders:
Bus 1: 311 to 319
Bus 2: 321 to 329

9.1.3.4. A disconnect switch between the collector substation and the utility interconnection facilities is required.

9.1.3.5. High side breaker and associated switches or bus position with multiple breakers and associated switches for each transformer

9.1.3.6. Low side bus and equipment shall be installed in accordance with acceptable industry standards and practices. Main breakers, a bus-tie breaker and associated switches shall be installed where applicable or required by Owner.

9.1.3.7. One grounding transformer per two circuits shall be incorporated into the design of the collector substation. Breakers that incorporate ground switching shall not be utilized.

9.1.3.8. The substation shall be constructed with steel structures. Use of wood poles is not allowed.

9.1.3.9. Bus spans shall be limited by switch pad loading.

9.1.3.10. Switches shall be group-operated.

9.1.3.11. Circuit breaker ratings shall be standard.

9.1.4. Fire Protection

9.1.4.1. Substation fire protection designs shall be in accordance with accepted industry standards and practices. IEEE 979 Guide for Substation Fire Protection shall be consulted for new facilities.

9.1.4.2. Protective firewalls or barriers should be considered whenever clearances from IEEE 979 cannot be achieved.

9.1.4.3. Electrical Equipment Enclosures shall have two exits on opposite sides or corners and the doors equipped with panic hardware. Fire extinguishers are to be provided at each exit of any enclosures within the substation.

9.1.5. Fault Duty Requirements

Design shall consider future fault values obtained from interconnecting utility for the worst-case value over a 30 year lifespan of the substation.

9.1.6. Environmental Requirements

9.1.6.1. Substation designs must be compatible with the environmental characteristics of the facility location. Table 21 gives typical design parameters for various regions. Particular sites within a given region may have different environmental conditions than that given in Table 21, the more stringent would apply. Additional environmental conditions for calculating bus conductor ampacity are in Table 22.

9.1.6.2. The existence of any unusual environmental conditions should be considered at each substation site. These conditions may include corrosive fumes or vapors, explosive mixtures of dust or gases, steam, magnesium chloride spray, and salt spray.

Table 21: Environmental design criteria.

	CO	MN/WI (South)(1)	MN/WI (North)(1)	NM	TX
Design Temperature Range (°C)	-40 to 40	-40 to 40	-50 to 40	-30 to 40	-30 to 40
Design Ice Loading(2) (inches, radial loading)	1 in	1 in	1 in	1 in	1 in
Elevation above mean sea level (feet/meters)	Min. design criteria is 5,900 ft (1800 m) Use 11,000 ft (3353 m) elev. at sites >8,500 ft (2591 m)	<3300 ft (1006 m)	<3300 ft (1006 m)	>=3700 ft (1128 m)	>=3700 ft (1128 m)

(1) The division between MN/WI north and south is roughly defined as the east-west line running between St. Cloud, MN and Eau Claire, WI.

(2) For issues related to structural design, including regional seismic zones, refer to the Civil/Structural Design Criteria.

Table 22: Design criteria for substation bus conductor and ampacity ratings.

	NSP	PSC	PSC ≥8500 ft	SPS
Summer Ambient Temp. (Deg. C)	40	40	35	40
Day of the Year	June 21 (172nd day)	June 21 (172nd day)	June 21 (172nd day)	June 21 (172nd day)
Temp. Rise (Deg. C)	45	45	50	45
Bus Temp. (Deg. C)	85	85	85	85
Emissivity Outdoors (*e*)	0.5	0.5	0.5	0.5
Emissivity Indoors (e)	0.35	0.35	0.35	0.35
Absorptivity (*a*)	0.5	0.5	0.5	0.5
Degrees N. Latitude	43	40	40	35
Time of Day	Noon	Noon	Noon	Noon
Atmospheric Conditions	Clear	Clear	Clear	Clear
Elevation	1,100 ft (336 m)	5,900 ft (1800m)	11,500 ft (3506 m)	>=3,700 ft (1128 m)
Wind Speed (ft/sec)	2	2	2	2
Wind Direction	90	90	90	90
Line Orientation	E/W (90°)	E/W (90°)	E/W (90°)	E/W (90°)

Note 1: For indoor calculations, solar heat gain should not be applied.
Note 2: When wind speeds are zero, forced convection heat loss rate should not be applied.

9.1.7. Bus layout criteria, clearances, etc.

9.1.7.1. A bus arrangement in substation should have “B” phase in the center. The phase sequence required for the transformers may fix the location of “A” and “C” phases. Coordination with the interconnecting utility is preferred. Tubular bus criteria — All tubular bus designs shall be in accordance with accepted industry standards and practices. The IEEE 605 - IEEE Guide for Bus Design in Air Insulated shall be followed in all cases.

9.1.7.2. Clearances – NESC C2 and ANSI C37.32 with any additional site specific requirements shall be considered and either meet or exceed the minimum requirements for design clearances. All substation arrangements will be designed to allow safe maintenance and repair of adjacent equipment.

9.1.7.3. Ampacity Ratings

9.1.7.3.1. Substation bus conductors are to be sized based on the ampacity requirements of the substation and any future expansions noted upon commencement of design. All conductor ratings shall follow the Environmental design requirements in Section 9.1.6. Once the bus conductor sizes are determined, switches and breakers are sized to meet or exceed the bus conductor ampacity ratings. In some cases, the determining factor in sizing the bus conductors will be structural and mechanical requirements.

9.1.7.3.2. The minimum standard continuous current rating that will be used for transmission switches and breakers is 1,200A. A load flow study should be performed to confirm ratings impacts on detailed high side facilities (ring bus, breaker and a half) that have influence other current sources.

9.1.7.4. Aluminum bus conductor applications

9.1.7.4.1. All Aluminum Conductor (AAC) is used for substation strain bus and connections where flexibility is required or rigid bus is not feasible. ACSR conductor can also be used where practical to gain rigidity in some special cable connections.

9.1.7.4.2. Aluminum tubing is used primarily to obtain structural rigidity in long unsupported spans of bus, usually in high voltage structures, and over designed in current carrying requirements is disregarded.

9.1.7.5. Bus Connections

9.1.7.5.1. All current carrying aluminum connections shall be thoroughly cleaned, coated and sealed with an oxide inhibiting agent. Aluminum oxide, which is a poor electrical conductor, forms rapidly on the surface of drawn or rolled aluminum. It must be removed and prevented from reforming after the connection is completed. This applies to all connections, whether bolted, clamp or compression type. Caution - Aluminum expands 30% (1.33 times) more than copper. Every connection involving a combination of aluminum and copper must be planned to avoid gradual loosening caused by large temperature changes. Unequal expansion of aluminum, copper and steel can cause extremely high pressure during hot conditions which stretches one or more of the metals leaving a loose connection when cold conditions occur

9.1.7.5.2. Bolted electrical connections shall be made on flat contact surfaces, completely cleaned with an oxidation inhibitor. This must be done by thoroughly scratch-brushing the contact surfaces through the inhibitor, leaving enough of it on the surface to control reformation of oxides. After the connection is completed, additional compound shall be applied and forced into every irregularity and opening in order to completely seal the joint against moisture and corrosion.

Aluminum to Aluminum connections shall be fastened with aluminum bolts, 2024-T4alloy with No. 205 alumalite finish and preferably NO-OX-ID coated. Nuts shall be of the same alloy and finish. Heavy series bolts and nuts (7/8" across flats) are preferred.

Aluminum to Copper connections shall be made only with flat contact surfaces. Dressing and sealing the connection with inhibitor is especially important where unlike metals are in contact. Care must be taken to place the aluminum above copper when in a horizontal plane so that corrosive copper salts do not flow onto the aluminum. The type of bolt used is also important because extreme temperature changes can cause a loose joint due to the expansion differential between copper and aluminum. Aluminum or bronze bolts will be used as specified below: (a) Use aluminum bolts if thickness of the aluminum conductor is the same or greater than the copper conductor. (b) Use bronze bolts (Everdur) if the copper conductor is thicker than the aluminum.

9.1.7.5.3. Cable terminations can be made with clamp, compression and welded type fittings; preferably welded or compression types. Welded fittings should be used only when there is enough other bus welding on the project to make it economical.

9.1.8. Ground Grid Criteria

9.1.8.1. The short-circuit design rating for a particular substation is selected based on the calculated maximum available fault current available at that location, and takes into account the future growth of the substation and power system. Step and touch potential calculations may be based on the estimated future maximum fault current level. Substation grounding design is based on the IEEE 80 standard.

9.1.8.2. Ground Potential Rise (GPR) calculations may be required to support the local telephone company provider design needs.

9.1.8.3. The substation grounding system is a grid buried 18" below rough grade and made of 4/0 - 19 strand soft drawn copper conductor, ¾" threaded ground rods, and appropriate connector fittings. The conductor is run as a continuous loop when attaching to ground rods, fence, structures, and most equipment (transformers are the exception).

9.1.8.4. The fence and the fence counterpoise (a conductor buried 3' beyond the substation fence) are both connected to the ground grid.

9.1.8.5. All equipment must have provisions for grounding in accordance with OSHA codes. The ground grid shall be attached to equipment at two different points such as opposite corners of a transformer or each leg of a switch stand. The grid shall be bolted or welded to all steel structures and fence posts.

9.1.8.6. Electrical Equipment Enclosure grounding shall be tied to the substation grounding system in two places, at opposite sides of the enclosure.

9.1.8.7. Cable Trench Conductor grounding shall conform to the following:

9.1.8.7.1. One #4/0 bare copper conductor is to be laid in all precast or direct burial cable trench. The ground conductor is required to protect control cables from stray ground currents or signals usually present in high voltage installations by equalizing the potential along the length of the cables.

9.1.8.7.2. The trench ground conductor must be connected to the station grounding system at every intersection and at the ends of each trench. In the case of direct buried trenches, the ground conductor shall be incorporated into the system grounding design.

9.1.8.8. Switch Handle grounding on steel structures shall have the operating pipe be bonded to the steel using a flexible grounding jumper.

9.1.8.9. Ground wells and other enhancements are utilized when required.

9.1.9. Conduit and Cable Trench Criteria

9.1.9.1. Direct buried cables shall not be used. If conduit size is greater than 4 inches then use multiple conduits instead. Does not apply to feeder risers.

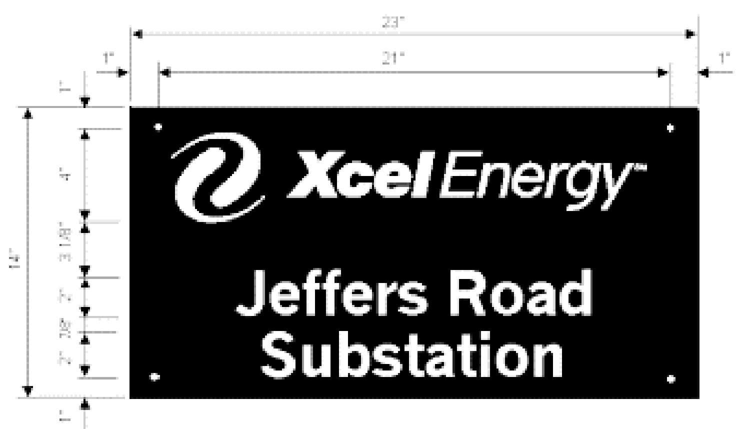
9.1.9.2. Cables within the substation shall be routed through a cable trench system extending from the Electrical Equipment Enclosure (EEE) to equipment located within the substation. The final route from the cable trench to the device shall be in schedule 40 PVC conduit for below grade portions of the conduit, and RGS conduit for bends / sweeps and above grade locations.

9.1.9.3. Cables shall be suitable for direct burial.

9.1.10. Outdoor Nameplate/Safety Sign Requirements

9.1.10.1. Each substation has a facility identification sign posted near the main entrance that gives the company name, substation name, and physical address. If there is a separate security gate installed at the entrance off of the public road, there will be a facility identification sign at this gate as well as at the main entrance. Additionally, warning signs are posted on each entrance gate and at intervals around the outside of the substation fence (typically every 50’). Within the substation, all power equipment and switches are labeled. Warnings signs are also posted for battery systems, buried cable, and areas of limited clearance. Substation signs must meet or exceed the requirements of the National Electric Safety Code.

9.1.10.2. Substation Identification Sign



14” x 23” sign

9.1.10.2.1. The sign should be placed on all substations unless this conflicts with local laws and ordinances.

9.1.10.2.2. The signs should be 6’-0” from grade to top of sign, placed adjacent to substation walk or drive gate and above the address sign.

9.1.10.2.3. Mount using a copper or aluminum wire tie in each hole.

9.1.10.2.4. Sign specifications:

Size: 14” x 23”

Material: 0.080 aluminum plate with 3M High Intensity Silver Scotchlite code #3870. Background to be silk-screened with 3M #845 black paint.

Text shall be 2” Helvetica Medium Upper and Lower Case. (example: Jeffers Road Substation).

Owner logo must be per company guidelines.

9.1.10.3. Substation Address Sign

9.1.10.3.1. The signs should be placed adjacent to substation walk or drive gate and under the Substation Identification Sign.

9.1.10.3.2. Mount using a copper or aluminum wire tie in each hole.

9.1.10.3.3. Sign specifications:

Size: 36” x 7” (vendor can make sign longer for longer addresses).

Material: 0.080 aluminum plate with 3M High Intensity Silver Scotchlite code #3870.

Background to be silk-screened with 3M #845 black paint.

Text shall be 3 ½” Helvetica Medium Upper and Lower Case.

9.1.10.4. Substation Safety Sign

9.1.10.4.1. The signs should be placed 2 to 3 times the readability distance of the message text (Table 1, ANSI Z535.2 “Minimum Letter Height Calculations”). In this case, 30 to 45 feet apart and no more than 15 feet from the corners of the enclosure.

9.1.10.4.2. Two signs should be placed on each drive gate, one on the inside and one on the outside (back to back). This is done so you can read the inside sign if the gate is open.

9.1.10.4.3. One sign should be placed on the outside of each walk gate.

9.1.10.4.4. The signs should be placed approximately 5’-0” form grade to top of sign.

9.1.10.4.5. Mount using a copper or aluminum wire tie in each hole.

9.1.10.5. Substation Battery Warning Sign

10” x 14”

9.1.10.5.1. Signs should be placed on the outside of all substation control house doors.

9.1.10.5.2. Sign is to be mounted to the door using sheet metal screws.

9.1.10.5.3. The signs should be placed approximately 5’-0” from the bottom of door to the top of the sign and centered on the door.

9.1.10.5.4. These signs are now required per the National Electrical Safety Code, Section 14, Part 146B.

9.1.10.6. Substation Buried Cable Sign

10” x 7” Sign

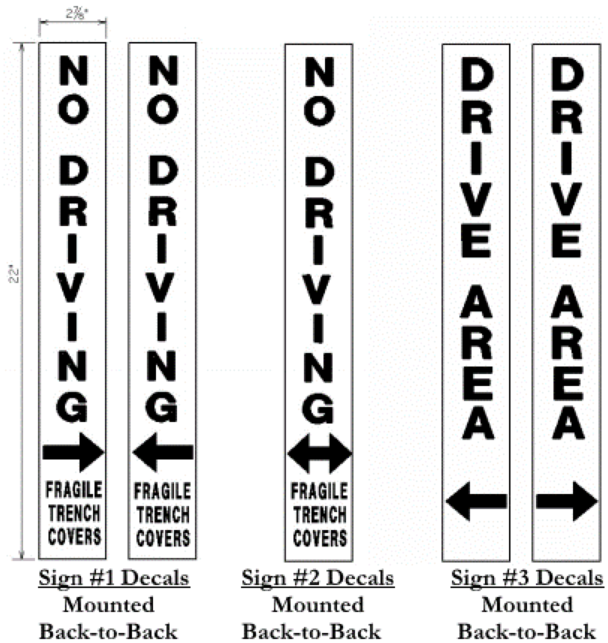
9.1.10.6.1. The sign should be placed at substations where cables are in the area and need to be marked to prevent accidental digging.

9.1.10.6.2. The signs should be mounted on each side of the substation fence fabric, back to back, at the location where cables pass under the fence.

9.1.10.6.3. Mount to fence using a copper or aluminum wire tie in each hole.

9.1.10.6.4. Outside of the substation fence this sign can be mounted to a steel channel post.

9.1.10.7. Substation Precast Cable Trench Signs



9.1.10.7.1. Vehicles cannot drive over precast cable trench without breaking covers. The warning signs shown above will be driven into the ground at strategic locations where vehicles could mistakenly drive over the precast cable trench.

9.1.11. Indoor Equipment and Panel Labels

9.1.11.1. All indoor equipment and devices shall be labeled.

9.1.11.2. Blocking bar switch handles shall be labeled with a white background, black lettered label describing where the other end of the wire is landed.

9.1.11.3. Every test switch shall have a trip switch index hung in a C-Line 46058 document protector on the relay panel where the test switch is located.

9.1.11.4. Labels shall be laminated phenolic plastic tags with the following color coding.

9.1.11.4.1. White with black lettering: all devices or items not specifically called out.

9.1.11.4.2. Yellow with red lettering: Operator switches; 43, 97, other control switches.

9.1.11.4.3. Red with white lettering: Test switches

9.1.11.4.4. Orange with black lettering: Lockout switches (86).

9.1.11.5. The font sizes and types show in Table 21 shall be used.

Table 21: Indoor equipment and panel labels labeling machine font size and type requirements.

Font Size	Application
36 pt Bold	Panel names (Front and Rear) ACT, APT Phase Designations
30 pt Medium*	97, 43, SS, 243, 283, Switches
24 pt Medium* (16 pt (8x2) where space is limited)	FT Boxes Individual Indicating Lights Metering Relays Annunciator Box Number Trip Switches In Rear
16Pt (8x2) Medium	Annunciator Point Numbers
12 pt.	Annunciator Labels Plug in and Draw Out Relays AC & DC Panel Circuit Descriptions Chrysler 8000 RTU: CKT Descriptions (On Panel)
16/8 pt. (Double Line)	Indicating Fuses DC Circuit Numbers In Fuse Cabinet

*If medium cartridge is not available use the "bold" function on the machine.

9.1.12. Site Lighting Criteria

9.1.12.1. Outdoor substation lighting shall be controlled from the interior of the Electrical Equipment Enclosure with a switch, or switches. Lighting contactors may be used with switching to turn the outdoor lights on and off.

9.1.12.2. Outdoor yard lighting for substation equipment shall provide an average of 2 foot-candles for safe operation/maintenance of equipment and for security. Remote areas of the substation yard shall have an average of 0.2 foot-candles.

9.1.13. Lightning Protection Requirements

9.1.13.1. All substation electric equipment, electric bus, and support structures shall be shielded from direct lightning strikes. Shield masts and shield wires are the preferred methods of lightning shielding within substations. When economical, it is preferred to not have shield wires directly over bus.

9.1.13.2. Two widely used methods for designing substation lightning shielding are i) “fixed angle zone of protection” or “traditional cone” and ii) “electro-geometric model” or “rolling sphere”. Although the traditional cone method is more commonly used, either method is acceptable. IEEE 998 standard shall be applied in the evaluation.

9.1.14. Wildlife Protection of Bushings

9.1.14.1. Outdoor bushings operating at 35KV and below shall have protection installed on them to reduce the potential for phase to ground or phase to phase faults caused by wildlife getting near the area of the bushings. The protection shall be applied on equipment such as transformer bushings, surge arrestors, circuit breakers, circuit switchers, auxiliary transformers, potential transformers, etc. The bushing protection shall be “Therm-A-Guard” or equal, and shall also include covers for conductors extending from the bushings.

9.1.14.2. Each bushing protector shall have two cable ties around it to ensure it stays in place.

9.1.15. Cable Raceway System

9.1.15.1. This Section describes the requirements for a complete and proper cable raceway installation for the substation, as shown in the Design Documents. Cable raceway systems shall include any system designed expressly for holding or routing wires and cables including excavated trenches.

9.1.15.2. Contractor shall install all direct buried conduit or duct, concrete encased conduit or duct, indoor and outdoor conduit, cable tray, cable trench and accessories required for embedded and exposed raceway systems. Conduit accessories shall include but not be limited to the following items: conduit fittings, conduit connectors, outlet boxes, outlet bodies, pull boxes, junction boxes, locknuts, bondnuts, bushings, materials for sealing joints and ends of conduits, panelboards, cabinets, tray hanger supports, bracket supports and clamps, excavation warning tape and all other material and devices required for a complete and proper electrical cable raceway system.

9.1.15.3. Referenced Codes and Standards

9.1.15.3.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard or code conflict with these Specifications Owner shall be notified at once and a remedy shall be determined.

9.1.15.3.2. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

9.1.15.3.3. National Electrical Manufacturers Association:

NEMA Publication 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

9.1.15.4. Materials

9.1.15.4.1. Conduit

Above grade conduit and conduit extending from above grade to below grade including below grade sweeps shall be rigid galvanized steel (RGS). Below grade conduit extending from RGS sweeps shall be schedule 40 -polyvinyl chloride (PVC) conduit.

Electrical Metallic Tubing (EMT) thin wall conduit may be used in indoor, non-hazardous or in embedded locations. EMT connectors and couplings shall be gland compression type. Set-screw type connectors shall not be used.

All flexible conduit shall be steel reinforced and liquid tight.

9.1.15.4.2. Raceway Accessories

Breaker panels, junction boxes and outlet boxes, together with associated items for attaching and making connections, shall be installed in conformance with the Design Documents and this Section.

All outdoor, surface-mounted outlet boxes shall be cast aluminum or cast iron, with gasketed steel or aluminum cover plates. Crouse-Hinds, Russel & Stoll or Owner approved equal shall be used. Formed metallic outlet boxes shall not be used in outdoor locations.

Junction boxes used in outdoor locations for splicing and terminating wires shall be NEMA Type 3R, 16 or 14 gauge galvanized steel or Owner approved equal, supplied without knockouts. The size of all enclosures shall be in accordance with all applicable codes. Connections to the top and sides shall be made with waterproof hubs. Connections to the bottom shall be made with a bushing and two (2) locknuts.

Formed metallic outlet boxes may be used in indoor, non-hazardous locations in accordance with the NEC. Cover plates shall be steel or aluminum.

9.1.15.5. Raceway Installation

9.1.15.5.1. All raceway shall be installed in accordance with the Design Documents and this Section.

9.1.15.5.2. Above-Grade Conduit

All above-grade exposed conduit shall be RGS unless otherwise stipulated. Where it is connected to buried conduit, the RGS conduit coupler shall extend to one (1) inch above finished grade, making the required bend radius into the horizontal run.

Where possible, conduit runs shall be parallel to the centerlines of structures or parallel to each other in the case of multiple runs. A run of conduit, embedded or exposed, shall not contain more than the equivalent of four (4) quarter-bends (360* total) between outlet boxes, outlet bodies, junction boxes and pull boxes., including bends located immediately at the outlet box, or junction box. All exposed conduit and conduit inside the control house shall be one-half (1/2) inch minimum.

Factory bends or bends made with a hydraulic power bender shall be used for conduit two (2) inch and smaller. The minimum bending radius of conduit shall be seven (7) times the nominal diameter of the conduit. All bends for conduit sizes above two (2) inches shall be factory bends.

All conduit runs shall be supported at least every five (5) feet. Fittings and outlets that are for conductor feed-through shall have the attached conduit supported within three (3) feet of the outlet. Place conduit supports within eighteen (18) inches of outlets that contain devices such as receptacles or boxes that support fixtures.

Where conduit enters a box, vault, cable trench or any other fitting or termination, a bushing shall be provided to protect the cable from abrasions. At all points where the conduit terminates, the bushing shall be grounding type to provide an effective connection to ground. The ends of conduit shall be protected to prevent the entrance of any foreign material.

All material and equipment shall be stored so as to be protected from deteriorating effects of the elements. All exposed ends of conduit shall be protected during construction to prevent the entrance of any foreign material or moisture. Touch-up paint shall be provided by Owner as required.

Burrs or sharp projections which might injure the cable shall be removed.

Round, flexible, nylon-covered tapes or nylon ropes shall be used for fishing and wire-pulling in conduit.

Pre-drilled holes (if furnished) shall be used for mounting boxes. Drilling through the top, sides or back of a junction box is not acceptable for NEMA Type 3 ratings or above. Drilling through the top or sides of junction boxes rated below NEMA Type 3 is not acceptable. Formed channels shall be used for mounting boxes unless otherwise indicated in the Design Documents.

9.1.15.5.3. Direct Buried Conduit or Duct

Horizontal runs of buried conduit shall be PVC conduit unless otherwise specified. Locate underground runs in accordance with the Design Documents. Pull boxes shall be installed to limit any run of conduit to (4) quarter bends (360° total). All conduit runs shall contain a cable pulling tape or rope.

Underground conduit runs shall be installed as shown in the Design Documents and as follows:

Excavated trench bottom shall be smooth or filled with clean sand as required to make it such.

Conduit shall be used for runs under roadways as shown in the Design Documents.

All bends, including those within or at the ends of PVC conduit sections, shall be made with RGS conduit. Adapter connectors shall be provided between PVC conduit and all RGS conduit sections.

Backfill around the conduit shall be in accordance with the Design Documents.

Conduits which enter manholes pull boxes or building foundations shall use end bells and be grouted in place. End bells shall be flush with the surface.

As soon as practical after conduit runs are completed and concrete forms are stripped, all conduit runs shall be swabbed free of foreign material. Plugs or caps shall be installed with greased threads and left in place until the wire is installed.

RGS conduit shall be used to make entrance connections into buildings or equipment foundations and vaults. The RGS conduit is to be extended a minimum of eighteen (18) inches beyond exterior walls for buried cables, or as shown in the Design Documents. All conduit entrances into the control building or into any outdoor enclosure or vault shall be sealed with Duxseal or other Owner approved material.

The 34.5kV collection feeder conduit shall be protected with concrete bollards. Contractor shall submit plans for protection to Owner for approval.

9.1.15.5.4. Concrete-Encased Conduit or Duct

Conduit, conduit fittings and conduit boxes to be embedded in concrete shall be held securely in position while the concrete is being placed.

The conduit shall rest on spacers to ensure that the spacing between conduit runs does not change during the placement of the concrete. The spacers shall be placed at regular intervals as specified in the Design Documents or as recommended by the manufacturer, whichever is less. Conduit shall be secured to the trench bottom to prevent flotation.

Concrete used for encased conduit or duct shall have a twenty-eight (28)-day compressive strength of at least 2000 psi. The aggregate shall be less than three-fourths (3/4) inch in diameter. Red Dye shall be incorporated into top of ductbank concrete or Caution Buried Electrical Line Below tape shall be placed 12" above top of ductbank. When the backfill above the concrete must be compacted, the concrete shall cure for seven (7) days before backfilling. When compaction of the backfill is not required, backfill can be placed twenty-four (24) hours after pouring.

After the forms are removed Contractor shall clean all concrete from the inside of conduit boxes and threads for attaching devices and covers.

9.1.15.5.5. Precast Concrete Trench

An assembled-component-type reinforced precast concrete cable trench system shall be installed in accordance with the Design Documents, this Section and the manufacturer's recommendations.

Contractor shall excavate all substances encountered to a depth necessary to properly install the concrete trench system. All previously installed buried conduits, buried cables, copper ground grid wire and site drainage systems shall be located, by digging or other methods, prior to excavating in concrete trench locations. Ground grid wires interfering with the trench installation shall be spliced exothermically and buried six inches below the trench. The site drainage system shall not be modified in any way to facilitate the concrete trench installation and drain pipe back fill shall be restored to original condition if disturbed. Any damage to existing installations shall be repaired to the satisfaction of Owner.

Precast trench members shall be set only on firm, compacted earth, sand or gravel mix, such that the top of the sidewall will be at the elevation indicated in the Design Documents.

Excavations shall be kept free from water during the placement of concrete trench system components and during inspection.

Conduits entering the concrete trench system shall be laid beneath the sides of the trench and terminated with an angle deflection and bushing or acceptable conduit fitting to enter the trench.

Following the concrete trench installation, all excavation shall be backfilled and mechanically compacted to grade. Backfill along the trench system shall be performed according to the manufacturer's recommendations and shall not deflect the trench sidewalls.

Covers shall be placed on the concrete trench after installation of cables is completed.

The concrete trench system shall be protected against entrance of construction debris, rock and earth during the construction and after placement of the sand bedding. Contractor shall clean the concrete trench system of any such foreign material immediately prior to placing cables and just before final placement of covers.

9.1.15.5.6. Overhead Cable Tray System

An assembled, overhead, indoor cable tray system shall be installed in the control building in accordance with the Design Documents, this Section and the Manufacturer's recommendations.

Cable entrances to equipment enclosures and panelboards from a cable tray shall be made with conduit runs or via openings in the tray bottom. All cable entrance cutouts in the cable tray bottom, or equipment enclosure shall have grommets to protect the cable jacket from cuts or abrasions. Conduits entering the cable tray shall be securely fastened to the tray sidewall with hardware specifically used for that purpose.

The overhead cable tray shall be supported as shown in the Design Documents. The preferred method of support utilizes roll-formed uniform channel framing members attached to the floor and wall. An alternate method uses a trapeze-type support made of roll-formed channel with threaded rods fastened to the ceiling. All tray supports connected to the ceiling of a metal building shall be directly attached to roof purlins or to formed channel fastened to the nearest roof purlin. Tray supports in the ceiling of a masonry building shall utilize properly-sized drilled expansion anchors.

Cable tray located above wall-mounted equipment shall be supported with brackets fastened directly to wall columns and specifically designed for that purpose.

9.1.15.6. See Section 13.2.3.4.23 for Cable Raceway System testing requirements.

9.1.16. Shielded Cable

9.1.16.1. Shielded control cable shall only be required if there is 230 kV or greater present in the substation.

9.2. Civil/Grading

9.2.1. All civil and earthwork shall meet the construction requirements set forth in Section 2 and the testing and inspection requirements set forth in Section 13.1.

9.2.2. Fill Material Applications

9.2.2.1. Fill material shall meet the requirements outlined in Section 4.1.2.

9.2.2.1.1. Common Fill

Used as backfill below frost line or in berms in the graded area.

9.2.2.1.2. Select Fill

Used as fill in the graded areas and as subbase for the access roads or subcuts required for shallow foundations.

9.2.2.1.3. Granular Fill

Shall meet the requirements of Section 4.1.2.3.

Used as a top course of the fill placement as shown in the Design Documents and as bedding and backfill for drainage piping or culverts.

A type of granular material used as a separation layer in substations is four (4) inches of 3/4" diameter clean crushed rock.

Granular Fill applications are as follows:

<u>GRADATION TYPE "A"</u>

a) wet-caving condition - all soils

b) suitable for pole excavation below water table where casing of hole is necessary to prevent soil caving.

<u>GRADATION TYPE "B"</u>

a) wet and caving condition with saturated granular or cohesive soils

b) dry and caving condition with sandy soils

c) dry condition with dense moist granular soils or stiff hard cohesive materials

<u>GRADATION TYPE "C"</u>

a) Dry condition with dense moist granular soils or stiff hard cohesive materials

9.2.2.1.4. Base Material

Base material is used primarily for improving roadway stability and shall be used as a top course on all access roads and over the substation graded area. Adequate compaction as specified in the Design Documents is essential in providing adequate material stability and long term durability. This material shall meet the Road Base and Cap Aggregate specification in Section 4.1.1.1.

9.2.2.1.5. Lean Concrete Backfill

Lean Concrete Backfill may be placed around buried conduit in conjunction with underground substation construction where compaction of granular material around conduit or piping is difficult and/or impractical. This material is recommended where existing slabs or foundations are in danger of being undermined. This material shall meet the Lean Concrete Backfill specification in Section 4.1.2.4.

9.2.3. Security Fence

9.2.3.1. The security fence shall adhere to the requirements proposed in Section 2.7.

9.2.4. Bollards

9.2.4.1. Bollards shall be placed around no drive areas and areas such as in front of feeder risers to protect them from damage.

9.2.5. Substation Access Road

9.2.5.1. Driveways should be designed with a minimum 50 foot inside radius and enough space to straighten a truck out before going through the gate. Driveway paths within the fenced substation should avoid crossing precast cable trenches if possible.

9.2.6. Finish Conditions

9.2.6.1. The substation shall be covered with 4” of clean crushed stone. The crushed stone shall extend 5 feet outside of the substation fence and provide an electrical resistivity value of greater than or equal to 3,000 ohm-meters. Prior to placement of the crushed stone, the surface upon which the rock is to be applied shall be smooth, well compacted and to the design elevation. If any previously graded section is damaged, it shall be regraded prior to rock placement. The crushed stone shall be free of debris and deleterious material with the gradation in accordance with ASTM C 136 and as listed in Section 0.

9.3. Structural

9.3.1. Structural Steel Erection

9.3.1.1. This section describes the requirements for the complete and proper erection of structural steel as shown in the Design Documents.

9.3.1.2. Structural steel consists of steel elements essential to support the design loads and includes but is not limited to the items listed below:

9.3.1.2.1. Anchor bolts.

9.3.1.2.2. Base plates.

9.3.1.2.3. Beams, girders, columns and posts.

9.3.1.2.4. Bracing.

9.3.1.2.5. Structural material for connecting structural element to structural element.

9.3.1.2.6. Fasteners.

9.3.1.2.7. Leveling plates and associated materials.

9.3.1.3. Referenced Codes and Standards

The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard or code conflict with these Specifications Owner shall be notified at once and a remedy shall be determined.

9.3.1.4. American Institute of Steel Construction:

9.3.1.4.1. AISC Steel Construction Manual

9.3.1.4.2. AISC Specification for Structural Steel Buildings.

9.3.1.4.3. AISC Code of Standard Practice for Steel Buildings and Bridges.

9.3.1.5. American Society for Testing and Materials

9.3.1.5.1. ASTM A36 Specification for Structural Steel.

9.3.1.5.2. ASTM A992 Standard Specification for Structural Steel Shapes

9.3.1.5.3. ASTM A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

9.3.1.5.4. ASTM A325 Specification for High-Strength Bolts for Structural Steel Joints.

9.3.1.5.5. ASTM A307 Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

9.3.1.5.6. ASTM F959 Specification for Compressible-Washer-Type Direct Tension Indicators for use With Structural Fasteners.

9.3.1.5.7. ASTM E94 Guide for Radiographic Testing.

9.3.1.5.8. ASTM E142 Methods for Controlling Quality of Radiographic Testing.

9.3.1.5.9. ASTM E164 Practice for Ultrasonic Contact Examination of Weldments.

9.3.1.5.10. ASTM E165 Practice for Liquid Penetrant Inspection Method.

9.3.1.5.11. ASTM E709 Practice for Magnetic Particle Examination.

9.3.1.6. American Welding Society:

9.3.1.6.1. AWS D1.1 Structural Welding Code – Steel

9.3.1.7. Research Council on Structural Connections:

9.3.1.7.1. Specification for Structural Joints Using ASTM A325 or A490 Bolts

9.3.1.8. Welder Certification

9.3.1.8.1. Contractor shall submit AWS qualifications of welders performing welding on structural steel.

9.3.1.9. Structure Erection

9.3.1.9.1. Contractor shall perform the following tasks to properly and completely erect each steel structure:

9.3.1.9.2. Set structural steel accurately to lines and elevations indicated.

9.3.1.9.3. Align and adjust various members forming part of a complete frame or structure before permanently fastening.

9.3.1.9.4. Clean bearing surfaces and other surfaces which will be in permanent contact before assembly.

9.3.1.9.5. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

9.3.1.9.6. Level and plumb individual members of each structure.

9.3.1.9.7. Splice members only where indicated in the Design Documents.

9.3.1.9.8. Complete all structural connections with proper installation and torque requirements of fasteners.

9.3.1.9.9. Foundation Loading

Steel structures shall not be erected on concrete foundations until the concrete has achieved 75% of design strength. Steel structures shall not be loaded until foundation concrete has achieved 100% of design strength.

9.3.1.9.10. Surveys

Contractor shall check elevations of concrete bearing surfaces and locations of anchor bolts and similar devices before erection work proceeds and report discrepancies to Owner. Contractor shall not proceed with erection until corrections have been made or until compensating adjustments to structural steel work have been approved by Owner.

9.3.1.9.11. Temporary Shoring and Bracing

Contractor shall provide temporary shoring and bracing members with connections of sufficient strength to bear loads imposed during construction. All temporary members and connections shall be removed when permanent members are in place and final connections are made. Temporary guy lines may be used to achieve proper alignment of structures as erection proceeds.

9.3.1.9.12. Setting Base and Bearing Plates

Contractor shall set loose and attached base plates and bearing plates for structural members on wedges or other Owner approved adjusting devices. Anchor bolts shall be tightened after supported members have been positioned and plumbed.

9.3.1.9.13. Bolted Connections

Wrenches which may deform the nuts or cut or flake the galvanizing will not be permitted.

Multiple-Bolt, Moment Connections

The bolts shall be tightened in accordance with Manufacturer's guidelines.

Single-Bolt, Pinned Connections

The bolts shall be tightened until the bolt head and nut are snug against the outer plates and the nut locking device is fully engaged. The inner plate surfaces do not necessarily need to be in full contact with each other to obtain an acceptable connection.

Enlarging Bolt Holes

Holes in members shall not be enlarged without Owner approval. Holes which must be enlarged shall be reamed, under the direction of Owner, to accommodate the next larger size bolt. Holes shall not be enlarged by burning or by using drift pins.

Substitution of Bolts

Substitution of the bolt sizes and materials specified in the Design Documents must be approved by Owner.

9.3.1.9.14. Field Correction of Fabrication Errors

Contractor shall not use gas cutting torches to correct fabrication errors in primary structural framing members. Gas cutting will be permitted only on secondary members that are not under stress.

Field Welding

Field welds shall not be permitted without review by Owner. All approved field welding shall be performed in accordance with AWS requirements for weld material and prequalified joints and shall be performed by certified welders.

Contractor shall submit AWS qualifications of welders performing field welding on structural steel.

Field Drilling

Missing holes shall be added by drilling or punching. Flame cutting of holes shall not be used.

Field Repair of Galvanizing

All metal exposed as a result of field repair activities shall be re-coated.

9.3.2. Surface Coating Repair

9.3.2.1. Reference Codes and Standards

The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

9.3.2.1.1. Steel Structures Painting Council:

SSPC-PA1 Shop, Field, and Maintenance Painting.

SSPC-SP3 Power Tool Cleaning.

9.3.2.1.2. American Society for Testing and Materials:

ASTM A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

9.3.2.2. Equipment

9.3.2.2.1. Surfaces of most electrical equipment (such as panels, switchgear, transformers, circuit breakers, cabinets, junction boxes, etc.) are finished at the factory. Contractor shall exercise great care to prevent damage to this original finish during installation of the equipment and during construction work. If the factory finish is damaged during shipment, installation or the course of construction, the damaged surface area of the component shall be refinished. The refinished surface shall be equivalent in every respect to the original surface, including color, texture, gloss, and smoothness. Refinishing paint if furnished with the equipment may be used; otherwise, the paint shall be obtained from the equipment manufacturer.

9.3.2.3. Structural Steel

9.3.2.3.1. Contractor shall be responsible for repairing galvanized surfaces of structural steel damaged during shipment, erection, field modifications or during the course of construction and for applying an approved surface coating over any bare metal areas which were not galvanized during fabrication. All bare metal areas and bolted connections which are subject to corrosion and requiring galvanizing repair shall be cleaned and repaired in conformance with SSPC-PA1, ASTM A780 and the manufacturer's instructions.

9.3.2.3.2. Immediately after structure erection has been completed, all field welds shall be ground smooth and the adjacent uncoated areas and any areas where the coating has been damaged shall be cleaned in conformance with SSPC-SP3.

9.3.2.3.3. All steel requiring galvanizing repairs shall be coated with an inorganic, zinc-rich coating in accordance with the following conditions:

a) The galvanizing repair paint shall be SSPC-Paint 20 or DOD-P-21035, with a dry film containing a minimum of 94 percent zinc dust by weight.
b) Surfaces to be coated shall be free of abrasives, oils, dirt or other contaminants.
c) Handling of coating equipment and the steel surfaces to be repaired shall be performed in a manner to avoid contamination prior to, during and following the application of the protective coat.
d) The surface temperature of the steel to be coated shall be 50°F minimum and at least 5°F above the wet-bulb air temperature reading.

e) The coating shall be allowed to cure prior to application of a second (or top) coating for at least the minimum time recommended by the coating manufacturer.

f) The coating thickness shall be 3.0 mils dry film thickness. The thickness shall be monitored by wet-film thickness measurements.

g) Areas with dry-film thickness of less than 1.7 mils or greater than 5.0 mils shall be corrected by additional surface coating or by wire brushing and recoating.

9.4. Electrical

9.4.1. Equipment Installation

9.4.1.1. Power Circuit Breakers and Circuit Interrupters

9.4.1.1.1. Contractor’s external inspection, receiving and installation activities shall include but not be limited to the following:

Receive the breaker at the shipping point.

Examine the shipment and note any obvious signs of damage or rough handling.

Inventory the shipment and check it against the shipping list.

Report any shortages to the Manufacturer and Owner.

Place the power circuit breaker on the foundation.

Orient the breaker mechanism cabinet as shown in the Design Documents.

Install SF6 gas if required.

Fill to proper pressure per name plate requirements.

Perform a gas system moisture check. (The gas should be processed and the breaker tank evacuated as need is indicated in the Manufacturer’s instructions.)

Check for gas leaks.

Install bushings.

Install ground assemblies.

Install bus system connections

Install conduit runs into the equipment cabinet.

Make all secondary electrical power connections.

Terminate all control cables.

9.4.1.2. Power Transformers

9.4.1.2.1. Power transformer purchaser’s activities shall include:

Delivery of transformer to site.

Offloading of transformer at site.

Assembly of transformer, including installation of all accessories that are shipped separately, filling of transformer with oil, oil processing, etc.

9.4.1.2.2. Contractor's installation activities shall include, but not be limited to:

Testing of transformer.

Install ground assemblies.

Install bus system connections.

Install conduit runs into the equipment cabinet.

Make all secondary electrical power connections.

Terminate all control cables.

9.4.1.3. Disconnect Switch and Fuse Installation

9.4.1.3.1. Contractor's installation activities shall include but not be limited to the following:

Install manual or motor operating mechanisms such that they affect a smooth and thoroughly controlled movement throughout the entire opening and closing cycles of the group operated switch. All rods, shafts, pipe linkages, connectors, operating levers, supports and fittings shall show no noticeable deflection when operating the switch.

Install group operated switches and operating mechanism such that the switch blades open and close simultaneously. All switches will be manually operated until approved by Owner. Adjust all cam, spare contacts and limit switches in accordance with the Manufacturer's installation and maintenance instructions.

Ground the switch handle as shown in the Design Documents. Arrange and align switch handles to ensure the proper switching of the unit from the operator's standing area. The switch operating mechanisms shall not be pierced until the installation has been inspected by Owner.

Install mechanical interlocks, electrical interlocks, or key interlocks in accordance with the Manufacturer's installation and maintenance instructions. Contractor shall be responsible for the final adjustment of the interlock schemes.

9.4.1.3.2. No drilling of any tubular member in the supporting structure to secure the switch-operating mechanism is allowed. All mounting assemblies shall require the approval of Owner.

9.4.1.3.3. Spare power fuse elements shall be stored by Contractor in the control building or other Owner approved shelter.

9.4.1.4. Lighting and Station Auxiliary Power

9.4.1.4.1. Contractor shall install the battery rack, install and test the battery cells, install intercell connectors and ready the battery terminals for Contractor connections.

9.4.1.4.2. Contractor's station auxiliary power installation activities shall include but not be limited to the following:

Locate . fixtures and outlet receptacles as shown in the Design Documents and coordinate with other work in the same area to prevent interference between fixtures and piping or other equipment. Contractor shall relocate any fixture or outlet if, after installation, it is found to interfere with other equipment or is so located to prevent its practical and intended use.

Install all lighting and receptacle load centers, AC control power panel boards and DC control power fuse cabinets as shown in the Design Documents.

Each cabinet shall be installed, conduits connected and wires pulled before the panel board interior is installed. Each panel board interior shall be carefully inspected, all connection and mounting screws tightened and mounted in the cabinet using all of the mounting provisions furnished. The panel board interior shall then be connected, with wires tightly secured in the terminals provided and with unnecessary lengths of wire eliminated. Wiring shall be neatly arranged in the gutters.

The circuit directory shall be accurately and neatly completed to permit ready location of the protective devices controlling circuit loads.

Install station service transformer(s), main disconnect safety switch(s) and automatic or manual transfer switch as shown in the Design Documents.

Install the battery charger as shown in the Design Documents.

9.4.1.5. Wall Mounted Equipment

9.4.1.5.1. All equipment located against the wall of the control building shall be secured by the following methods:

Equipment weighing less than 150 pounds shall be fastened to formed channel members that are secured directly to wall purlins or columns. The formed channel shall be configured in a neat arrangement utilizing the minimum number of members to mount all present and future equipment in the locations shown in the Design Documents.

Equipment weighing more than 150 pounds shall not be supported by the wall. Support stands, fabricated from formed channel and fastened to the floor, shall be used to transfer equipment load to the floor.

9.4.1.5.2. All field-fabricated equipment mounting arrangements shall be subject to Owner approval.

9.4.1.6. Reactive Compensation Equipment

9.4.1.6.1. The contractor shall evaluate the need for reactive compensation equipment as follows:

The facility shall be designed and constructed in accordance with FERC Order 827 as well as any Regional Transmission Organization (RTO) requirements. In the case of conflicting direction the more stringent requirement shall govern.

The capabilities of the proposed turbines as outlined in the provided turbine supply agreement (TSA) document, as well as transmission line lengths and/or joint use assets (multiple facilities sharing an element) shall be factored in.

Any applicable requirements of an interconnect agreement (IA) and/or system impact study (SIS) shall also be upheld.

9.4.1.6.2. Based on the above factors, any necessary capacitor banks, reactor banks, dynamic VAR equipment, etc. shall be included in the substation design, including all necessary related equipment such as circuit breakers, circuit switchers, bus, foundations, protective relaying, and any other necessary items for the full operation of the VAR equipment.

9.4.1.6.3. Coordination, design, and checkout with the turbine manufacturer based on the TSA documentation shall also be included.

9.4.1.6.4. An interlock system shall be provided to prevent the opening of energized ground switches.

9.4.2. Grounding System

Contractor shall install a complete buried ground grid system and a grounding system for all equipment and devices including, but not limited to, switch operating mechanisms, overhead shield wires, surge arresters, circuit breakers, regulators, meter cabinets, cable termination cabinets, potential and current transformers, power transformers, auxiliary power transformers, structures, fence, control building, relay and control panels, cable trays, AC distribution panels, conduit bushings, shielded cables and cable trench.

9.4.2.1. Referenced Codes and Standards

9.4.2.1.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

9.4.2.1.2. ANSI/IEEE Standards:

a) IEEE Std. 80Guide for Safety in AC Substation Grounding.
b) American Society for Testing and Materials:
c) ASTM B3 Soft or Annealed Copper Wire.
d) ASTM B-8 Concentric-Lay Stranded Copper Conductor.

9.4.2.1.3. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

9.4.2.2. Installation

9.4.2.2.1. Grounding conductors shall be straight and free from kinks, breaks and other damage after installation. Connections shall be made in conformance with the manufacturer's instructions. Conductors shall be thoroughly cleaned prior to making connections. All junctions and splices of buried ground grid conductors shall be made at a ground rod location, wherever reasonably possible. Likewise, ground rods shall be installed at intersecting points of the ground grid conductors and at all equipment locations as shown in the Design Documents. Driving studs shall be utilized.

9.4.2.2.2. All bolted installations shall use lock washers. Paint, rust or other non-conducting material shall be completely removed from the contact surfaces until the bonding surfaces are clean and bright and these surfaces coated with an oxide-inhibitor compound such as Burndy "Penetrox A", Alcoa “No-Ox-Id”, Alcoa No. 2 or other Owner approved equal before making ground connections. Galvanized steel surfaces shall be cleaned with emery paper prior to the application of oxide-inhibitor compound. After the connection has been made any exposed metal subject to corrosion shall be coated.

9.4.2.2.3. Equipment and Structure Grounding

a) All equipment and all steel or aluminum structures shall be solidly connected to the buried ground grid system as shown in the Design Documents. Grounding conductor to loop up to the steel to be CAD welded rather than a pigtail coming up.

b) All neutral conductors, ground electrodes and groundable parts of equipment shall be interconnected as shown in the Design Documents

9.4.2.2.4. Fence Grounding

The fence system, that includes but is not limited to the fence gates, line posts, corner posts, top rail, fence fabric and barbed security wire, shall be solidly connected to the buried ground grid as shown in the Design Documents.

9.4.2.2.5. Electrical Equipment Enclosure Grounding

All ground bus bars in panels and on the interior walls and equipment within the control building shall be connected solidly to the ground grid as shown in the Design Documents.

9.4.2.2.6. Underground Power Circuits

All metallic conduits, metallic cable shielding and sheath and concentric neutral wires shall be effectively grounded at terminations only as shown in the Design Documents.

9.4.2.2.7. Ground Wells

Ground wells shall be located and installed as shown in the Design Documents. The Ground wells shall be installed after all other ground systems have been installed.

9.4.2.3. Grounding inspection and testing requirements.

9.4.2.3.1. All below-grade taps, junctions and splices shall be left uncovered until inspected by the Owner or owner's representative. All unsatisfactory ground connections shall be replaced at the Contractor's expense.

9.4.2.3.2. All exothermic welded connections shall not appear porous or deformed. All bolted ground connections shall be securely tightened.

9.4.2.4. Grid Resistance Test

9.4.2.4.1. The results of the ground grid resistance tests shall include a plan view diagram of the measurement area and a graph for each individual measurement. Appropriate dimensions shall be included on the plan view diagrams. A copy of each test result shall be forwarded immediately to the Owner.

9.4.3. Bus Systems

This Section describes the complete and proper installation of a substation bus system. All work described in this Section and shown in the Design Documents shall be thorough and performed in a neat and workmanlike manner. Bus systems shall include but are not limited to rigid buses, conductors, flexible strain and equipment jumper buses, cable jumpers, overhead shield wires, suspension insulators, station post insulators, fittings, and all hardware required to form a complete system of current-carrying paths connecting the equipment as shown in the Design Documents. Connectors shall include but are not limited to bolted devices, welded devices, clamps, strain clamps, dead-end fittings, terminal devices, and couplings as shown in the Design Documents.

9.4.3.1. Referenced Codes and Standards

The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

9.4.3.1.1. American Welding Society

Welding Handbook RP69

AWS D-1.2Structural Welding Code-Aluminum

9.4.3.1.2. American Society for Testing and Materials

ASTM B-8 Standard Specification for Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

ASTM B-230 Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes.

ASTM B-231 Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors.

ASTM B-232 Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated Steel-Reinforced (ACSR).

ASTM B 345 Standard Specification for Seamless Aluminum Pipe, 6063-T6 alloy.

ASTM B 49 Standard Specification for Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel-Reinforced (ACSR).

9.4.3.1.3. The Institute of Electrical and Electronic Engineers

IEEE 524; IEEE Guide to the Installation of Overhead Transmission Line Conductors.

9.4.3.2. Rigid Bus Installation

All tubular bus connectors shall be welded type unless otherwise noted in the Design Documents. Welding of buses and connectors shall conform to the Manufacturer's recommendations and these Specifications. Welded bus couplers shall be located and installed as shown in the Design Documents. End plugs or caps shall be installed at all open ends of bus tubing including bus ends within an expansion fitting.

9.4.3.3. Tubular Bus

9.4.3.3.1. Tubular bus conductor bends shall be formed using a hydraulic conduit bending tool. The inside radii of bends shall be no less than seven (7) times the nominal diameter of the bus. The bus shall be free of kinks, indentations and flattened surfaces.

9.4.3.3.2. One-fourth (1/4)-inch weep holes shall be drilled in all bus risers, bends, A-frames and horizontal runs at the lowest practical point to drain moisture accumulation. All holes shall be reamed to remove sharp edges.

9.4.3.4. Bolted Connections

9.4.3.4.1. Utmost care shall be exercised when installing clamps, connectors, and other bolted devices. The contact surface of the flat surface, clamp or connectors and the bonding surface of the wire or tubing shall be clean and bright and an oxide-inhibitor compound such as Burndy "Penetrox A", Alcoa “No-Ox-Id”, Alcoa No. 2 or other Owner approved equal shall be applied. Use a stainless steel brush to clean mating surfaces by thoroughly scratch-brushing the contact surfaces through the inhibitor, leaving enough inhibitor on the surface to prevent reformation of oxides. Plated surfaces shall not be brushed. After the connection is completed, additional compound shall be applied and forced into every irregularity and opening to completely seal the joint.

9.4.3.4.2. Aluminum to Copper connections shall be made only with flat contact surfaces prepared as indicated above. The aluminum connector shall be located above the copper connector when placed in a horizontal plane. Bolts for aluminum to copper connections shall be used as specified below:

Aluminum bolts shall be used if the copper conductor is less than 1.5 times the thickness of the aluminum conductor.

Bronze (Everdur) bolts shall be used if the copper conductor is more than 1.5 times the thickness of the aluminum conductor.

9.4.3.4.3. Aluminum conductor shall not be used with bronze clamp-type equipment terminal lugs.

9.4.3.4.4. All bolted electrical connections shall be made with anodized aluminum hardware as shown in the Design Documents. Bolts shall be tightened firmly, but threads must not be over-stressed. Bolts in clamps over stranded conductor shall be tightened sufficiently to flatten the lock washers. Do not deform or damage the conductor. Bolts shall extend beyond the nut a minimum of one-half (1/2) bolt diameter. Aluminum bolts shall not be cut off and shall be tightened with a torque wrench per the following recommendations:

9.4.3.4.5. Required tightening torque for anodized aluminum 2024-T4 National Course thread bolts and nuts tightened against aluminum 2024-T4 washers and all parts being pre-coated with oxide inhibitor compound are as shown in Table 23.

Table 23: Required tightening torque for anodized aluminum 2024-T4 National Course thread bolts and nuts tightened against aluminum 2024-T4 washers.

Bolt Size (in.)	Torque (ft.-lb.)
3/8	15
7/16	20
1/2	25
5/8	40
¾	60

9.4.3.5. Welded Connections

9.4.3.5.1. Welder Qualifications

All aluminum bus welds shall be performed and welded-type connectors shall be installed by a welder qualified per AWS D-1.2. The welder must be qualified for the following categories:

Materials: No.23, aluminum base alloys.

Weld: groove.

Position: 6G.

A current welding certificate for each on-site welder must be submitted to Owner prior to task mobilization.

9.4.3.5.2. Preparation and Materials

All aluminum welding shall be done in strict conformance with the latest recommendations of the American Welding Society and the Aluminum Association in addition to the requirements stated herein. All surfaces to be welded shall be thoroughly cleaned to remove all moisture, grease, oil, grit and other foreign material prior to welding. Cleaning shall be performed as close to actual welding time as possible while still allowing sufficient time for complete drying of cleaning solvent. Surfaces shall then be wiped just prior to welding with a clean, dry cloth to remove solvent scum and any moisture that may be present. Surfaces shall be wire brushed immediately prior to welding.

The edges of the materials to be butt-welded together shall be prepared in conformance with the data tables and joint design drawings of Table 69.14, Table 69.16, and Figure 69.22 of Chapter 69, Welding Handbook RP69 of the American Welding Society. Where other than butt-weld joints are to be made, if joint details are not shown in the Design Documents, Contractor shall submit proposed joint designs for approval to Owner.

When the ambient temperature is below 40°F, the base metal shall be preheated for both tack welding and finish welding in such manner that the surface temperature of the parts to be welded are at or above 72°F for at least three (3) inches both laterally and in advance of the welding. Preheat temperature shall not exceed 400°F. Suitable enclosures shall be constructed as needed to protect the inert-gas envelope from interference by air currents or wind.

9.4.3.6. Bus Damping

9.4.3.6.1. External bolted-type tubular bus vibration dampers shall be installed on all horizontal bus spans in the locations shown in the Design Documents.

9.4.3.7. Strain and Jumper Bus Installation

9.4.3.7.1. Strain and jumper buses shall be installed in conformance with the Design Documents and manufacturer's recommendations. Cable for the strain and jumper buses shall conform to ASTM B-232. Each individual aluminum wire entering into the construction of the completed conductors shall conform to ASTM B-230.

9.4.3.7.2. Contractor shall install conductors, shield wire and accessories in accordance with the Manufacturer's recommendations and IEEE Std. 524-1992. This IEEE standard, covering conductor handling, grounding, stringing, sagging, dead-ending, splicing, equipment, installation of accessories and special conductors shall be followed in all respects with the exception of items defined in this Section.

9.4.3.7.3. Handling, stringing, sagging and clipping in of the conductor and shield wire shall be by methods which will prevent damage to the conductor, shield wire or line structures. Contact with the ground or other abrasive surfaces shall be prevented. Any remedial action regarding handling of the conductor will be at Owners direction, including replacing rejected material at no cost to Owner.

9.4.3.7.4. Jumper buses shall be smoothly formed and adjacent runs shall be similarly and symmetrically shaped to provide a uniform and pleasing appearance throughout. Stranded conductor shall be installed without twists “bird caging” or kinks and shall be handled to avoid abrasions or other damage. Splices shall not be allowed in overhead strain buses. Strain buses shall be sagged in conformance to sag tables supplied by Owner.

9.4.3.7.5. Contractor shall furnish Owner, at least two (2) weeks prior to intended use, the information detailed below. Failure to provide this information and receive approval shall be cause for the suspension of stringing operations.

A list showing the type, size, brand name and catalog number of all grips (including stocking type and come along) and/or other tools and equipment used for attachment to the conductor, shield wire and guys for the purpose of pulling and sagging conductors and shield wires and installing guys.

A list of the manufacturer and catalog numbers for all compressive type (hydraulic compression or implosive) dead-ends, splices, sleeving presses and dies.

9.4.3.7.6. Compression Connections

Cable connectors shall be compression or welded type as shown in the Design Documents.

All conductors at joints and fittings shall be clean and free of foreign matter. An oxide-inhibiting compound such as Burndy "Penetrox A", Alcoa “No-Ox-Id”, Alcoa No.2 or Owner approved equal shall be used on all aluminum conductor connections.

Compression type terminal lugs shall be made using a compression tool provided with a ratchet or toggle mechanism that ensures complete crimping before the tool can be removed.

Enough inhibitor must be in the barrel of each terminal lug such that it squeezes out around the conductor when inserted and compressed.

9.4.3.8. Insulator Installation

9.4.3.8.1. Station post insulators shall be installed in accordance with the Manufacturer's recommended procedures and the Design Documents.

9.4.3.8.2. All insulators shall be cleaned of oil, dirt, paper, tape or other foreign materials. Any insulator having the surface glaze damaged in any way shall not be installed.

9.4.3.8.3. Contractor shall be responsible for furnishing and installing all missing miscellaneous hardware necessary for a complete insulation system. Miscellaneous hardware can include but is not limited to bolts, nuts, lock washers, eye-bolts, shackles, clevis-pieces, etc.

9.4.3.9. Clearances

9.4.3.9.1. Clearances and spacing of bus work and conductors shall be equal to or greater than those shown in the Design Documents.

9.4.4. Panels and Instrumentation

9.4.4.1. Contractor shall install all mounting and attachment hardware for the panels and instrument racks. Instrument racks shall be securely attached to the floor with anchor bolts in accordance with the Design Documents.

9.4.4.2. Contractor shall install all components not installed by the panel fabricator and shall complete all internal panel wiring to these components.

9.4.4.3. Field Installation of Instruments

9.4.4.3.1. The installation of all field-added instruments, meters, terminal blocks, relays, switches, fuse blocks, terminal blocks, strip heaters and control devices shall conform to the Design Documents. In addition to the panel-front labels, device identification labels shall be placed on the back of the panels adjacent to, or on each device by the method described in the Design Documents.

9.4.4.3.2. All field cutting for the instrument mounting panel or enclosure shall be punched, drilled, or sawed. Contractor shall use the utmost care to avoid damaging the panel or enclosure finish. Thermal cutting shall not be used.

9.4.4.3.3. A minimum of a three (3) inch vertical space shall be maintained between all rear mounted test switches, blocking bar switches and fuse blocks. All rear mounted test switches, fuse blocks and devices shall be located on the wing pan near the relays or meters they are connected to.

9.4.4.4. Field Wiring

9.4.4.4.1. All wire installed in the field shall conform to the Design Documents

9.4.4.4.2. Internal panel wiring installed in the field shall be bundled, routed and secured adjacent to the side wing panels and back of the front panel using cable ties in a neat and workmanship like manner. The use of Panduit or other raceways will be accepted only on the side wing panels adjacent to terminal blocks as shown in the Design Documents or directed by Owner. The conductors shall not cross the width of the panel unsupported. The conductors shall be routed or secured in a manner that will not obstruct subsequent additional wiring, to the terminals of any installed component. Looping of excess wire in Panduit wireways is to be limited. Splicing of internal panel wiring will not be accepted.

9.4.5. Wiring Systems (600V and below)

9.4.5.1. Contractor shall install all indoor and outdoor lighting fixtures, panelboards, switches, indoor and outdoor outlets, wiring accessories and devices and all other electrical materials to complete the indoor and outdoor secondary electrical system. Contractor shall be responsible for all attachment materials to complete the installations. All materials and equipment to be used during installation of the wire and cable shall be stored so as to protect them from deterioration or damage. All control and power cables shall be unshielded, unless specifically stated otherwise in the Design Documents or this Specification.

9.4.5.2. Referenced Codes and Standards

9.4.5.2.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

9.4.5.2.2. National Electrical Manufacturers Association:

NEMA WC-3 Also known as ICEA S-19-81.

NEMA WC-7 Also known as ICEA S-66-524.

NEMA WC-8 Also known as ICEA S-68-516.

9.4.5.2.3. The Institute of Electrical and Electronic Engineers:

IEEE 383; Type Test of Class 1E Electric Cables, Field Splices and Connections

9.4.5.2.4. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

9.4.5.3. Installation

9.4.5.3.1. Wire and cable shall be installed in such a manner that the cable jacket is not damaged. Any wire or cable that is damaged during installation shall be removed and replaced at Contractor's expense.

9.4.5.3.2. Labeling

All wire terminations shall be labeled.

The labeling method chosen shall not cover the barrel of the terminal lug or otherwise interfere in any way with access to the barrel of the lug.

The wire identification number used with the labeling system shall match the identification number on the terminal block marking strip that it originated from.

Instrumentation and control cables and wires in the same circuit or grouping shall be identified by circuit numbers as indicated in the Design Documents. The circuit number shall be fastened to each cable or wire grouping at each terminal, cable trench, pull box, manhole, hand hole and junction point. Ty-Rap cable markers, type TY551M or TY-546, manufactured by the Thomas & Betts Co., or other Owner approved equal are required.

Contractor shall use accepted NEC code practices for providing the required colors at the wire ends of AC power circuits.

9.4.5.3.3. Splices

Cables or wires, except for lighting and receptacle cable, shall not be spliced.

Wire for lighting circuits shall be continuous from outlet to outlet. Splices shall be made in outlet or junction boxes. At least six (6) inches of free conductor shall be left at each outlet to make splices of joints, except where it is intended to loop through sockets, receptacles and other fixtures without splices or joints.

9.4.5.3.4. Terminations

Solderless-type terminal lugs and connectors shall be used for connecting #9 AWG wire and smaller stranded cable to studs.

Terminations shall be made with pressure-type terminal lugs using a compression tool provided with a ratchet or toggle mechanism that ensures a complete and positive crimp before the tool can be removed.

Terminations for wire sizes larger than #8 AWG shall have at least two (2) indentations.

Cables and wires used for all instrumentation and control connections shall be terminated with seamless, non-insulated, ring-type Burndy YAV hylug-type compression connectors. Substitute connectors must be submitted for Owner approval at the time of bid with the following documentation:

Type of connector proposed.

Sample of proposed connector for Owner inspection.

Documentation of the process used for making the terminations and quality control measures.

Wire strands shall not be removed from the end of a cable in order to reduce the conductor diameter. Appropriately sized terminal lugs must be used to maintain the same ampacity rating as the cable.

Sufficient length shall be left at all ends of wires and cables to conveniently make connections to equipment and devices. Spare conductors at the end of a multiconductor cable shall be coiled neatly and retained in a length equal to that of the longest single conductor at each end of the multiple-conductor cable. All cables entering a terminal cabinet, switchgear compartment, distribution board, or other such device from a conduit, cable slot, or cable trench shall be clamped securely at the opening. All exposed cable or wire runs shall be bunched and tied so as to prevent movement.

Cable connections to pad-mounted equipment shall have enough slack left in the cable to allow for thermal expansion and contraction. When pad-mounted equipment has a wiring compartment underneath, a full coil of cable shall be installed before the cable is terminated.

Cables and wires shall not be bundled in a cable tray or floor trench, but shall be bundled and laced immediately after passing through an opening in the tray or trench cover at each instrument panel rack.

Spare conductors in a cable shall be neatly coiled with taped ends or terminated as shown in the Design Documents.

A threaded stud shall be used if more than two wires are landed on the same point on a terminal block.

9.4.5.3.5. Cable Pulling

A careful determination of the length of all wire and cable runs shall be made by Contractor prior to any cable installation in order to minimize pulling stresses. Cable pulling tensions shall not exceed those recommended by the cable vendor or supplier. Wire and cable shall be handled with care to avoid damage. Contractor shall carefully inspect all wire or cable for visible defects. Instances of damaged wire or cable shall be promptly brought to the attention of Owner or its representative, who shall determine the action to be taken to correct such defects.

A clean, dry, tight-fitting rag shall be drawn through the conduit immediately before installing the wire or cable. No wire or cable shall be installed in conduit unless it is free of all foreign material.

An Owner approved water-based lubricating material non-injurious to the insulation or jacket shall be used when necessary to prevent mechanical damage.

No cable shall be installed prior to the completion of the raceway system in which the cable is routed in.

9.4.5.3.6. Grounding of Shielded Wire and Cable

Shielded wire and cable shall have the shield grounded strictly in accordance with the Design Documents.

9.4.6. Fiber Optic Cable System

9.4.6.1. Contractor shall be responsible for supplying all attachment materials to complete the installation. All materials, equipment and accessories to be used during installation of the fiber optic cable shall be stored so as to protect them from deterioration or damage.

9.4.6.2. Referenced Codes and Standards:

9.4.6.2.1. The following codes and standards, amended to date, shall govern this work and are considered a part of these Specifications. If requirements in a referenced specification, standard, or code conflict with these Specifications, Owner shall be notified at once and a remedy shall be determined.

9.4.6.2.2. National Fire Protection Association:

Most recent version of the National Electrical Code (NEC)

9.4.6.2.3. Electronics Industry Association:

EIA-455 Series Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices

9.4.6.3. Installation

9.4.6.3.1. All fiber optic cable must be handled with care. The fiber optic cable must not be trampled upon, run over by vehicles or pulled over fences or metal fittings. Contractor shall not place any fiber optic cable without notifying Owner at least one working day prior to placement.

9.4.6.3.2. Fiber optic cable shall not be bent in a radius less than 16 times the outside diameter of the cable during the placing operations.

9.4.6.3.3. All open cable ends, either placed or remaining on a cable reel, shall have a cable cap placed on them. Cable caps shall be molded neoprene with adjustable stainless steel band for tightening cap to cable.

9.4.6.3.4. Contractor shall install all fiber optic cable in direct buried non-conducting conduit.

9.4.6.3.5. Temporary bonds to ground the splice cases shall be established during the construction and subsequent splice maintenance work to mitigate any possible electrical shock.

9.4.6.3.6. Care must be exercised to ensure that a solid bond is established between the Optical Phase Ground Wire (OPGW) and ground clamps without crushing the optical fiber unit.

9.4.6.3.7. Fiber patch panel schedules shall be updated when fibers are spliced in the panel.

9.4.6.4. Splices

9.4.6.4.1. Splicing of fiber optic cables shall be performed using the fusion splicing method utilizing an electric arc. Chemical bonding or mechanical splicing methods shall not be used. Fusion splicing equipment shall have the following features:

a) Optical viewing to simplify pre-alignment.
b) A pre-fusion process to round the fiber ends to avoid bubble formations.
c) Controllable inward movement of the fibers to prevent necking at the joint.

9.4.6.4.2. Contractor shall provide all tools, and labor to connect, via fusion splicing, the optical fibers of the direct buried fiber optic cable to the optical fibers of the OPGW.

9.4.6.4.3. The splices are to be housed in an outdoor weatherproof housing supplied with the OPGW. Owner reserves the right to reject any splices with losses in excess of 1 dB.

9.4.6.4.4. All splicing of fiber optic cable shall be performed at ground level in accordance with the Manufacturer's recommendations.

9.4.6.4.5. All fusion splices shall be housed in splice trays.

9.5. Submittals

9.5.1. Control Drawings

9.5.1.1. Owner utilizes template drawings for most control schematics, panel elevations, and other protection and control related drawings which are called **CONTROL MASTER**. Contractor shall reference these master drawings in the development of the substation control drawings along with this specification, and drawings provided with this specification.

9.5.2. The following drawings to be submitted:

9.5.2.1. Topography Layout

9.5.2.2. Contour and Grading Layout

9.5.2.3. Foundation Layout

9.5.2.4. Electrical Equipment Enclosure Architectural Layout

9.5.2.5. Steel Details

9.5.2.6. Circuit Diagram

9.5.2.7. Substation Operating One Line

9.5.2.8. General Arrangement

9.5.2.9. Electrical Layout

9.5.2.10. Minor Material List

9.5.2.11. Grounding Layout

9.5.2.12. Control and Lighting Layout

9.5.2.13. Electrical Equipment Enclosure

9.5.2.14. Metering and Relaying Diagram

9.5.2.15. Panel Elevation

9.5.2.16. Schematic Diagram

9.5.2.17. Data Retrieval Schematic Diagram

9.5.2.18. External Connections

9.5.2.19. Major Material Vendor Drawings

9.5.3. Other Substation Studies and Information

9.5.3.1. AC Service Sizing calculations to include transformer and fuse sizing, fault levels, and voltage drop.

9.5.3.2. DC Service Sizing calculations to include battery and fuse sizing, fault levels, and voltage drop.

9.5.3.3. AC and DC Voltage Drop calculations

9.5.3.4. CT burden and fault current saturation calculations

9.5.3.5. Ground Grid calculations

9.5.3.6. Lightning Shielding Design

9.5.3.7. RTU Points List

9.5.3.8. Relay Settings

9.5.3.9. RTU Settings

9.5.4. See Section 1.3 for more submittals information.

10. Electrical Equipment Enclosure

10.1. Design

10.1.1. The electrical equipment enclosure (EEE) shall be pre-manufactured and pre-wired prior to delivery.

10.1.2. The location and orientation of the (EEE) including accurate dimensions shall be indicated on the overall substation location plan. The EEE shall be located near the entrance gate.

10.1.3. Construction of the EEE shall be suited for its intended application. All material shall be new, of recent manufacture, and free from defects. The EEE shall be fully assembled and suitable for use upon completion of installation.

10.1.4. The EEE shall be designed to be installed in the environmental conditions typical for the substation location. Submittals shall indicate these design considerations, including but not limited to: insulation, snow loading, and HVAC capability.

10.1.5. The EEE furnished under this specification shall be designed in compliance with the latest published standards of the International Building Code (IBC), ANSI, IEEE, NEMA, NEC, NESC, MBMA, ASME, ASTM, and ASCE-7 unless otherwise noted. Any applicable local building codes for the location where the substation is being constructed shall be taken into account. If any of the requirements of this specification are in conflict with these standards, Contractor shall notify Owner immediately.

10.1.6. The EEE shall be at a minimum 14 feet x 40 feet (nominal). The size of the EEE shall be appropriate to house all indoor equipment for the substation, including but not limited to:

10.1.6.1. Relay and control panels. Optimize the panel space to keep the EEE size to a minimum, up to three relays on a panel.

10.1.6.2. Fiber patch panels & other communication equipment

10.1.6.3. Wind turbine generator management equipment

10.1.6.4. Field termination cabinets

10.1.6.5. Station service equipment, including AC panel boards and automatic transfer switches

10.1.6.6. DC panel boards, batteries, and battery chargers

10.1.6.7. Eye wash station

10.1.6.8. Lighting contactor for control of substation lighting

10.1.6.9. HVAC equipment

10.1.6.10. Interior and exterior lights and receptacles, including exterior receptacles for servicing HVAC units.

10.1.6.11. Small desk for operators

10.1.6.12. Hot-stick

10.1.6.13. Additional space for equipment not provided by Contractor

10.1.7. Stairs leading up to the entry/exit doors of the EEE. A three foot landing as wide as the door shall be provided.

10.1.8. A ground bus shall be provided in the EEE to provide grounding for all control, SCADA, and AC and DC panels. Ground location shall be indicated on submitted drawings.

10.1.9. Building alarms such as fire alarms, intrusion alarms, and temperature alarms shall be submitted for review. Note that the standard Owner termination cabinet includes temperature alarms for the EEE.

10.1.10. The eye wash station shall be located immediately adjacent to the area designated for the substation battery.

10.1.11. Cellular phone booster shall be included.

10.1.12. The following minimum requirements shall be met:

10.1.12.1. Steel Framing Members

10.1.12.1.1. Structural steel framing members 1/4 inch and thicker shall be of ASTM A36 or A572 steel. Hot rolled steel shall conform to ASTM A36, A500, A529, A570, A992 or A572, as required by design.

10.1.12.1.2. Structural steel framing members less than 1/4 inch thick shall be steel conforming to ASTM A446 Grade B (37,000 psi minimum yield strength) zinc-coated per ASTM A525 coating designation G90.

10.1.12.2. Fasteners

10.1.12.2.1. Structural framing shall utilize high strength bolts. Bolts shall conform to ASTM A325, Type 1 and shall be galvanized per ASTM A153, Class C or ASTM B695, Class 50.

10.1.12.2.2. Other bolts, nuts, and tap bolts shall conform to ASTM A307, Grade B, and shall be galvanized according to ASTM A153, Class C.

10.1.12.2.3. Sheet metal screws and/or self-tapping screws shall be zinc or cadmium-plated steel conforming to ANSI B-18.6.4, or equal.

10.1.12.2.4. Exposed wall and fascia panel fasteners shall have color-coated hearts to match the panel and washers for weather tightness.

10.1.12.3. Roof System

10.1.12.3.1. The Roof system shall include a 20-year warranty on material and weather tightness, and shall carry an Underwriters Laboratory (UL) Class 90 listing in accordance with UL 580.

10.1.12.3.2. The roof covering shall include exposed metal roof panels of 12 gauge (minimum) commercially pure aluminum coated steel, “Galvalume”, or coated steel (Galvanneal) with a color finish. As a minimum, base metal panels shall conform to the physical requirements of ASTM A446, Grade B. Panels shall be of such configuration to provide the load carrying capability and meet the deflection requirements specified herein. The coating shall have a 20 year warranty against rust perforation, a 20 year warranty against fading and chalking, and a 25 year warranty against flaking and peeling. Exterior color finish of roof, walls, doors shall be tan in color. Paint samples to be submitted for Owner approval.

10.1.12.3.3. Roof panels shall be “standing-seam interlocking” design and shall be secured to the roof purlins with a concealed structural fastening system. The concealed system shall provide minimal through penetration of the roof surface and allow the roof covering to move independently of any differential thermal movement by the structural framing system. Except at the concealed fastener, there shall be no thermal contact between the roof panels and supporting purlin. The standing seams shall have a factory-applied, non-hardening sealant.

10.1.12.3.4. Roof covering shall be properly designed with a sealing system provided at all roof and wall seams to provide a watertight building. The ridge, eaves, and openings together with necessary fascia and trim shall be caulked and sealed to provide a weather tight system.

10.1.12.3.5. Properly sized attic space ventilation shall be provided. All attic openings shall be screened to prevent entrance of bees, large insects, or birds.

10.1.12.4. Exterior Wall System

10.1.12.4.1. The exterior walls shall be comprised of galvanized steel panels with a PVDF resin-based finish. Exterior siding panels shall be overlapped and installed with appropriate self-tapping fasteners with integral gaskets and shall be removable without any disturbance to internal panels. The wall covering shall include a minimum 15-year warranty on paint. As a minimum, the panels shall be galvanized according to ASTM A525, coating designation G90.

10.1.12.4.2. Manufacturer’s standard exterior base flashing shall be provided with the building. Material shall be zinc-coated steel conforming to ASTM A446, Grade B and ASTM A525, coating designation G90. Flashing shall be manufacturer’s standard white in color, and have a baked silicon polyester (or equivalent) enamel coating.

10.1.12.4.3. Butted seams are not permissible.

10.1.12.4.4. All openings in the walls are to be structurally framed, sleeved, trimmed, and provided with external drip caps.

10.1.12.4.5. Repair or replacement of external panels must be able to be done entirely from the exterior of the EEE structure.

10.1.12.5. Interior Liner Panels

10.1.12.5.1. The EEE interior walls shall be lined with flush-fit with a minimum of 16 gauge, roll-formed liner panels. Liners shall be zinc-coated steel conforming to ASTM A446, Grade B and ASTM A525, coating designation G90. Liners shall be provided with base and ceiling trim. Panels shall be manufacturer’s standard white in color, and have a baked silicon polyester (or equivalent) enamel coating.

10.1.12.5.2. Liner panels shall be fully reinforced with concealed fasteners.

10.1.12.5.3. The EEE interior shall feature a complete trim system, including base, jamb, header, and ceiling trim.

10.1.12.6. Floor System

10.1.12.6.1. The EEE floor shall have a hot-rolled welded steel framework, comprised of hot-rolled steel or steel tube supports with a maximum deflection of L/240 under required loads. Cold formed joists shall be sized and spaced to meet design loads. The steel framework shall be supported on concrete piers, spacing, anchorage requirements, and layout to be indicated by the building designer. Steel floor members shall be hot-rolled steel that meets a minimum standard ASTM-A36. All galvanized steel shall meet ASTM-A653.

10.1.12.6.2. Steel floor shall be a welded steel top surface of at least ¼” thickness to handle floor design loads with a maximum deflection of L/240. The floor shall have a painted, slip-resistant finish. The bottom of the floor shall have a rodent and moisture barrier of recessed 26 gauge sheet galvanized steel. Floor welding standards shall meet all AWS recommended practices.

10.1.12.6.3. The floor framework and floor deck plates shall be fully cleaned, primed, and painted with a self-priming coating system designed to provide a durable finish, suitable for heavy resistance to fading. Paint is to have a minimum Dry Film Thickness per coat of 3-5 mils. Color is to be ANSI 61. A non-slip texture shall be added to the paint.

10.1.12.7. Insulation

10.1.12.7.1. Floor shall be insulated with fiberglass batt insulation between the joists and rigid polystyrene insulation between joists and fully hot-dipped steel rodent and insect barrier. The insulation shall be at least R-13 for the floors and walls and R-19 for the roof, or a higher specific insulation value called out in applicable state and local codes. The entire Electrical Equipment Enclosure shall be insulated to thermal transmittance value of no more than 0.05 for walls and 0.03 for roofs when tested in accordance with ASTM C236.

10.1.12.8. Exterior Doors

10.1.12.8.1. There shall be two doors in the EEE, at least one of which is a 72-inch wide double door to facilitate the installation of equipment. Both doors shall have the same access key. Enclosure doors shall comply with Steel Door Institute directive SDI-100 and SDI-107. Doors shall have an insulated core and be constructed of no less than 18-gage steel-faced leafs with stiffeners and 16 gauge door frames. Doors and frames are to be hot-dipped galvanized to ASTM-A294 and ASTM-A653, then factory primed and painted with epoxy enamel to match the enclosure or trim.

10.1.12.8.2. There shall be three stainless steel ball bearing hinges per door.

10.1.12.8.3. A drip cap shall be provided on the exterior top and bottom of each door.

10.1.12.8.4. Each door shall have Sergeant 2828F low-profile rim device type panic interior openers, with cylinder lock keyed entry and thumb latch exterior.

10.1.12.8.5. A door closer with hold open arm shall be installed on each door.

10.1.12.8.6. Shock absorbing restraints shall be provided on the doors to prevent damage from high wind conditions.

10.1.12.9. HVAC

10.1.12.9.1. Heating, ventilating, and air conditioning (HVAC) equipment shall be sized and provided. HVAC equipment size shall be based on maintaining an interior temperature range of 60-80 degrees F, taking into consideration the heat load of present and future equipment and the site conditions. HVAC equipment shall consist of self-contained wall mount units, complete with supply and return grilles, lockable circuit breaker or disconnect switch, manual thermostat, barometric fresh air damper, and a disposable air filter. The following controls shall be supplied: high-pressure controls, low pressure controls, low ambient control, compressor anti-cycle relay, and alarm relay.

10.2. Civil/Grading

10.2.1. Erection Requirements

10.2.1.1. Defective material, such as bent, buckled, or scarred panels, shall not be erected. If such panels are erected, they shall be removed and replaced. The siding, roofing, corners, closures, and flashings shall be without wrinkles, buckles, or dimples.

10.2.1.2. Any and all marks, scrapes, scratches, etc. on each building component shall be repaired, at Contractor’s expense prior to building acceptance, with the manufacturer’s recommended coating matching the component’s original color.

10.2.1.3. After the work has been completed, the surface of the sheeting shall be inspected for integrity of the coating. Where the coating is scratched or scraped off, Contractor shall touch-up such places with a coating of identical color compatible with the shop finish. Sheeting scratched, dented, or otherwise damaged which, after repair and touch-up, does not present a uniform appearance from the closest ground or public approach shall be replaced.

10.2.2. The Electrical Equipment Enclosure structure shall be designed for a minimum of 30-year life. The structure shall be designed and detailed in a manner which produces a weather tight, draft proof, and aesthetically pleasing building. The interior shall be fully lined with no exposed columns. All ceiling and wall surfaces shall be detailed and furnished flat, to allow for attachment of additional materials such as cabinets and equipment support.

10.2.3. The Electrical Equipment Enclosure structure shall be the design of a manufacturer regularly engaged in the fabrication of pre-engineered structures conforming to the recommendations of the MBMA Manual.

10.2.4. Contractor shall provide all static and dynamic loading calculations and analysis for the EEE as well as all mounting information.

10.2.5. The EEE manufacturer shall supply plans and calculations stamped by a Registered Professional Engineer for the state where the EEE is to be installed and is responsible for obtaining all State Industrial Building Commission Approvals and Third Party Inspections that are required by the state in which the EEE is to be installed.

10.2.6. Heavy duty lifting plates or similar hardware shall be supplied and mounted to the EEE as needed for lifting the enclosure.

10.2.7. The EEE shall have a minimum internal ceiling height of 10'-0" to allow for adequate equipment clearance below the cable tray.

10.2.8. The enclosure shall be able to be shipped via a semi-trailer method. The enclosure may be separated into two or more sections for shipment as required. If shipping splits are necessary, they shall be documented on all drawings and any wiring that is split shall be tagged and marked for easy field assembly. Any field installed wiring across shipping splits shall be done in ceiling mounted J-boxes.

10.2.9. The EEE roof shall be pitched to 2 inch in 12 inches or greater and shall be comprised of mechanically-seamed standing-seam roofing with a minimum seam height of 2".

10.2.10. Cable Tray shall be installed to facilitate external and internal connections.

10.2.10.1. The cable tray shall contain a 4/0 copper ground conductor as a ground bus for the cable tray and equipment to which it connects. Conductor shall be bonded to each cable tray section and all panels and cabinets per NEC requirements.

10.2.10.2. Cable tray shall be sized for all anticipated cables plus 50% margin.

10.2.10.3. Cable tray shall contain a 4" x 4" fiber tray for fiber optic cables. Fiber tray shall be installed in such a manner that the radius in corners shall not reduce the cable trays' capacity for copper cables.

10.2.10.4. The fiber tray shall utilize a trumpet spillout device above each panel to provide an appropriate radius vertical transition into each panel.

10.2.10.5. Cable tray shall be designed for an ultimate load of 100 pounds per foot.

10.3. Structural

10.3.1. Structural steel shall be designed according to the AISC Specification. Cold formed members shall be designed according to the AISI Specification.

10.3.2. The EEE shall have an internal, self-supporting structural steel frame that meets all structural loads without relying on exterior, interior, or roof panels for structural strength.

10.3.3. The EEE shall be designed to support roof live and dead loads that account for ice, snow, and wind loading, ceiling live and dead loads, wall loads, floor loads, and seismic requirements.

10.3.3.1. Dead loads - weight of permanent construction

10.3.3.2. Snow load - Design in accordance with ASCE 7.

10.3.3.3. Roof Live Load – minimum 20 lbs/sf.

10.3.3.4. Wind load - Design for basic wind speed per ASCE 7 in a terrain Exposure C (unless otherwise noted) in accordance with International Building Code Section 1609 or ASCE 7-10.

10.3.3.5. Suspended Systems from interior roof members - 10 psf.

10.3.3.6. Construction Maintenance load - concentrated weight of 250 lbs placed at any point on the roof.

10.3.3.7. The building shall be designed to withstand lifting loads during delivery, unloading, storing or erection of the building.

10.3.3.8. Floors – Equipment Area – Loading shall be rated at least 200 lbs/sf while on the foundation.

10.3.3.9. Floors – Battery Area – The area of the floor designated as the battery area on the control house layout shall be reinforced to 400 lbs./sf minimum while on the foundation.

10.3.3.10. The above loads or combination of loads shall be applied in conformance with the recommendations of the MBMA Manual.

10.3.3.11. Deflection Criteria - Deflection of primary structural framing members shall not exceed L/240. Deflection of secondary framing members and exterior wall and roof panels shall not exceed L/180.

10.3.3.12. Lateral deflection criteria – not exceed L/120 of eave height

10.4. Electrical

10.4.1. Wiring

10.4.1.1. All grounding, workmanship and materials shall conform as a minimum to the latest version of the National Electrical Code (NEC).

10.4.1.2. All wiring shall run tight to and parallel with walls and ceiling. All required wiring between equipment located within the Electrical Equipment Enclosure shall be installed at the factory.

10.4.1.3. Interior conduit shall be electrical thin wall EMT, all interior junction boxes NEMA 1, with flexible metallic conduit used for motor and fixture connections. Do not run conduit horizontally along walls, use cable tray or run along ceiling.

10.4.1.4. All conductors installed from the EEE field termination cabinets to the substation cable trench system shall be installed in RGS conduit. Ends of conduits shall be sealed following installation of conductors to block rodents from entering the conduits.

10.4.1.5. Duplex receptacles with weatherproof covers, and GFI protection shall be provided on the exterior of the enclosure near each entrance, and for service use at each HVAC unit.

10.4.1.6. Power wiring for 120V lighting and receptacles shall be single conductor THHN/THWN 600V insulation in EMT conduit with a minimum size of #12 AWG.

10.4.2. Electrical equipment enclosure lighting shall be in accordance with accepted industry standards and practices. The National Electric Safety Code (ANSI C2) shall be followed in all cases. Sufficient lighting is required for safe operation and testing in front and back of all control panels.

10.4.2.1. Exterior Lighting shall be provided above each personnel door. Exterior lights shall be wall mounted LED suitable for use in wet locations and have automatic dusk to dawn photo control.

10.4.2.2. Emergency lighting shall be a self-contained battery powered unit with two directionally adjustable illuminating heads. The units shall switch on automatically upon loss of AC power and provide 1.5 hours of continuous illumination, and then turn off automatically and recharge when AC power is restored.

10.4.3. AC and DC Station Service Criteria

10.4.3.1. AC Auxiliary Service:

Every substation shall include an AC auxiliary supply system for lighting, heating, maintenance, and other electrical loads. Additionally, each substation that has primary and secondary protective relays and a battery system should have two AC auxiliary sources. An automatic transfer switch will be included to switch between the two sources (preferred and emergency).

The sources for auxiliary power are usually transformer tertiary windings or medium voltage busses. If these sources are not available or are not economically feasible, auxiliary power may be obtained from the local distribution company, an emergency generator, or a voltage transformer connected to a transmission bus. No distribution load from the tertiary windings shall be outside of the substation yard.

The standard AC auxiliary system rating is 120/240V single-phase, and this is used with auxiliary equipment rated up to 400Amp. However, for substations that would require auxiliary equipment rated higher than 400Amp with a 120/240 single-phase system, a three-phase auxiliary system should be considered.

The AC Auxiliary System shall be in accordance with accepted industry standards and practices. The National Electric Safety Code shall be followed in all cases.

10.4.3.2. Primary Fusing and Switching

10.4.3.2.1. Fused Disconnects

Substation auxiliary power transformers shall be fused on the high side using S&C SM5 fused disconnects and fuses. The fuse sizes are selected by choosing the smallest rating, which is at least 150% of the high-side full load ampere current. In order to promote standardization of fuses 5E and 10E, standard time-rated fuses are used in the system, sizes 3E and 7E are not typically used.

Current-limiting Back-up Fuses

Some substations may have available fault currents greater than the interrupt rating of the fused disconnect. In these cases, current-limiting back-up fuses should be used in series with the fused disconnect. The current-limiting back-up fuse will limit the fault current and also provide for clearing of faults up to its interrupt rating. Note that the interrupt rating of the current-limiting back-up fuse must be greater than the available fault current. If it is not, then this approach is not sufficient and further engineering will be necessary (possibility of needing current-limiting reactors)

The back-up fuse should be placed downstream of the fused disconnect; in this way, the back-up fuse can be replaced by opening the fused disconnect, and without de-energizing the source. The design should make sure, to the greatest extent possible, that there is adequate clearance to replace the back-up fuse without de-energizing the source.

With this configuration, there is an accepted risk of a fault occurring in the lead between the two fuses which could not be cleared by the fused disconnect. This would be a bus fault, and would have to be cleared by the station relaying.

10.4.3.3. Secondary Fusing and Switching

10.4.3.3.1. AC Load calculations shall be provided. The station service and associated equipment will be sized in accordance with these calculations.

10.4.3.3.2. Automatic Transfer Switch

The Preferred and Emergency supplies to the electrical equipment enclosure shall brought into an Automatic Transfer Switch (ATS) before going to a Main Breaker Panelboard.

10.4.3.4. DC Auxiliary Service

10.4.3.4.1. The DC system supplies power for the circuit breakers, motor operated switches, instrumentation, emergency lighting, communications, fire protection system, annunciators, protective relaying and fault recorders at substations and includes a 125VDC battery bank and battery charger.

10.4.3.4.2. The DC Auxiliary System shall be accordance with accepted industry standards and practices. The National Electric Safety Code shall be followed in all cases.

10.4.3.4.3. Consideration of any applicable regulations regarding redundant battery systems shall be given. NERC and RTO regulations may be applicable. A redundant battery shall not be used except where required.

10.4.3.4.4. The Battery system and charger shall be sized to recharge the battery to 95% of full capacity within 12 hours. The battery sizing criteria is summarized below:

Summary of Battery Sizing

Beginning event	Loss of battery charger occurs, but no tripping event
Time which battery must carry continuous load (without battery charger)	8 hours
Final event, which battery must be able to supply	Worst case tripping event occurs, including one breaker failure event.

Notes:

- The tripping event that causes the most current to be drawn from the battery is considered the “worst case” event.
- Continuous loads are loads that the battery would have to carry throughout the duty cycle once the battery charger quits operating (Examples: indicating lights, relays).

10.4.3.4.5. DC Continuous Load Calculations shall be provided. The battery system and charger will be sized in accordance with these calculations.

10.4.3.4.6. Main Battery Fusing

The battery main fuses protect the battery against faults in the cable between the battery and the DC fuse cabinet or against faults on the bus in the DC fuse cabinet. These fuses shall not be considered as backup protection for the branch fuses. The main fuses are sized to allow all but a solidly bolted fault to cause them to operate. This is to avoid the nuisance of blown fuses and keep DC power operating the control systems as long as possible. The fuse is also used as a disconnect point to isolate the battery when necessary.

10.4.4. Relaying and Protection Criteria

10.4.4.1. See WIND FARM EEE AND PANEL ELEVATIONS and WIND FARM ONE LINE METERING AND RELAYING.

10.4.5. SCADA / RTU / Communication requirements,.

10.4.5.1. See WIND FARM EEE AND PANEL ELEVATIONS and WIND FARM ONE LINE METERING AND RELAYING.

10.5. Submittals

10.5.1. Design documents shall be stamped by a professional engineer registered in the state where the building will be installed. Calculations shall be submitted for review with the approval drawings.

10.5.2. Submittals for the EEE shall include an overhead layout and elevations which clearly identify all equipment by bubble numbering. Drawings shall be accompanied by a spreadsheet which details each item number.

10.5.3. The building manufacturer shall prepare design and shop drawings and shall include the following:

10.5.3.1. Physical outlines as required to show the overall size and space requirements including doors, clear heights and floor area.

10.5.3.2. Cross sections and details as required demonstrating framing details and that components conform with specification requirements. It shall also include design and physical arrangements such as horizontal and vertical clearance.

10.5.3.3. Erection drawings and anchor bolt plans including foundation loads.

10.5.3.4. Cross sections and details as necessary to provide a complete and finished structure.

10.5.3.5. Item identification marks shall be included. Equipment identified by such marks shall be detailed in tabular format.

10.5.3.6. Manufacturer’s submittals for fans, louvers, door frames, hardware and doors shall be provided with the Design Documents.

10.5.3.7. One reproducible set of “record” drawings, incorporating any approval comments and certified by a registered engineer, shall be submitted to Owner prior to shipment of the building.

10.5.4. See Section 1.3 for more submittals information.

11. Operations and Maintenance Building

11.1. Design

11.1.1. Contractor shall procure and deliver and provide, in accordance with the Project Schedule and Design Documents, all services, labor, equipment, land rights, Permits, Approvals, and materials necessary to construct, assemble, erect and install a fully finished O&M building and sand shed in accordance with the Outline Specifications in this Section, but not limited to: heated & air conditioned office/SCADA space, heated shop & warehouse space, security system, paved driveway, potable water, septic system, single phase electrical service with a 400 amp minimum rating, communication wiring, exterior water faucets, outlets, and security lighting, 5 acre minimum building site, fenced gravel storage area suitable for large parts such as blades, and landscaping and wind screen.

11.1.2. Building type shall be standardized metal panel and steel support and framing by Butler, Morton, or Owner approved alternate.

11.1.3. The minimum building size shall be based on the Project size and may be adjusted slightly to match standard materials:

Turbine Quantity	Building Size (square feet)
50 – 150	7,200
151 – 250	8,300
251+	9,400

11.1.4. Floor plan layouts are shown in Figure 10, Figure 11, and Figure 12.

11.1.5. The site layout is shown in Figure 13 and Figure 14. The building orientation shall be fixed and the entrance road shall enter from the south.

11.1.6. The final floor and site plans shall be agreed to within 30 days following execution of the Project agreement. Issued for construction plans and specifications shall be submitted to Owner for review and approval prior to construction. Building design and construction shall be in accordance with all current state and local codes.

11.1.7. Office finished ceiling height to be 9’.

11.1.8. SCADA room ceiling minimum height is 10’.

11.1.9. Mechanical room ceiling to be building height and walls shall extend to the ceiling.

11.1.10. Shop area garage door height to be 12’.

11.1.11. Shop area ceiling height to be high enough to allow room for garage door track and lighting above garage door. Shop walls shall be finished with metal to the ceiling, including around the office area. Ceiling shall be finished in metal.

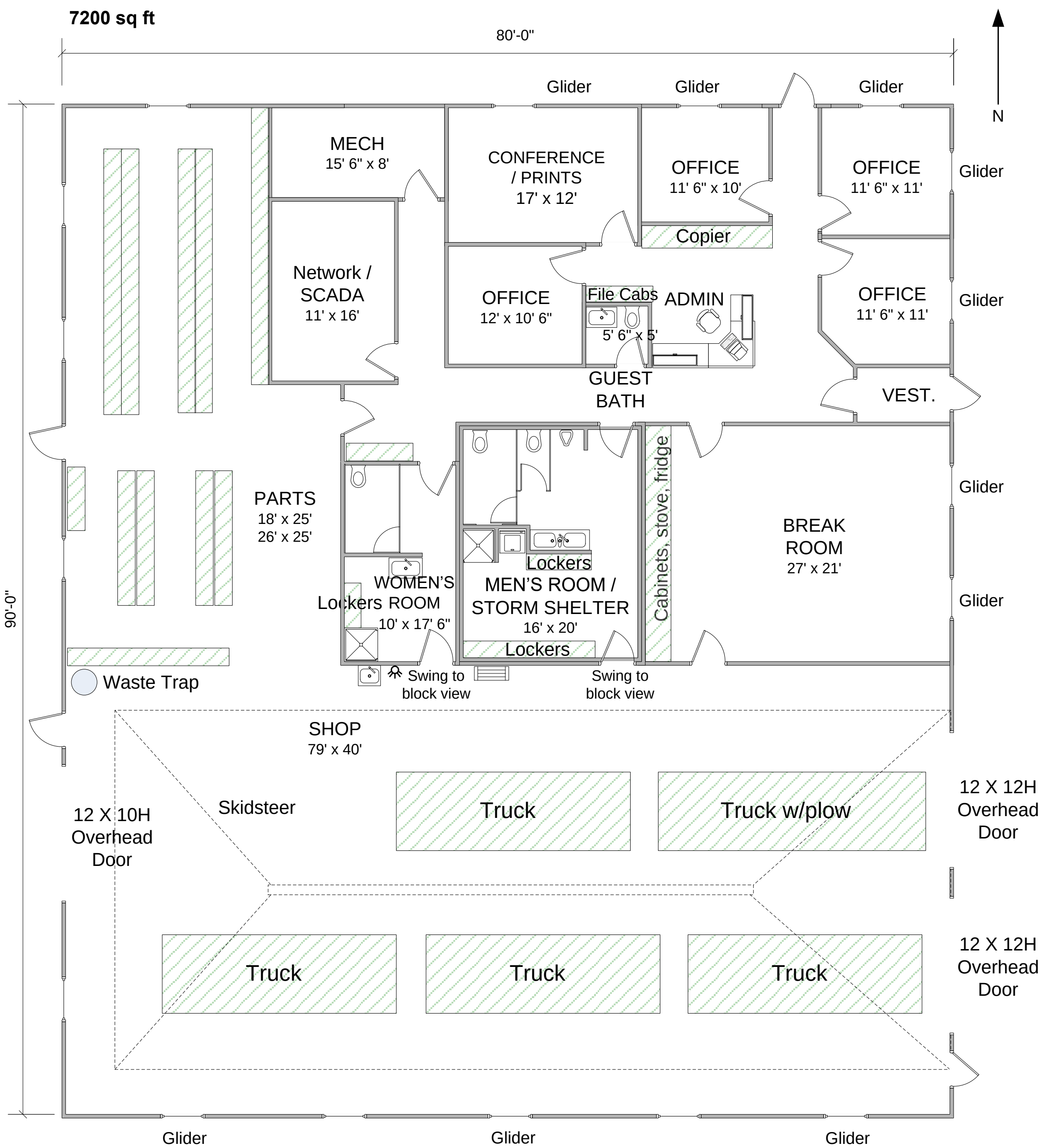


Figure 10: O&M building interior layout - 7,200 sq. ft.

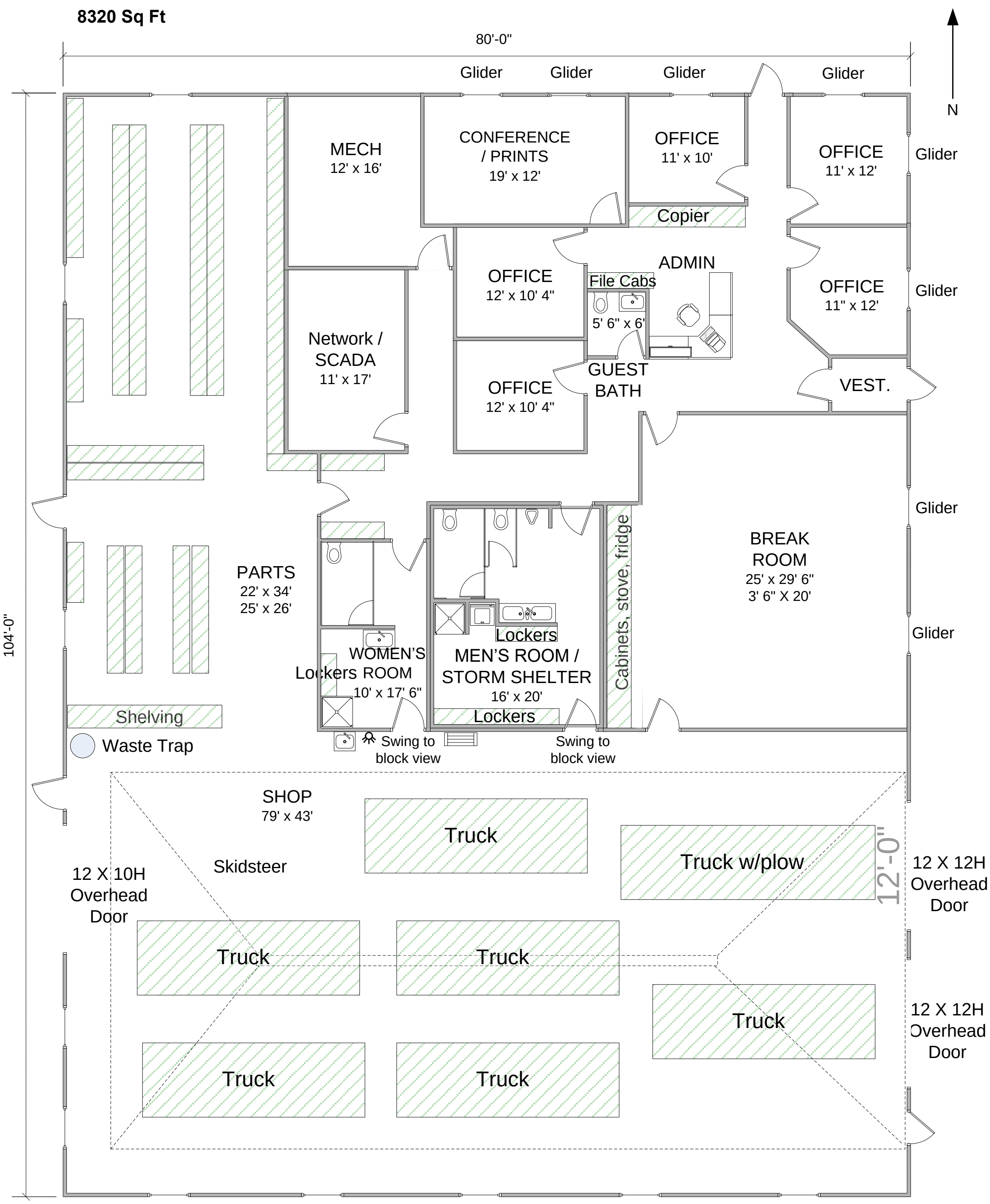


Figure 11: O&M building interior layout - 8,300 sq. ft.

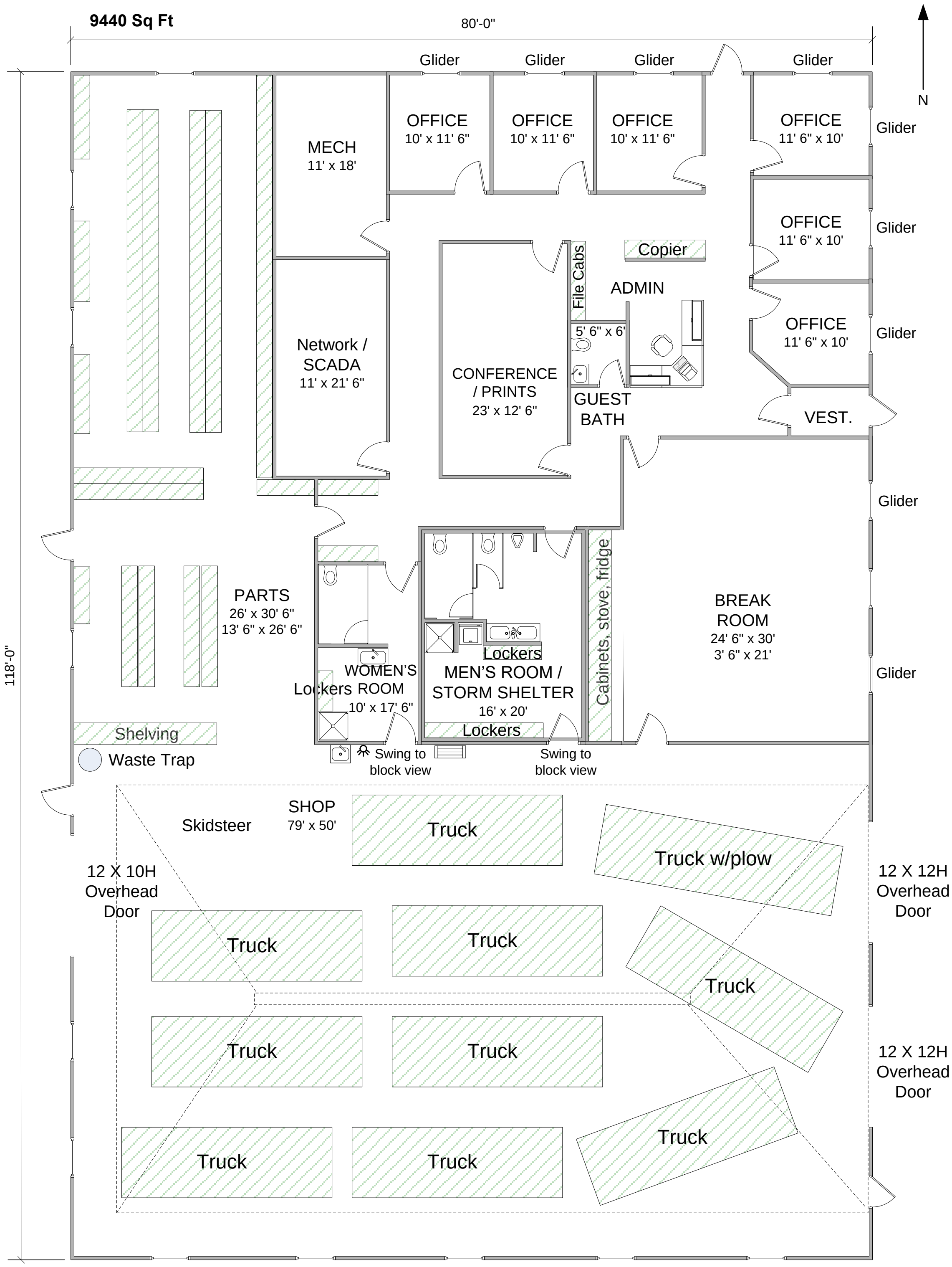


Figure 12: O&M building interior layout - 9,400 sq. ft.

Site Layout

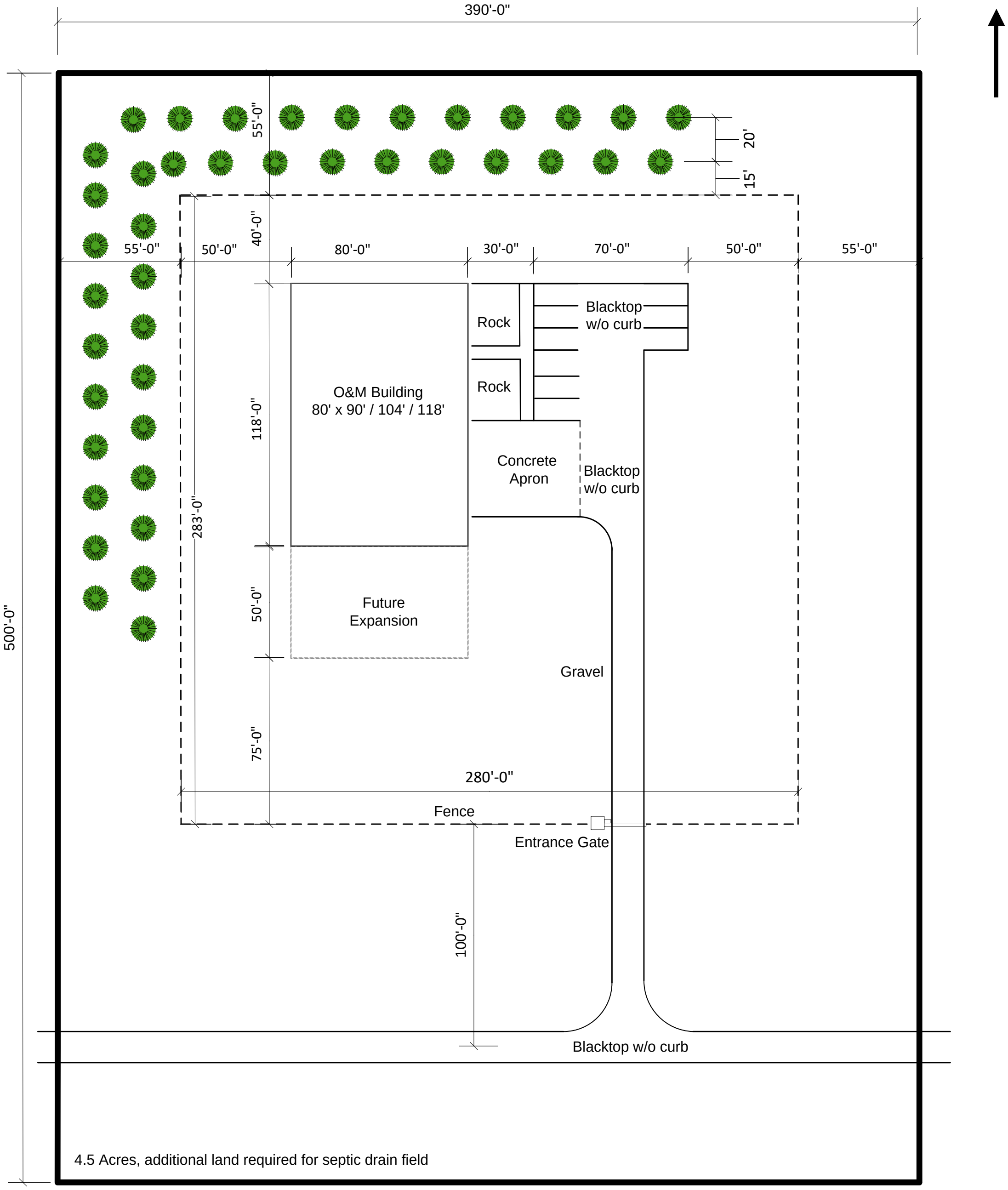


Figure 13: Typical O&M building exterior layout.

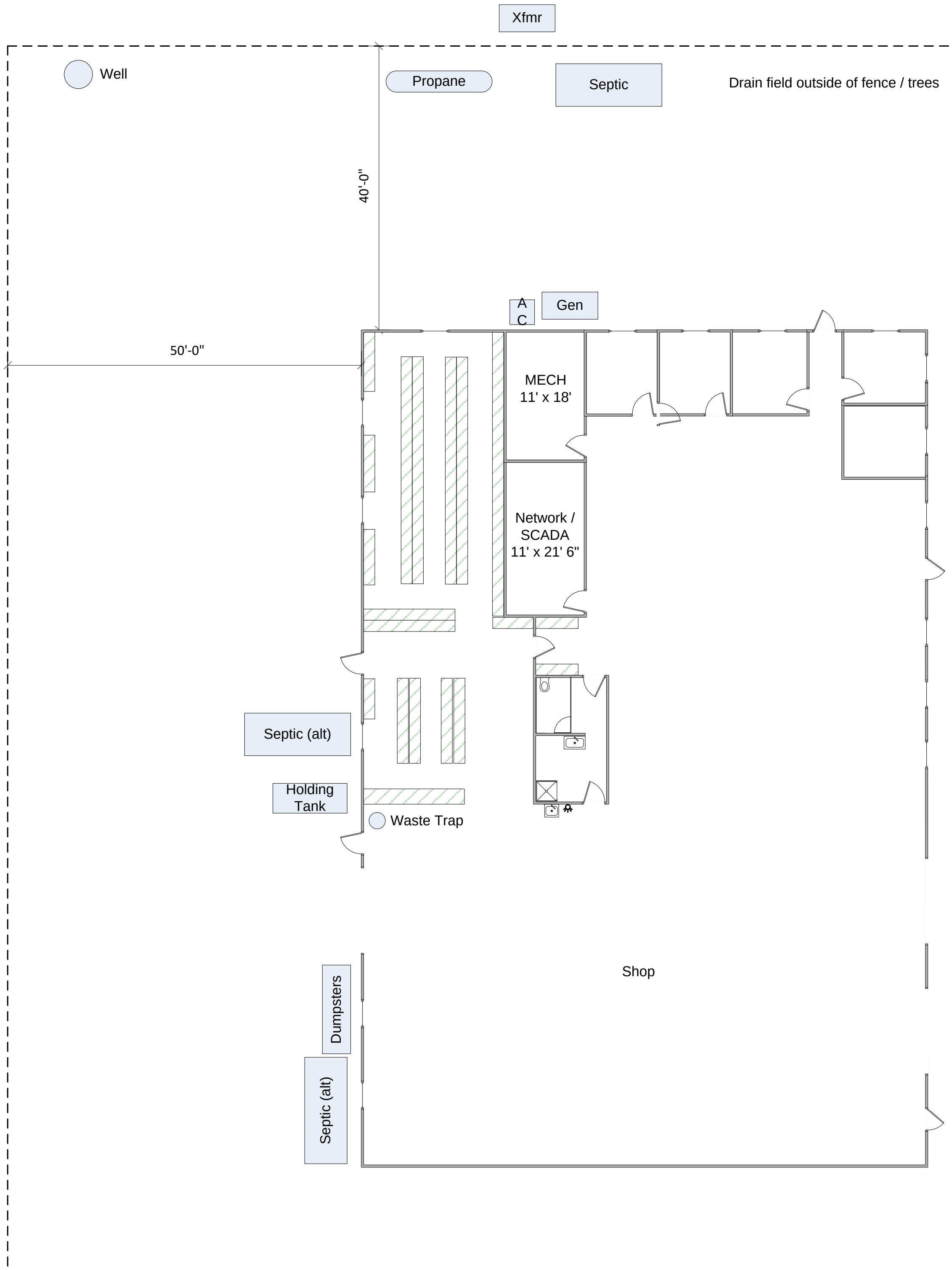


Figure 144: O&M building exterior utility layout.

11.2. Civil/Grading

11.2.1. Provide for excavation, grading, and backfilling as necessary for the construction of the Project, including coordination of installation of all utility services. Provide proper grade so that water shall drain away from the building.

11.2.2. Provide bollards around all exterior septic and plumbing systems including, but not limited to, holding tanks, septic tanks, and drain fields.

11.2.3. Drain field shall be sectioned off and protected from all construction equipment and traffic to prevent unnecessary soil compaction in the area.

11.2.4. Any fill necessary for yard development shall be clean granular fill supplied by Contractor.

11.2.5. Footing design shall be in accordance with the Geotechnical Report and associated soil testing.

11.2.6. Contractor shall provide drive accesses, as required, and shall obtain any necessary permits.

11.2.7. Provide lawns and planting for new building. Work shall be performed as follows:

11.2.7.1. Spread fertile topsoil stripped from site over all seeded grass and sod areas to a minimum of 4”.

11.2.7.2. Select vegetation shall be suitable for the location and climate and be free of weeds. Select vegetation shall be established on all disturbed land on the O&M property outside of the security fence. The Contractor shall submit the select vegetation type to be used for approval prior to planting. Disturbed areas shall be vegetated within the specified time period as indicated in the project SWPPP to minimize/eliminate runoff. All vegetated areas shall be free of weeds.

11.2.7.3. In NSP and PSCo regions, plant evergreen trees around the exterior of the fence enclosure on north and west sides of the building in order to provide protection during the winter season. On the west side of the building, the trees shall extend past the future building expansion area while the trees on the north side shall extend 100 ft beyond the building. Shrubs shall be planted on the remaining sides. Minimum tree height shall be 8 feet. Trees shall be planted every 18 feet in two rows separated by 20 feet, staggered between rows.

11.2.7.3.1. Watering and periodic inspections shall be performed and documented in a maintenance log on a bi-weekly basis.

11.2.7.4. Washed rock with landscaping fabric shall be used between the sidewalk and East wall of the building.

11.2.7.5. Landscape plan shall be submitted for approval by Owner prior to construction.

11.2.8. Provide concrete apron in front of garage doors and bituminous paved driveway and parking area for 8 cars. Work shall be performed as follows:

11.2.8.1. Contractor shall perform final grading as necessary for proper drainage, and furnish and install base and wearing surface complete, compacted, and rolled as per standards of the State's Department of Transportation.

11.2.8.2. Area receiving concrete or bituminous paving shall have an 8" compacted base meeting Section 4.1.1.1 and the paving shall be applied in two layers: 3" of plant mixed bituminous base and 1 1/2" of plant mixed bituminous surfacing.

11.2.8.3. Concrete and bituminous paving shall meet design and installation requirements per the State's Department of Transportation Standard Specification in which the project is located.

11.2.8.4. Slope 1/8" per foot away from the building.

11.2.8.5. Stripe all parking positions as required for handicap and standard parking. Handicap parking stall shall be an end stall if possible.

11.2.9. Gravel areas shall have a minimum of 6" of compacted base or crushed gravel per Section 4.1.1.1 and shall have elevations graded to accomplish a proper drainage pattern. Slope 1/8" per foot.

11.2.10. Security fencing information can be found in Section 2.7.

11.2.11. Provide 6" diameter guard posts constructed of 1/4" thick steel pipe, filled with concrete, at overhead doors interior and exterior to building. Guard posts shall be a minimum of 4 feet above the concrete and shall be designed and installed to prevent frost heave at exterior applications. Paint guard posts yellow.

11.2.12. Exterior Walls

11.2.12.1. Exterior walls shall be insulated 26 gauge pre-finished metal panel. Color selected by Owner.

11.2.12.2. Exterior walls shall have an R value in accordance with the current International Energy Code with Local and State Building Code amendments.

11.2.12.3. Exterior office area walls shall be spray foamed at least 1" thick to seal air gaps up to a height of 10 ft in the NSP region.

11.2.13. Roof System

11.2.13.1. Roof to be a standing seam metal-roof sloped with gable ends. All roofing materials are to be installed and constructed to provide a ten-year guarantee against leakage.

11.2.13.2. The roof shall have an overall R value in accordance with the current International Energy Code with Local and State Building Code amendments.

11.2.13.3. Roof sloped to drain.

11.2.13.4. Gutters provided in areas over walkways, doors, exterior equipment, or office windows. Gutters on the east wall shall only have 2 discharge locations, 1 at each end of the building to prevent ice buildup on the concrete and flooding of the rock area. Double down spouts may be required and overtopping of the gutters is acceptable during heavy rain. Include erosion measures, rock and/or splash block, from each down spout on the building.

11.2.13.5. Gutters shall incorporate back-up drain scuppers.

11.2.13.6. Detail roof edge to prevent built up snow drop-off.

11.2.13.7. Provide awnings over building access doors located on non-gable end walls. Awnings are to be directly attached to building walls, i.e. no exterior columns. Awnings shall be constructed of light gage steel.

11.2.13.8. Provide perimeter fascia with factory applied baked enamel finish and constructed of 24 gauge steel minimum. Owner will select color from manufacturer’s standard colors.

11.2.13.9. Provide insulated roof curbing as required for all roof-mounted equipment.

11.2.14. Interior Walls

11.2.14.1. All interior walls shall be constructed as shown in the Design Documents.

11.2.14.2. All masonry walls are to be constructed of a minimum of 8” standard weight block.

11.2.14.3. Stud and sheet rock walls are to be framed with 3 5/8” 18 gauge metal studs, 24” o.c., and covered with 5/8” gypsum board taped and sanded to accept paint or vinyl. Provide 3 1/2” thick sound control butt insulation (FHC 25/50) as manufactured by U.S. Gypsum or equal in all walls.

11.2.14.4. All interior shop walls, to include the office/shop wall, shall be finished with white 29 gauge liner panels that extend to the ceiling.

11.2.14.5. Interior shop ceiling shall be finished with white 29 gauge liner panels

11.2.14.6. The SCADA room shall be protected with ½” thick layer of plywood under the drywall.

11.2.14.7. Men’s locker room shall be built to provide an effective storm shelter and safe room constructed of 8” reinforced masonry walls or 6” reinforced concrete wall, 6” hollow core precast plank or 18 gauge roof joists and 18 gauge metal roof decking with 6” minimum concrete slab, footing depths to withstand overturning/uplift and designed to withstand wind gusts during an extreme event. Design shall be in accordance with International Code Council 500 (ICC) and FEMA P-361 Safe Rooms for Tornados and Hurricanes – Guidance for Community and Residential Safe Rooms. The locker room roof shall be used for storage and signage with roof deck rating shall be posted.

11.2.15. Doors and Windows

11.2.15.1. All doors and hardware shall comply with table below.

11.2.15.2. All doors and frames shall meet building code requirements for fire ratings. Minimum door width shall be 36”.

11.2.15.3. All doors shall have locking capabilities.

11.2.15.4. All exterior doors shall push open to the north and west into the prevailing wind direction.

11.2.15.5. All exterior doors and windows shall be properly insulated to meet current energy code requirements and shall be installed per manufacturer’s recommendations.

11.2.15.6. Storm shelter doors shall be equipped with 3 latch points operated by a single handle, and include a deadbolt lock.

11.2.15.7. Steel Frames and Doors

Hollow metal work shall be as manufactured by Steelcraft Mfg. or equal SDI Member, as approved. Frames shall be welded unit type with a minimum thickness of 16 gauge. Exterior hollow metal doors shall be insulated (U value of 0.24 or less). All exterior doors shall be weather-stripped. Interior hollow metal doors shall be a minimum thickness of 18 gauge. Doors constructed of aluminum are not allowed.

11.2.15.8. Interior Wood Doors

Provide flush 5-ply door construction with solid particle core bonded to stiles and rails using Type 1 waterproof glue, conforming to AWI Type PC-5. Quality grade to be AWI Premium, 1 3/4” thickness, with AWI Grade A oak face veneer on all sides and edges. All interior doors except the bathrooms, SCADA, and Mechanical shall have a vertical ¼ light glass.

11.2.15.9. Overhead Doors

Provide 24 gauge factory finished (color selected by Owner) steel insulated overhead doors with 2 foot panel sections. Minimum R value to be 4.0. Doors to have perimeter brush seal weather-stripping, and bottom astragals. Doors to have chain releases so they can be opened and closed by hand in case of power failure. Provide heavy duty cycling springs. Doors to be manufactured by Overhead Door, or equal. Provide power operators with complete control. Provide one set of controls for each door with open-close-stop functions. Provide photoelectric sensors and automatic close function.

11.2.15.10. Door Glass Lights

Provide tempered clear float glass, ASTM C1048, Type I, Class 1, q3, Kind FT, horizontally tempered, 1/4” thick, as required for door glass lights.

11.2.15.11. Door Hardware

Provide the following hardware by the listed manufacturers or approved equals:

11.2.15.11.1. Butts -- Stanley FBB199, US26D, 1 1/2 pair

11.2.15.11.2. Closer -- LCN 4010/4111 Series, Exposed overhead surface type, Alum., see table below for applicable locations.

11.2.15.11.3. Kick Plates -- Hiawatha 10" x 34", US32D

11.2.15.11.4. Stops and Holders -- Ives, US32D

11.2.15.11.5. Push-Pulls -- Hiawatha, US32D, ADA approved

11.2.15.11.6. Lock Sets -- Schlage L9000 Series, US26D, mortised (no substitutions), Function as noted on Design Documents, ADA approved lever. All exterior doors and SCADA room lock sets shall be card reader capable and comply with security system requirements. Owner shall supply additional requirements.

11.2.15.11.7. Passage Sets -- Schlage L9010 Passage Function, US26D, mortised (no substitutions), ADA approved lever

11.2.15.11.8. All locks shall be master keyed with a restrictive key way master keying system as directed by Owner.

11.2.15.11.9. All required blank plates.

11.2.15.12.Door Detail – Install per the following table:

Location	**Material**	**Light**	**Closure**	**Handle**
Breakroom to Hall	Wood	1/4	N	Lever
Breakroom to Shop	Metal	1/4	Y	Lever
Exterior excl Vestibule	Metal	1/4	Y	Lever Lock / Card
Hall to Shop ceiling	Metal	1/4	Y	Lever
Mechanical	Wood	None	N	Lever
Offices & Conference	Wood	1/4	N	Lever Lock
Restroom - Guest	Wood	None	Y	Lever Lock
Restroom – Mens	Metal	None	Y	Lever lock w/3 point
Restroom – Womens	Metal	None	Y	Lever
Restroom – Womens to Hall	Wood	None	Y	Lever
SCADA	Wood	None	Y	Lever Lock / Card
Vestibule – Exterior	Metal	1/2	Y	Lever
Vestibule – Interior	Metal	1/2	Y	Lever Lock / Card

11.2.15.13.Exterior Windows

All windows shall be of vinyl construction. Face shall snap out for easy glass replacement. Windows shall be tinted insulated glass units; IGCC

Class CBA when tested per ASTM E773 and E774; dual sealed unit with primary polyisobutylene seal, secondary silicone seal. Provide outer and inner lights of ¼" thick tinted glass conforming to ASTM C1036 Type I, Class 1, q3; and a ½" argon filled airspace; total thickness of 1". Windows shall have a U value in accordance with the current International Energy Code with state building code amendments.

Operable windows shall be gliding type and shall be located in all offices and break room.

11.2.16. Admin Area Desk

11.2.16.1. Construct a built in reception style desk with studs and drywall for the veritical frame and 24" deep countertops for the sit down desk and 15" deep countertops for the walk up portion. Overall height to be 42".

11.2.17. Finishes

11.2.17.1. Ceramic Tile

11.2.17.1.1. Ceramic tile shall be installed, grouted, cleaned, protected, and cured per standard specifications of the American National Standards Institute (ANSI) and the Tile Council of America (TCA). Grout shall be Latex-Portland Cement Tile Grout as made by Custom Building Products, Mapei Corp. or approved equal. Grout and ceramic tile colors to be selected by Owner.

11.2.17.2. Floor Tile

11.2.17.2.1. Provide ceramic standard mosaic floor tile with smooth, all- purpose edge. Tile shall be 1' x 1' unglazed as manufactured by American Olean or approved equal. Provide all special shapes as required.

11.2.17.3. Wall Tile

11.2.17.3.1. Provide standard glazed 6" x 6" or 4" x 4" wall tile as manufactured by American Olean or approved equal. Provide all special shapes as required. Wall tile shall cover all locker rooms and unisex bathrooms to a minimum height of 4'-6" from the top of finished floor.

11.2.17.4. Ceiling Treatment

11.2.17.4.1. For ceilings outside the high bay area, but excluding the SCADA room, Vestibule, and Mechanical Room, provide a lay-in type ceiling. Lay-in ceiling shall be a 24” x 24” with 15/16” exposed white grid system. Grid system shall be USG Interiors or approved equal. Acoustical panels shall be non-combustible (Flame Spread A), smooth-texture with reveal edge, factory white finish similar to USG Interiors, Millennia ClimaPlus 76705, 2’ x 2’ x ¾”, SLT edge. Acoustical ceiling panels to have a minimum Noise Reduction Coefficient (NRC) rating of 0.7, Ceiling Attenuation Class (CAC) of 35 minimum and Light Reflectance of 85 (LR-1).

11.2.17.4.2. SCADA room and the Vestibule ceiling shall be covered with 5/8 gypsum board taped and sanded to accept paint or vinyl and backed with 3 ½ thick sound control butt insulation (FHC 25/50) as manufactured by U.S. Gypsum or equal.

11.2.17.4.3. Mechanical Room ceiling to be metal panel or drywall at full building height.

11.2.17.5. Resilient Flooring

11.2.17.5.1. Clean and prepare floors as necessary for proper application of vinyl tile. Provide 12” x 12” x 1/8” thick vinyl composition tile (VCT) similar to Armstrong “Excelon” or Tarkett “Expressions.” Owner will select colors from manufacturer’s standard colors.

11.2.17.6. Carpet

11.2.17.6.1. The following manufacturers meet Owner’s standard for carpet tiles:

Constantine Commercial

Mannington

Lees

11.2.17.6.2. Yarn

100% advanced generation nylon such as type 6.6 produce by:

BASF

DuPont

Monsanto

11.2.17.6.3. Minimum yarn wt. 26 oz.

11.2.17.6.4. Minimum construction features

Pile height 0.170 to 0.28 inches

1/8 gauge with 8 stitches per inch or,

1/10 gauge with 10 stitches per inch

11.2.17.6.5. Primary Backing Synthetic

Polypropylene

11.2.17.6.6. Vinyl Base

Provide 4” high vinyl base as manufactured by VPI, Johnsonite or approved equal. Use coved base with vinyl composition tile (VCT) and carpet tiles. Colors to be selected by Owner from manufacturer’s standard colors.

11.2.17.7. Paint

11.2.17.7.1. Strictly follow manufacturer’s recommendations for surface preparation and paint application. Colors to be selected by Owner. Paint to be Benjamin Moore, Sherwin-Williams or approved equal.

11.2.17.7.2. Wood

Sand and prepare surfaces to receive finish. All finished hardwood to receive one coat of stain, one coat of sealer, and two coats of varnish.

11.2.17.7.3. Metal

All metal doorframes and doors and miscellaneous metals shall receive one coat of primer and two coats of enamel.

11.2.17.7.4. Interior Walls

Masonry interior walls shall receive one coat of block filler and two coats of finish paint. Gypsum board walls shall receive one coat of primer and two coats of finish paint.

11.2.17.7.5. Exterior Walls

Exterior walls to be finished as required by the exterior wall material. If exterior walls are masonry, apply one coat of block filler and two coats of enamel.

11.2.17.8. Millwork

11.2.17.8.1. Provide custom millwork in the breakroom consisting of upper and lower cabinets with stove and fridge cutouts in the location shown on floor plan Figures 10-12. Cabinets shall fill the area from wall to wall, include a short upper cabinet for a microwave over the stove, and be similar in arrange to the reference picture at the end of this section. Millwork shall be, of quality fire retardant particleboard core finished with wood veneer (AWI “premium” grade) or plastic laminate (NEMA LD 3, GP-50 for horizontal surfaces and GP-28 for vertical surfaces). Pattern and color selected by Owner. Tops to be 1 3/4” thick and sides to be 3/4” thick. Countertops and Vanities are to have a 4” backsplash. Provide adequate bracing hidden from view.

11.2.17.9. Lockers – 72” tall lockers shall be installed in both restrooms and shall be wall hung with an integrated bench. Owner to specify quantity relative to building size.

11.2.17.10. Finish Schedule – See Table 24, all final colors subject to Owner approval.

Table 24: Finish schedule.

Material	Color	Location
Acoustical grid	White	
Acoustical tile	White w/reveal edge	
Canopy	Brown	
Canopy soffit	White	
Carpet tile	Dark blue speckled w/various	Offices, conference
Ceramic floor tile	Matt dark grey, light black	Restrooms, vestibule
Ceramic grout	Pewter	Restrooms, vestibule
Ceramic wall tile	Matte grey / smoke	Restrooms
Door hardware	Satin Nickel	
Laminate cabinet	Honey oak to light cherry	Break room
Laminate countertop	Matte black marble	Break room, restrooms, admin
Locker	Tan	Restrooms
Locker bench	Honey oak	
Metal roof panel	Galvalume	Roof
Metal trim	Tan	Exterior
Metal wall panel	Tan	Exterior
Metal wall panel	White	Shop/parts walls and ceiling
Outlet cover	Light almond	All but shop/parts
Outlet cover	Steel grey	Shop, parts
Overhead door	Brown	Shop
Paint	SW 6101 Sands of Time	Vestibule, admin, hallways
Paint	SW 7059 Unusual Grey	All other areas
Plumbing fixture	Satin Nickel	
Steel door and frame	Black	
Toilet Partition	Slate	
VCT	Tan	Breakroom, SCADA, hallways
Vinyl base	Black	
Wood door	Light cherry	

11.3. Structural

11.3.1. The Work under this section shall include the complete construction of all concrete work on the Project for concrete footings, floors, sidewalks, and all necessary accessories, setting of anchor bolts, ties, etc.

11.3.1.1. All concrete shall have a minimum compressive strength per Section 4.1.3:

11.3.1.2. Provide two (2) coats of sealer over all concrete slab-on-grade areas per manufacturer's recommendations, except those areas receiving floor finishes, e.g. VCT tile, carpet, etc. Sealer to be Sonneborn, Tremco, or equal.

11.3.1.3. Provide cork expansion joint material, ASTM D1752-67, Type II in expansion joints for interior work as required, and seal over with Vulkem 116 or equal. Provide fiber expansion joint material, Flexcell or equal in expansion joints for exterior work as required, and seal over with Vulkem 200 or equal.

11.3.1.4. Concrete reinforcement shall be shop fabricated per design drawings. Field bending of reinforcement shall be in accordance with applicable sections of ACI 318. Shop drawings shall be submitted for review prior to construction.

11.3.1.5. Column anchor bolts, dowels, reinforcement, embed plates, etc. shall be supported by chairs, bolsters, bar supports, spacers, etc. prior to concrete placement. "Wet Setting" of reinforcement, dowels, anchor bolts, embed plates, etc. is not allowed.

11.3.1.6. Embeds for shop floor drain shall be galvanized.

11.3.1.7. Floor slab and aprons to be 6" thick minimum, and sidewalks to be 4" thick minimum.

11.3.1.8. Slope exterior concrete surfaces away from the building. Sidewalk slope shall be at least ¼" per foot while driving paths and parking lots shall be sloped at least 1/8" per foot.

11.3.1.9. Concrete Specialties

11.3.1.9.1. Provide concrete steps or aprons at personnel door(s), overhead doors, and at bottom of stairs.

11.3.1.10. Construction

11.3.1.10.1. Contractor shall require that the concrete subcontractor has a minimum of 3 years of experience with commercial concrete construction and concrete floor finishing.

11.3.2. Foundation wall and under slab insulation, when required by location, shall be extruded polystyrene board insulation, ASTM C578, Type IV, 1.6 pcf density minimum, "k" factor of 0.20 at 75 deg. F (R-5), 25 psi minimum compressive strength, 0.3 percent maximum water absorption by volume, square edges, manufacturer's standard board size, such as Styrofoam SM manufactured by Dow Chemical Co., Foamular 250 manufactured by Owens Corning, or approved equal. Thickness noted on Design Documents. Install on the perimeter of the foundation and wrap around under the concrete slab floor 4'-0".

11.4. Electrical

11.4.1. All Electrical Works shall be in accordance with the regulations of the latest edition of the National Electrical Code and all state and local codes. All wiring to be copper and in conduit.

11.4.2. Service Entrance

11.4.2.1. The local utility shall provide a transformer and primary service to the transformer. Contractor shall provide the secondary service into the building and is responsible for verifying the entrance location with the local utility. Contractor shall be responsible for the coordination with the local utility on the placement of the transformer. Contractor shall coordinate with local utility in metering installation.

11.4.2.2. The electrical service to this building shall be single phase and sized to accommodate all electrical loads with 30% contingency and a 400 amp minimum. The service entrance equipment shall be grounded per code, and the grounding conductor installed in conduit.

11.4.3. Power Distribution

11.4.3.1. Provide a Square D or equal panel board type NQOD.

11.4.3.2. Provide panel board identification with an engraved plastic laminate nameplate.

11.4.3.3. Panelboards shall have Square D QO breakers rated for a minimum of 10,000 A.I.C. at 240V Panel boards to be suitable for use as service entrance equipment and shall have a hinged door and lock.

11.4.3.4. Panel boards shall have a minimum of 42 circuits and a 200A minimum bus rating. Contractor shall size breakers and provide power for all electrical loads.

11.4.3.5. Provide a typed directory of circuits mounted behind clear plastic inside the panel board door.

11.4.4. Lighting System

11.4.4.1. Provide lighting throughout the building as follows:

11.4.4.1.1. All rooms except shop, parts storage, and mechanical room: Lay-in type 2, 3, or 4 lamp LED fixtures with parabolic lens, electronic ballasts, T-8 lamps, lighting level 40 foot-candles at 3 feet off floor, Lithonia or equal.

11.4.4.1.2. Shop, parts storage, and mechanical room: Industrial type 2 lamp, 4 and/or 8 foot long LED fixture with baked enamel reflector, electronic ballast, T-8 lamps, lighting level 20 foot-candles at 3 feet off floor, Lithonia or equal.

11.4.4.1.3. Exterior: LED wall mounted fixtures suitable for outdoor wet location centered on each exterior wall (quantity 4), prismatic lens, factory installed photo electric control on each fixture.

11.4.4.1.4. Exit Lights: LED type exit lights.

11.4.4.1.5. Recessed can light with shower trim in each shower stall.

11.4.5. Wiring Devices

11.4.5.1. Shop to have quiet toggle wall switches. Switches shall be rated at 15 or 20 A, 120 VAC. Switches shall be similar to Hubbell 1221 Series. Receptacles shall be similar to Hubbell 5262 Series.

11.4.5.2. Furnish and install occupancy sensors in offices, conference room, break room, mechanical room, SCADA room, small parts room, locker rooms and restrooms.

11.4.5.3. Switches and receptacles shall be light almond in all areas except the shop, which shall be gray. Cover plates shall match switches and receptacles in all areas except for shop and parts storage areas where the covers shall be galvanized steel.

11.4.5.4. Provide a 240 VAC outlet in the shop to the south of the west garage door and to the south of the man door from the office to the parts area.

11.4.5.5. Provide a 240 VAC outlet in the Men's Locker room for the stackable washer and dryer unit.

11.4.5.6. Provide one 120 VAC exterior receptacle on each side and in between the two shop overhead doors and one 120 VAC exterior receptacle on each of the remaining 3 sides of the building.

11.4.5.7. Provide a 120 VAC flush mount floor receptacle in the center of the conference and break rooms.

11.4.5.8. Provide two 120 VAC twist lock 30A receptacles and one 120 VAC 20A duplex receptacle to Owner corporate network rack. Receptacles shall be mounted in 4 square boxes. Owner to confirm mounting locations.

11.4.5.9. Provide two 120 or 240 VAC 30A circuits and one 120 VAC 20A circuit to each Turbine Supplier server cabinet. Confirm size with Turbine Supplier.

11.4.5.10. Provide 5 lug ground bar that is grounded directly to the service ground mounted on the wall of the SCADA room.

11.4.6. Communications/Data Telephone System

11.4.6.1. Contractor shall provide all necessary wire and conduit/raceway including conduit for communications/data needs. Communication circuits shall be ran in cable tray above ceiling with conduit extending down into walls.

11.4.6.2. A single wall box with 2 data ports is required in each office, parts room, admin area, and conference room.

11.4.6.3. The break room shall have 2 wall boxes with 2 data ports each with both located on the wall between the break room and the shop.

11.4.6.4. Flush mounted floor boxes with 3 data ports shall be installed in the center of the conference room.

11.4.6.5. Flush mounted floor boxes with 7 data ports shall be installed in the center of the break room.

11.4.6.6. Provide a telephone jack in each of the wall and floor boxes listed above.

11.4.6.7. All Ethernet wiring shall be Cat 6 type cable.

11.4.6.8. Coordinate installation work with local telephone Owner and Owner's Communication Technicians.

11.4.6.9. Owner will order communication circuits.

11.4.7. Low Voltage Wiring

11.4.7.1. Provide all low voltage wiring for HVAC control and run in conduit.

11.4.8. Back-up Generator

11.4.8.1. Contractor shall supply and install a propane powered Generac, or Owner approved equivalent, back-up generator with the extreme cold weather kit. Generator capacity shall be 40kVA

11.4.8.2. Contractor shall supply and install an automatic transfer switch and a propane vaporizer.

11.4.8.3. All items related to the backup generator require Owner approval.

11.5. Mechanical

11.5.1. Plumbing

11.5.1.1. Contractor shall furnish and install all plumbing work in strict accordance with the State Plumbing Code and requirement of the municipality.

11.5.1.2. Contractor shall be responsible for the proper designing, sizing, and installation of all piping and equipment, specialties, etc. to provide a complete and professional plumbing design and installation.

11.5.1.3. Vehicle parking area of shop shall include a floor trench drain that flows into a minimum 260 gallon oil and water separator located to the south of the west wall garage door and then into a holding tank located outside to the north of the west wall shop door. Minimum trench width shall be 12" and depth shall be 8" below the bottom of the grating at the low point. Grating shall be galvanized.

11.5.1.4. Mechanical Room floor drain shall be positioned to allow all equipment to drain to it without the use of a condensate pump or in the walk path to the slop sink.

11.5.1.5. Provide drain in SCADA room for wall mount AC unit.

11.5.1.6. Drain line from the building to the septic tank shall be at a depth to prevent freezing from HVAC condensate flow.

11.5.1.7. The following piping shall be insulated when required by location: domestic water, refrigerant, roof drain piping.

11.5.1.8. Domestic water and refrigerant piping shall be type L copper tubing with soldered joints and fittings using lead-free No. 95-5 solders. All valves shall have brass bodies and shall be designed for a working pressure of 125 PSI. Alternatively, domestic water pipe material may be PEX type upon owner approval.

11.5.1.9. All water supply lines shall be insulated with foam pipe insulation when required by location.

11.5.1.10. Water closets – furnish floor mount, elongated rim, vitreous china water closet with tank and solid plastic open front seat. Unit to be the Toto brand. Units are to be suitable for the handicapped and mounted in accordance with ADA requirements.

11.5.1.11. Urinal – Furnish wall hung, vitreous china washout urinal and flush valve. Unit to be equal to American Standard Lynbrook 6601 with Sloan Royal Model 180-ESS flush valve.

11.5.1.12. Lavatories – Lavatory consoles are to be furnished per Design Documents. Vanity surface is to be a high-pressure plastic laminate, color and design to be selected by Owner. Lavatory unit to be vitreous china, front overflow unit. Provide fauctet and pop-up drain assembly. Console and faucet shall conform to all code requirements for the handicapped. Stand-alone sink units are not acceptable.

11.5.1.13. Water Heater – Furnish a U.L. listed tank less water heater. Unit and its installation to conform to all code requirements.

11.5.1.14. Slop Sink - Provide a 36” x 24” x 10” molded stone service basin with shelf and vinyl bumper guards on exposed faces. Equip with Chicago chrome plated service mixing faucet with vacuum breaker, wall brace, pail hook, and 3/4” hose thread on spout with 30” long 5/8” rubber hose with 3/4” chrome coupling. Provide 24” high water proof wall boards above sink basin on wall(s) adjacent to the sink along with a mop hanger above unit with three (3) rubber tool grips. Service basin to be Fiat or equal. Sink shall be located in the mechanical room.

11.5.1.15. Wash Tub - Provide a 24” x 24” wash tub in the shop between the bathroom doors. Sink shall have both hot and cold water supplied to it, along with a drain. A separate cold water hose bib shall be located next to the sink.

11.5.1.16. Eye Wash - Provide a wall mount eye wash station with drain next to the shop sink. Eyewash shall meet all applicable OSHA regulations and supply temperate water. Mixing valve shall be near the unit and accessible from ground level.

11.5.1.17. Hose Bibs – Provide freeze less hose bibs, one on each side of the building.

11.5.1.18. Domestic water, waste, and vent piping fittings and joints shall be in accordance with the State Plumbing Code and applicable local ordinances. Insulate hot and cold domestic water pipes with 1" minimum fiberglass insulation by Certainteed or equal insulation when required by location.

11.5.1.19. Break Room Sink -- Provide Elkay LR series or equal Stainless Steel sink with duo strainer and faucet.

11.5.1.20. Shower -- Provide molded fiberglass shower cabinets complete with 32" x 32" base with drain, door, Chicago or equal flow saver shower head with single lever hot and cold water operator, soap dish, and shampoo bottle holder. Cabinet to be approximately 6'-6" high and shall be seamless, rustproof, and leak proof.

11.5.1.21. Washer and Dryer hookups – Provide hot and cold water and drain hookups for stackable W/D unit in the Men's Locker Room.

11.5.1.22. Cleanout -- Provide cleanouts in areas behind water closets and as required by code.

11.5.1.23. Faucets – All faucets shall be dual handle controlled. Auto sensing devices shall not be used.

11.5.1.24. All plumbing faucets, fixtures, etc. shall be of commercial grade. Brand, type, style and color shall be approved by Owner prior to installation.

11.5.2. HVAC

11.5.2.1. Heating, ventilation, and air conditioning work shall be done in strict accordance with all applicable codes, including the State Mechanical Code, requirements of the municipality, and ASHRAE recommendations.

11.5.2.2. HVAC system shall be designed and sized to meet regional climate conditions. See Section 11.5.2.4.3 for Northern States Power regional HVAC system requirements.

11.5.2.3. Recommended Manufacturers

11.5.2.3.1. Trane

11.5.2.3.2. McQuay

11.5.2.3.3. AAON

11.5.2.3.4. York

11.5.2.4. General

11.5.2.4.1. Multi-zone air distribution using variable air volume (VAV)

11.5.2.4.2. Good indoor air quality design

11.5.2.4.3. All thermostat locations shall be in room programmable units with a minimum 5-2 day program and be hard-wired to a circuit board zone controller. Wireless devices are not allowed.

11.5.2.5. In-floor Heat

11.5.2.5.1. Hydronic in-floor radiant heat system shall be installed in regions subject to prolonged freezing conditions and shall be manufactured by Wirsbo or equivalent, and zoned to match forced air zones (zones to be approved by Owner).

11.5.2.5.2. Propane or gas boiler with at least 92% efficiency

11.5.2.5.3. Radiant or forced air propane or gas heaters shall be installed in the shop area in regions where radiant floor heat is not used. Placement and quantity to depend on climate and be approved by Owner.

11.5.2.6. Forced Air Furnace

11.5.2.6.1. Propane or gas furnace with at least 92% efficiency

11.5.2.6.2. 30% efficient pleated 4 inch throw away filter

11.5.2.6.3. Supply and return casing

11.5.2.6.4. Variable speed supply air drive with premium efficiency motor

11.5.2.6.5. Economizer package

11.5.2.7. Air Conditioner

11.5.2.7.1. Minimum EER or SEER ratings for package cooling unit to meet current Code requirements

11.5.2.7.2. Low-ambient operation control

11.5.2.7.3. 5 year compressor warranty

11.5.2.8. SCADA Room

11.5.2.8.1. Ductless mini-split air conditioning unit. Condensing unit to be mounted on the ground in shop area along the bathroom wall..

11.5.2.9. Shop Ventilation

11.5.2.9.1. Provide shop ventilation system with CO detector with manual override timer.

11.5.2.10. Exhaust Fans

11.5.2.10.1. Provide Greenheck vent set exhaust fans, complete with insulated roof curbs, bird screens, and back draft dampers. Restroom fans shall provide a ventilation rate meeting current Mechanical Code and ASHRAE requirements for restroom areas. Exhaust fans shall be controlled by the room automatic light switch. Provide for make-up air. Units shall be U.L. listed. Exhaust ductwork shall have 1-1/2” exterior insulation with foil extending from the roof curb to at least 6’-0” from the roof curb.

11.5.2.11. Ductwork Systems

11.5.2.11.1. All ductwork, construction, and installation shall be in accordance with latest SMACNA standards. Ductwork shall be isolated from fans and furnace via flexible connections. Ductwork shall be equipped with fire dampers as required by codes. Branch ducts in mains shall be equipped with dampers for balancing. Flex duct shall be used for the run outs to supply air diffusers. Flex duct runs shall be no longer than 5’-0” long. Each run out to each diffuser shall be equipped with a butterfly type balancing damper. Supply air ductwork shall be insulated with minimum 1-1/2” thick glass fiber exterior duct insulation with foil vapor barrier. Insulation conductivity not to exceed 0.25 BTU/in./sq. ft./hr. at a mean temperature to 75° F.

11.5.2.12. Diffusers

11.5.2.12.1. Provide Price, Titus, Hart & Cooley or equal square lay-in 2’ x 2’ adjustable pattern supply air diffusers.

11.5.2.12.2. Diffusers shall provide ability to manually adjust air flow in each room.

11.5.2.13. Return air ducts shall be wall mounted near the floor.

11.5.3. Security and Fire Alarm system

11.5.3.1.1. Building and Site shall include a security system provided and installed by VTI Security.

11.5.3.1.2. The system shall include card readers, associated door handles and locks, and fixed interior cameras on all exterior doors and all controlled access areas within the building as specified by Owner, two exterior mounted PTZ tower cameras and 1 fixed exterior camera with locations specified by Owner, operable entrance gate with loop detector, photo eye sensor, and call box with external dialing capabilities and pin hole camera.

11.5.3.1.3. The security system shall have a UPS, local control pad and monitor, video recording capabilities, and be linked to Owner’s Security Operations Center.

11.5.3.1.4. Smoke detectors shall be installed throughout the building in a quantity large enough to effectively detect a fire.

11.5.3.1.5. Detectors shall be hardwired to a central alarm panel in the Mechanical Room, and be supplied with all necessary equipment to send an alarm signal to the Xcel Energy Security Operations Center.

11.6. Submittals

11.6.1. Contractor shall submit construction drawings for approval by Owner prior to construction.

11.6.2. Contractor shall submit to Owner copies of all equipment operating and maintenance manuals.

11.6.3. Contractor is responsible for submitting all extended warranty certificates of equipment.

11.6.4. Contractor shall submit a training plan for the O&M building operations and conduct training with select Owner personnel after the building is completed.

11.6.5. See Section 1.3 for more submittals information.

11.7. Reference Pictures

12. Wind Turbines

12.1. Execution

12.1.1. The wind turbines and associated equipment provided by the turbine manufacturer shall be new and shipped directly from the factory to the project site and shall comply with all Occupational Safety and Health Administration (OSHA) regulations.

12.1.2. On-site staging area shall be provided to accommodate staging of the complete set of tower component delivery trucks. The staging area shall allow the safe entrance and exit of loaded delivery trucks.

12.1.3. Subject to Owner approval, the turbine manufacturer may update tower designs prior to project delivery so long as all current specifications and designs are met or exceeded.

12.1.4. The wind turbines shall be assembled and commissioned in strict compliance with the wind turbine manufactures requirements and procedures.

12.1.5. Contractor shall install the climb assist cable such that it extends to the same elevation that the lad safe cable is terminated at (i.e., into the Yaw Deck).

12.1.6. Contractor shall continue to meet all permit requirements (e.g., FAA lighting requirements) throughout wind turbine erection.

12.1.7. All turbine components shall be internally and externally cleaned down to the final exterior surface coating and be free of surface coating scratches, chips, and etc. The subject scratches, chips, and etc. shall be repaired prior to being lifted into place. All damage shall be repaired in strict compliance with turbine manufacturer requirements.

12.1.8. No operational parts shall be moved between towers (cannibalization) without Owner approval.

12.1.9. Temporary obstruction lighting as required by the FAA shall be supplied and installed by Contractor.

12.1.10. Permanent obstruction lighting as required by the FAA and manufactured by Owner approved vendor shall be supplied and installed by Contractor.

12.1.11. Radar detection equipment, if required by Owner, shall be supplied by Owner and installed by Contractor. Equipment consists of lattice structure, antennae, and foundation, small equipment cabinet, and control units that will be installed alongside obstruction lighting.

12.1.11.1. Power and Ethernet for the antennae and small equipment cabinet shall be provided and installed by contractor.

12.1.12. Precast concrete pad at base of tower entrance stairs with a minimum size of 4 foot by 4 foot by 6 inch thick and offset forward of the steps as a stair landing area.

12.1.13. Turbine foundation engineered to not require periodic base bolt tensioning.

12.1.14. Exterior foundation anchor rods shall be coated with UV resistant anti-seize coating applied to all exposed metal and covered with climate appropriate bolt covers that seal to the tower flange. Prior to coating, anchor rods shall be clean and free of oil and foreign materials.

12.1.15. Tower number labels shall be facing the immediate tower access road at an elevation which is above the tower door. The labels shall be UV resistant and climate appropriate stickers 9 inches in height.

12.2. Required Features

This section is for information purposes only if turbines are supplied by Owner.

12.2.1. All available OEM turbine upgrade and enhancement options available at the time of TSA execution, including but not limited to software, controller parameters, blade attachments, and power curve enhancements.

12.2.2. "Cold weather package" that allows turbine operation at least minus 30 degrees C (-30°C) and has a sealed and insulated (R10 min) nacelle and heater(s) capable of producing 20,000 Btu/hr.

12.2.3. Complete detailed and comprehensive set of schematic diagrams for all the electrical circuits and control systems.

12.2.4. Lockable tower door keyed alike.

12.2.5. No exterior light fixtures attached to the tower.

12.2.6. Internal tower lighting located at each tower deck, along the full length of the tower ladder, within the nacelle and at control cabinet locations to fully aluminate the work areas.

12.2.7. 240 VAC electrical receptacles at all tower deck locations.

12.2.8. 120 VAC and 240 VAC electrical receptacles in nacelle and tower entry platform.

12.2.9. Steel cable safety system centrally located on the tower ladder.

12.2.10. Service lift or electric motor continuous loop type climb assist with remote control for start, stop, load control and integrated power supply with the turbine. All climb assist equipment shall be manufactured by Power Climber and permanently attached to the turbine or ladder system except for the climbing pendant/remote.

12.2.11. Disconnect switch located on the yaw deck to allow isolation of the yaw motors prior to nacelle entry.

12.2.12. Tool/equipment hoist located at the yaw deck or within the nacelle and extends its reach to the tower entry deck level or exterior ground level.

12.2.13. Main bearings supplied by SKF, Timken or FAG/Schaeffler.

12.2.14. Gearbox meeting IEC 61400-4 CDV international standard "Design Requirements for Wind Turbine Gearboxes".

12.2.15. Gearbox oil water content less than 200 ppm and particulate to the ISO 4406 cleanliness standard of -/16-13 at Wind Turbine final factory acceptance test.

12.2.16. Hydraulic oil water content less than 500 ppm and required to meet cleanliness levels of 21/19/16 according to ISO 4406: 1999 at Wind Turbine final factory acceptance test.

12.2.17. Gearbox oil filtration package with a 10 micron full flow filter and 3 micron kidney loop filter or equivalent to meet the cleanliness standards in the preceding section.

12.2.18. Ceramic generator bearings.

12.2.19. Ice detection sensors. Sensors shall be located on a minimum of five turbines with one centrally located within the wind farm and four located on perimeter turbines spaced 90 degrees apart.

12.2.20. A backup mechanical anemometer with an ultrasonic anemometer as the primary supply. The controls shall be wired to transfer upon failure of the ultrasonic unit.

12.2.21. One wind vane.

12.2.22. Liquid applied blade leading edge erosion protection. Erosion protection shall be from blade mid-point to the blade tip and shall be applied at a thickness recommended by the coating manufacturer, but not less than 12 mils. The coating shall fully protect the pre-coated blade surface for a minimum of 10 years.

12.2.23. Transformer – Up tower transformer room shall have arc flash and access protection systems. The access door shall have a hasp and lock keyed alike.

12.2.24. Central Automatic Greasing System

12.2.24.1. Pre-filled greasing units shall be provided that are permanently, externally, and non-intrusively mounted at the locations listed below in each turbine. The units shall be pump driven and capable of mixing the grease to prevent separation. Units in the hub shall be supplied with spring loaded pump units.

12.2.24.1.1. Main bearings (3pt mount turbines only)

12.2.24.1.2. Generator bearings

12.2.24.1.3. Yaw bearing (if applicable)

12.2.24.1.4. Yaw gear teeth

12.2.24.1.5. Pitch gear teeth (if applicable)

12.2.24.2. The units at minimum shall send one digital signal for each pump indicating an alarm condition and shall be integrated into the SCADA or CBM system.

12.2.24.3. All lines and cables shall be oil and grease resistant, cold weather flexible, and routed in existing trays or routes that are clear of all walkways and maintenance points.

12.2.24.4. Grease catch units shall be provided that are permanently, externally, and non-intrusively mounted on the yaw gear in each turbine.

12.2.25. Condition Based Monitoring System

12.2.25.1. Hardware

Sensors shall be permanently, externally, and non-intrusively mounted at the following locations. Additional sensors shall be added as needed to provide a comprehensive diagnostic system.

12.2.25.1.1. Main Bearing – 1 sensor per bearing (2 total).

12.2.25.1.2. Gearbox – 3 sensors to detect low, intermediate and high speed shafts.

12.2.25.1.3. Generator – 2 sensors, drive and non-drive end bearings.

12.2.25.1.4. Drive train – 1 Proximity Induction sensor.

12.2.25.1.5. The data collection / signal processing unit shall be installed in a serviceable location in the nacelle and connected via the turbine network to the server.

12.2.25.1.6. All cables shall be oil and grease resistant, cold weather flexible, and routed in existing trays, conduit or routes.

12.2.25.2. Server and Software

A rack mounted server shall be installed in the turbine SCADA rack and meet the following requirements:

12.2.25.2.1. Windows Server latest version with SQL database.

12.2.25.2.2. Ability to communicate with other servers and backup devices via Modbus TCP, OPC, PI, or similar protocols.

12.2.25.2.3. Capable of quickly running the provided analysis software.

12.2.25.2.4. Capable of storing 1 year of data.

12.2.25.2.5. Unrestricted access without user count based licensing

12.2.25.2.6. Any connection to Company network shall be in accordance with Company Cybersecurity standards and policies.

12.2.25.2.7. Analysis software shall be pre-installed and meet the following requirements:

Unrestricted access and configuration ability without individual user licensing. This shall include the ability to modify, add, and delete all configurable points such as gearbox models, bearing frequencies, sensor parameters, alarm points, etc.

High level display to view all turbines' status on 1 page.

Detailed display for each turbine.

Record data at least once per day.

Access to all raw data.

12.2.25.3. Monitoring Service

12.2.25.3.1. 2 years of full fault monitoring, analysis, and evaluation service shall be included and all materials covered under the turbine warranty. Provide next business day alarm response reports with specific fault locations and recommended corrective actions. Phone and/or webcast conferences shall be used to discuss results when necessary during normal business hours, Monday through Friday excluding Holidays. Conferences shall not be expected to last more than 15 minutes each.

12.2.25.3.2. Provide a monthly summary report detailing activity for the previous month

12.2.25.3.3. All data obtained shall remain the property of Owner.

12.3. Minimum SCADA Features

This section is for information purposes only if turbines are supplied by Owner.

12.3.1. Company Enterprise network standards require a dedicated room for network, security, and IT hardware. Space shall meet the requirements of Company Technology Communications Construction Requirements & Infrastructure Standards. If possible, Wind turbine operation and control shall be from a central server located in the O&M building SCADA room. Server rack shall be an open-air rack. A remote operator station shall be connected and placed in the O&M building break room. Network architecture or servers that require dongle authentication shall be capable of authentication within a virtual session such as RDP or VNC.

12.3.2. Main control server with 3-year minimum data storage and OPC software.

12.3.3. Remote access server

12.3.4. Single display with 4 channel KVM switch

12.3.5. Backup power supply

12.3.6. All applicable software licenses without individual user licensing

12.3.7. Unrestricted access and configuration ability to all hardware, servers, software and control logic. This shall include the ability to modify, add, and delete all configurable points.

12.3.8. Automatic backup software

12.3.9. Software to modify SCADA screens

12.3.10. Microsoft Office Excel on each server with lifetime license

12.3.11. Substation monitoring screen(s) integrated with the SCADA system. Display all alarms and statuses along with a 1-line overview of breaker position and MWs, volts, amps, and VARs at all metered locations. For clarification purposes, metered locations include relays or other equipment that monitors the listed values.

12.3.12. Remote alarm notification capable of sending emails

12.3.13. Power curtailment at the substation level

12.3.14. 95% load reduction capability using equalized turbine curtailment. On/off control of turbines is not acceptable.

12.3.15. Analog signal capability with local/remote selection for power and voltage/VAR control.

12.3.16. Actual possible power signal the value of which is bases on actual on site wind speed

12.3.17. Power ramp rate control

12.3.18. Substation VAR control

12.3.19. Substation Voltage control

12.3.20. Aviation light monitoring and failure alarm integrated with the SCADA

12.3.21. The Turbine Supplier shall supply a data logger that provides data to the plant SCADA System.

12.3.22. The Turbine Supplier shall provide all meteorological tower instrumentation such as two sets of anemometers, wind vanes, barometers, and thermocouples at tip elevation.

12.4. Meteorological Monitoring Tower

12.4.1. If required by a permit, install and test one (1) fully furnished meteorological tower at wind turbine hub height, lightning and surge protection, grounding and 120 VAC utility receptacles. The meteorological tower will be a self-supporting designed for a 110 mph minimum wind load and installed according to the manufacturers specifications. Meteorological tower will be equipped with FAA compliant lighting.

12.4.2. If a full height tower is not required by a permit, install and test one (1) fully furnished meteorological tower next to the collection substation electrical equipment enclosure with lightning and surge protection. The meteorological tower shall be a self-supporting base hinged unit designed for an 80 mph minimum wind load and installed according to the manufacturers specifications. Tower shall be by Great Plains Towers model number DT/MHP20'/6 or equivalent with concrete pier foundation.

12.5. Submittals

12.5.1. All Turbine Supplier commissioning and testing procedures, checklists, inspection reports, punch lists and other records related to wind turbine assembly, inspection, commissioning and testing shall be submitted to Owner.

12.5.2. Turbine Supplier, Contractor and Subcontractor(s) commissioning and testing procedures, checklists, inspection reports, punch lists and other records related to wind turbine assembly, inspection, commissioning and testing shall be submitted to Owner.

12.5.3. One full electronic set of turbine electrical schematics, control system wiring diagrams and turbine operation and maintenance manual.

12.5.4. Gearbox oil analysis report including ISO particle counts, contaminates, additives and water levels which includes the limits of values acceptable to the turbine and oil manufacturers shall be submitted to Owner.

12.5.5. Pictures of all punch list items before and after the repairs are completed shall be submitted to Owner.

12.5.6. The final resolution of all component damage noted on component inspection receiving reports shall be documented. This documentation shall include, but not be limited to, inspection reports, repair procedures and before and after pictures.

12.5.7. See Section 1.3 for more submittals information.

13. Testing and Inspections

Contractor shall submit a Project Quality Assurance Plan that includes all testing and inspection procedures as outlined in this Specification. The Project Quality Assurance Plan shall be submitted to Owner for review and comment. Contractor shall provide designated individual(s) to conduct QA/QC oversight of inspection and testing performance.

Contractor shall develop and implement an inspection and test plan as part of its Project Quality Assurance Plan. The inspection and test plan, provided to Company by Contractor, shall describe all inspections and tests to be performed and shall identify the equipment with which such inspections and tests will be performed. The inspection and test plan shall refer to the applicable inspection and test instruction, whether for source, incoming, intermediary, or final inspections and tests at Contractor’s or its Subcontractors’ facilities. Contractor's inspection and test requirements shall fulfill the minimum inspection and test requirements set forth in this Specification

All testing and inspections shall be performed as required by the Design Documents and Project Quality Assurance Plan, and comply with the Special Conditions for Quality Management 2.0 set forth by the Agreement, but at a minimum all tests described in this Specification shall be completed. Contractor is responsible to ensure all testing and inspections performed by subcontractors and/or 3rd party inspection firms are performed and completed as required by this specification including retention of completed inspection records for archive.

Contractor shall document all non-conformances, deficiencies, or deviations identified during the inspection and test process in detail through their non-conformance reporting process and submit to the Company for review and approval of the resolution. Contractor shall respond to all non-conformances, deficiencies, or deviations identified by the Company in accordance with the requirements of the Special Conditions for Quality Management 2.0 set forth by the Agreement. All deficiencies shall be corrected at Contractor’s expense.

All testing and inspection records shall be sent to the engineer of record for review. A copy of all testing and inspection records and any recommendations made by the engineer shall be sent to Owner. Review of testing and inspection records does not alleviate Contractor from the responsibility of correcting deficient areas or work.

13.1. Civil

13.1.1. The testing requirements identified in this section apply to all civil work for the Project including access roads, foundations, collection, transmission, substation, electrical equipment enclosure, O&M building, etc.

13.1.2. Earthwork

13.1.2.1. All common, select, or granular fill material shall be qualified by testing to assure minimum gradation requirements. Material selected for use as fill, shall be sampled and a gradation test performed in accordance with ASTM C136. A gradation test shall be performed at a frequency of one for each source or each 10,000 cu. yds. of fill placed. On-site excavated material or imported material from other sources must be tested.

13.1.2.2. Soils used for Fill Material shall be tested for Grain Size Analysis (AASHTO T27), Atterberg Limits (AASHTO T89 and T90), Moisture Content (AASHTO T265), Proctor Tests (AASHTO T99), and LA Abrasion Tests (AASHTO T96). Tests shall be performed at a frequency of one for each source or 10,000 cubic yards of filled placed.

13.1.2.3. For placed and compacted fills for wind turbine foundations, provide one relative moisture and compaction test per lift indicating test location, dry density, moisture content and % proctor maximum dry density.

13.1.2.4. For placed and compacted fills for other locations, provide the greater of 3 relative moisture and compaction tests per lift or 1,000 cubic yards placed, indicating test locations, dry density, moisture content and % proctor maximum dry density.

13.1.2.5. Compaction tests shall be taken as required by the Design Documents. In the event of failed tests, Contractor shall not place additional fill until acceptable test results are obtained.

13.1.3. Crane Pads

13.1.3.1. Provide adequate testing, as specified by Engineer of Record, to ensure field subgrade bearing capacities meet or exceed main erection crane bearing pad and critical lift requirements.

13.1.4. Access Roads

13.1.4.1. Compacted Subgrade

13.1.4.1.1. Access roads shall be proof-rolled the full length in the presence of a geotechnical engineer or qualified and approved representative with a loaded tandem axle dump truck having a minimum gross weight of 25 tons. Subgrade shall be corrected if rutting greater than 1.5 inches and/or “pumping” of the subgrade occurs.

13.1.4.1.2. The method to scarify, dry and recompact subgrade shall not be allowed unless the material is proven not to contain organic material and/or material unable to remain compacted during or after a rain event.

13.1.4.1.3. The requirements set forth in Section 13.1.5 shall be met if access road subgrade is cement stabilized.

13.1.4.2. Nuclear Density Tests (AASHTO T310) shall be taken every 500 linear feet of road or a minimum of 3 tests per access road.

13.1.4.3. Aggregate Base and Top Course

13.1.4.3.1. Entire road length shall be proof-rolled. Where geogrid membrane is used, a Dynamic Cone Penetrometer (DCP) test (ASTM D6951-03) shall be taken at a frequency of 1 for every 500 lineal feet of road. A DCP test shall also be taken at a frequency of 1 for every 500 lineal feet of road in areas where an initial proof-roll test has failed. A sieve analysis shall be taken for placed base material and cap material at a frequency of 1 for every 2500 cu yd. A minimum of 2 standard Proctors should be performed on the road base and top course aggregate materials.

13.1.5. Cement Stabilization

13.1.5.1. Density tests shall be taken at the rate of one test every 1,000 square yards (i.e., approximately seven tests per eight ft. pass per mile).

13.1.5.2. Subgrade strength testing by DCP shall be done randomly for every 300 LF in each pass of the reclaimer. After at least two days of production, or when the engineer of record deems the procedure satisfactory, the testing may be increased to every 500 LF. Subgrade strength testing shall be done at 24 hours (plus or minus 4 hours) from the time of final compaction of the stabilized material. A minimum of 15 CBR is required prior to proof rolling by Contractor.

13.1.5.3. Additional subgrade strength testing by DCP shall be done at two to seven days from the time of final compaction on a 500 LF spacing. The test must confirm a CBR of 20 is achieved. If a CBR of 20 is not achieved, additional gravel surfacing will be required and the cement content for future stabilization will be adjusted.

13.1.5.4. Prior to placement of gravel surface, the subgrade shall be proof-rolled.

13.1.6. Concrete Works

13.1.6.1. All concrete, reinforcement, anchor bolts, embed plates, formwork, etc. shall be inspected per the current International Building Code (IBC), Chapter 17, “Special Inspections.”

13.1.6.2. After all wind turbine anchor bolts have been tensioned or torqued; a minimum of 10% shall be tested to verify that the final design tension has been achieved by use of an approved testing procedure.

13.1.6.3. General Concrete Tests

13.1.6.3.1. Tests shall be conducted by an independent third party Owner in accordance with ASTM standards. The location, date, mix, temperature, slump and percent air shall be recorded. Concrete deliveries that do not meet the design specifications shall be rejected.

13.1.6.3.2. Cast cylinders at least once per day, between batches of differing concrete mix designs, or for every 150 cubic yards of concrete placed. Perform laboratory strength testing per ASTM C39 at 7, 14, and 28 days.

13.1.6.3.3. Perform a minimum of one air test in accordance with ASTM C231 per set of strength test cylinders cast.

13.1.6.3.4. Perform a minimum of one slump test in accordance with ASTM C143 per set of strength test cylinders cast.

13.1.6.3.5. Cast a minimum of nine grout cubes for each foundation and perform laboratory strength testing in accordance with ASTM C109 at 3 and 28 days.

13.1.6.3.6. Each test cylinder shall be identified by number and record each concrete truck number, date and time batched, number of yards, additives in the mix, the time the concrete was placed, and the structure number of the foundation poured. These records shall be reviewed by the Engineer of Record and submitted to Owner. Test reports shall be labeled in a manner that will allow each test cylinder to be identified with a particular day, time, concrete truck, and structure number.

13.1.6.3.7. A report of each test cylinder break shall be e-mailed to the Engineer of Record, Owner, and concrete supplier within 2-business days from date of test.

13.1.6.3.8. Concrete that appears to be of low strength, as evaluated by ACI 214R - Guide to Evaluation of Strength Test Results of Concrete, shall be replaced at no additional cost to Owner.

13.2. Electrical

13.2.1. Collection

13.2.1.1. Upon completing installation of all systems and equipment, but prior to electrical substantial completion, Contractor shall conduct an operational test of all equipment, controls, and devices installed or modified by Contractor.

13.2.1.2. Contractor shall notify Owner in writing a minimum of three (3) Business Days in advance of any test. This operational testing is in addition to testing required in separate sections of this specification. Where possible, combination of this testing and other testing required should be accomplished to minimize travel requirements.

13.2.1.3. Power Cable Acceptance Testing

Installations of power cable including terminations are to be acceptance tested using D-C or low frequency AC high potential (Hipot) testing, and at a minimum to include the following tests. After completion of a test and before handling the cable, the conductor shall be grounded to permit any charge to drain to earth.

13.2.1.3.1. Continuity

After installation of the cable and prior to the high potential test specified below, a simple continuity test shall be conducted on the system. This can be accomplished by grounding the conductor at the source and checking for continuity from the end of each tap with an ohmmeter.

13.2.1.3.2. Cable Jacket Integrity Test

Cable Jacket integrity testing shall be performed on all collection cables. Defects or damage to cable jackets shall be repaired using a cable OEM approved method, or the damaged cable section shall be replaced.

13.2.1.3.3. High Potential

After successful continuity tests of the 34.5 KV collection system, high potential tests on each length of cable, with terminations in place but disconnected from the system. The installation shall withstand a minimum of fifteen (15) minutes D-C test potential or as recommended by the cable and connector manufacturers. The voltage may either be increased continuously or in steps to the maximum test value.

If increased continuously, the rate of increase of test voltage should be approximately uniform and increasing to maximum voltage in not less than ten (10) seconds or more than sixty (60) seconds.

If applied in steps, the rate of test voltage increase from one step to the next should be approximately uniform. The duration at each step shall be long enough for the absorption current to attain reasonable stabilization (one minute minimum). Current and voltage readings should be taken at the end of each step duration. The number of steps should be from five to eight.

Once VLF testing has been completed a test voltage shall be applied to the collection feeder riser conductors. Every switchgear in that feeder should then be checked with a meter to verify collection phasing is correct. This test can only be conducted once all collection cable has been terminated and landed for each feeder.

13.2.1.3.4. If more than three failures of any particular component occur within six months of commercial operation, then partial discharge testing shall be performed on all similar components.

13.2.1.3.5. Other Test and Inspections: All other tests and inspections described in the Project Quality Assurance Plan.

13.2.1.4. Wind Turbine Tower Ground Loop Testing

13.2.1.4.1. The Turbine Supplier shall provide the specification for the installation of the turbine grounding grid but does not require the achievement of a specific ohmic value for the ground grid impedance. The collection system interconnected grounding grid shall be designed to meet the latest issue of IEEE Std 80 requirement for personnel safety.

13.2.1.4.2. Testing of the wind turbine standalone ground impedance using a variation of the fall-of-potential method (also known as 3 probes method) per IEEE std 81 section 8.2.1.5 or IEEE std80 section 19.1. The variation used is the slope method which is particularly suitable for testing large ground grid without the need for very long distance to connect test lead.

13.2.1.5. Padmount Transformer Testing

13.2.1.5.1. The following transformer checks and tests shall be completed on all units:

13.2.1.5.2. Inspection of satisfactory mechanical installation including proper torque on bolts, labeling and grounding.

13.2.1.5.3. Insulation resistance test for winding to winding and each winding to ground. Calculate Polarization Index.

13.2.1.5.4. Field test of transformer turns ratio test on all taps.

13.2.1.5.5. Routine and Design tests specified for Class I power transformers identified in IEEEC57.12.00 2010 table 18

13.2.1.5.6. Oil analysis for visual inspection, gas, liquid screen, and Karl Fischer moisture at minimum.

13.2.1.5.7. All other test and inspections described in the Project Quality Assurance Plan.

13.2.1.6. Quality Control Testing

13.2.1.7. Upon completing installation of all systems and equipment, but prior to electrical substantial completion, Contractor shall conduct an operational test of all equipment, controls, and devices installed or modified by Contractor.

13.2.1.8. Contractor shall notify Owner in writing a minimum of three (3) Business Days in advance of any test. This operational testing is in addition to testing required in separate sections of this specification. Where possible, combination of this testing and other testing required should be accomplished to minimize travel requirements.

13.2.2. Transmission Line

13.2.2.1. A visual inspection of phasing and overall construction shall be conducted by all interested parties prior to energization.

13.2.2.2. Ground resistance testing.

13.2.2.3. OPGW

13.2.2.3.1. Pre-installation Acceptance Testing

Contractor will require the cable manufacturer to ship the cables such that both cable ends are exposed allowing for testing in both directions

After the fiber optic cables are received, but prior to Contractor installing the cables, Contractor shall make sure there has been a bidirectional OTDR test of the cables on the reels. All fibers shall be tested.

All testing shall be done at both optical wavelengths 1300 and 1550 nanometers and results recorded and copies of the testing supplied to Owner. These tests shall be compared with the reel tests performed by the manufacturer. Contractor shall immediately report any discrepancies, defects or anomalies to the supplier and is responsible for any replacement costs incurred.

13.2.2.3.2. Installed Testing

After installing the fiber optic cables and after all required splicing and termination work, Contractor shall perform a final bidirectional OTDR test on each cable segment. All terminated fibers shall be tested from termination to termination.

Testing shall be performed for each fiber at two wavelengths (1300 and 1550 nanometers). The OTDR shall have a hardcopy feature and digital storage media compatible with standard software such as Excel or Word.

Each OTDR trance shall be identified by fiber ID (tube/color or number), end points (by site name), and launch point. Contractor shall completely investigate any discrepancies, defects or anomalies, as indicated by Owner immediately. Any damage to the fiber optic cables detected during final testing shall be repaired by Contractor at Contractor's sole expense.

In addition to OTDR testing, an optical attenuation test shall be performed on selected fiber circuits. This test shall be performed at 1300 and 1550 nanometers, using a calibrated light source and optical power meter.

Any cable that is tested with negative performance characteristics will be replaced or adjusted as necessary.

Copies of the test results shall be submitted to Owner and Engineer of Record for review and approval prior to final acceptance.

13.2.3. Substation

13.2.3.1. Tests

13.2.3.1.1. Upon completing installation of all systems and equipment, but prior to electrical substantial completion, Contractor shall conduct an operational test of all equipment, controls, and devices installed or modified by Contractor.

13.2.3.1.2. Contractor shall notify Owner in writing a minimum of three (3) Business Days in advance of any test. This operational testing is in addition to testing required in separate sections of this specification. Where possible, combination of this testing and other testing required should be accomplished to minimize travel requirements.

13.2.3.1.3. For the following sections, the term “function” or “function testing” means applying the appropriate inputs (voltage, current, pressure, temperature, etc.) to a device, and verifying all required responses or outputs. Testing shall be completed on the specified equipment after it is fully assembled and installed at its permanent location. The types of tests covered by this criteria document include, but are not be limited to the following:

13.2.3.1.4. In general, all equipment will require the following:

Inspection - Visual and mechanical inspections shall be performed.

Verify the nameplate data against the design criteria and the "Bill of Materials".

Check that there are no broken or cracked parts or other physical damage. Check that screws are tight. This includes relays, synchronizers, cases, and covers.

Check devices for moisture or damage from moisture and foreign materials that could inhibit the proper operation and functioning of the devices.

Check for proper contact alignment and travel, disc rotation for freedom of movement, target operation, etc. Adjust mechanical alignments per the manufacturer's specification.

13.2.3.2. Grade Tolerances

13.2.3.2.1. Grade for “rough grade” elevations shall be established to a tolerance of ± 5/8”. Horizontal plan dimensions shall be maintained within 0.05 feet of plan location. Road elevations and line shall be located within the same tolerance limits.

13.2.3.3. Structural Steel Erection

13.2.3.3.1. Contractor shall accommodate all inspection and testing activities of high-strength bolted connections and field-welded connections by Owner. Contractor shall perform tests and prepare test reports as required to ensure the complete and finished erection of steel structures.

13.2.3.3.2. Contractor shall document all non-conformances, deficiencies, or deviations identified during the inspection and test process in detail through their non-conformance reporting process and submit to the Company for review and approval of the resolution. Deficiencies revealed through inspections and laboratory tests which are determined to be in non-compliance with this Specification shall be corrected at Contractor's expense. Additional tests shall be performed at Contractor's expense, as necessary, to remove a non-compliance of the original steel erection.

13.2.3.3.3. Bolted Connections

Field bolted connections shall be inspected in accordance with AISC specifications using the turn of the nut method.

13.2.3.3.4. Field Welded Connections

Contractor shall perform inspection and testing of field welded connections during the erection of the structural steel. The following activities shall be performed:

Visual inspection of all welds for weld profile and surface defects.

Instrument inspection of selected welds to check for defects and discontinuities which are not visible on the surface involving one or more of the following methods:

Ultrasonic Inspection: ASTM E 164.

Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not acceptable.

Radiographic Inspection: ASTM E 94 and ASTM E 142; minimum quality level "2-2T."

Contractor shall record the types and locations of any defects found in field welds and will outline work to be performed by Contractor to correct all deficiencies in field welded connections.

13.2.3.4. Individual Equipment Testing

13.2.3.4.1. Power Transformers

Main Power Transformers shall be tested from the field device to the EEE.

See Wind MPT Specification Rev 3 for more information.

13.2.3.4.2. Circuit Breakers

Physical Testing

Fill with gas (SF-6 breakers only) and have SF-6 tested as required.

Connect operating Linkage (for independent pole breakers)

Perform Hi-Pot vacuum bottles and check measurements (vacuum breakers only)

Perform visual and operational check of mechanism

Perform timing and velocity tests

Perform power factor test on individual bushings and overall power factor

Sniff/soap for leaks on gas breakers

Measure contact resistance

Control Testing

Perform current transformer (CT) Tests

Local checks at the breaker:

Check function of heater circuit.

Check function of controls (trip, close, block trip/close, dual trip coil, anti-pump, etc.)

Check alarms to terminal blocks

Check labeling of fuses, switches and relays

Check calibration of relays at breaker

Wire check AC circuit

Calibrate relaying

All associated breaker failure relays

All associated sync-check and voltage monitoring relays

All associated reclosing relays

Any synchronous pole operation controls

All associated PLC/DCS alarm and control schemes

13.2.3.4.3. Circuit Switchers and Motor Operated Disconnect Switches

Physical Testing

Verify pole synchronism. Switches should be adjusted to manufacturer tolerances.

For Circuit Switcher and interrupter type devices, perform insulation resistance tests on each pole in accordance with the manufacturer's recommendations.

Measure the contact resistance across each closed switchblade.

High-Pot vacuum bottles

Power factor test on individual bushings and overall power factor

Check and align switch/fuse combinations

Verify that expulsion limiting devices are present on all holders having expulsion type elements.

All problems shall be resolved and all adjustments completed prior to driving the piercing bolts.

For Circuit Switchers, interrupters, and similar devices, check the timing of the shunt trips and the mechanical trips on the attachments.

Control Testing (MOD’s and Circuit Switchers Only)

Check function of heater circuit.

Check local function of limit switches.

Verify proper cam positioning.

Check local function of interlocks.

Check function of controls from control house.

Test and document EMS control and status

13.2.3.4.4. Capacitor Banks

Physical Testing

Measure and record capacitance of strings/series groups with capacitance meter.

Verify equipment is properly grounded

Control Testing

Perform Current Transformer (CT) Tests

Perform VT testing

Perform capacitance value check - by voltage method (fuseless only) verify equal voltage distribution across each can

Perform wire check of AC circuits

Calibrate relaying

Verify metering calibration

Verify function of control circuits

Test alarms to annunciator and to RTU/PLC (remote terminal unit) inputs

Test and document EMS analog, control, alarms and status

13.2.3.4.5. Transmission Line Relaying

Control Testing

Wire check AC circuits

Check Line VTs

Perform manufacturer's acceptance tests for all line relays

Calibrate relaying, and verify settings for all line relays

Set up pilot relaying and transfer trip equipment common to all piloted systems

Apply settings

Perform "back to back" local function tests

Perform "end to end" piloted relaying and transfer trip tests

Record installed signal receive levels

Check alarms to annunciator and EMS

Tone equipment

Carrier equipment

Verify metering calibration

Function relaying control circuits

Perform tuning of carrier equipment on ungrounded line

Test and document EMS analog, control, alarms and status

Download as-left relay setting files and turn as-left setting files over to Owner.

13.2.3.4.6. SCADA Systems and Annunciators

SCADA Tests

Set-up Remote Terminal Unit (RTU) equipment

Function test all control, indication, alarm, and analog points in the RTU, to and from the EMS. Verify SCADA descriptions match inputs.

Test for connection and functionality to the Turbine Supplier's SCADA system.

Traditional Annunciator Tests

Check all points including spares along to verify operation of lights, bells, cutoffs, and resets.

Verify labeling matches print and is to standard

Programmable display panel tests

Load configuration software

Verify labels are correct in both the schematic and settings spreadsheet.

Save final configuration to disk to leave on site. Supply final configuration files to Owner.

13.2.3.4.7. Substation Batteries & Chargers

Physical Testing

Clean, lubricate and install inter-cell connectors.

Torque inter-cell connectors to manufacturer's specifications

Measure and record resistance of inter-cell connectors

Test DC voltage (float & equalize)

Measure temperature and specific gravity of each cell.

Perform a battery discharge test per IEEE 450 (if required)

Control Testing

Check loss of AC alarm

Calibrate battery monitoring relay

Test alarms to annunciator and to RTU/PLC inputs

Test and document EMS alarms

Verify DC lighting system (if required)

Verify correct coordination of charger with vent fan operation (if required)

13.2.3.4.8. Station Aux./ Transfer Switches/Load Centers

Check all circuit connections immediately prior to energization

Energize equipment one stage, section, circuit, or piece at a time to minimize the damage in the event of an equipment failure and to aid in locating trouble areas.

Put settings on transfer switch, verify proper voltage magnitudes, current magnitudes, phasing, and correct operation during energizing

Check all interlocks and verify the correct operation of keyed interlocks (Kirk® key). (If required)

Equipment ground verification.

All measurements and tests shall be recorded.

Load centers

Verify correct labeling and fusing of load center circuits

Check or verify that construction has functionally checked the labeling of the load center loads

13.2.3.4.9. Miscellaneous equipment

Control & instrument switches

Verify operation and design function of and proper operation sequence of all devices.

Check control house temp alarm (check to annunciator and EMS)

Check control heater and vent fan controls and proper labeling

Verify time stamp and time reference systems.

Doble® surge arresters, bus work, free standing CT's, coupling capacitors (CCs), VTs, CVTs, and CCVTs, and air core reactors.

Verify functionality of HVAC systems.

Verify functionality of security intrusion alarm systems.

Verify functionality of fire alarm systems.

Verify functionality of substation lighting control system.

13.2.3.4.10. Motors

Verify that the correct voltage taps are in use.

Verify that the proper direction of rotation is present on the three-phase motors.

Verify that the motor is properly lubricated.

13.2.3.4.11. Phasing and Synchronizing

Maintain the correct phasing on all circuits and buses. The substation buses and connections shall have the phasing as shown in the Design Documents. All bus work shall be physically checked for phasing and verified to be correct and as shown on the station general arrangement drawings, the bus plans, the three line drawings, and the relaying schematics.

Perform phasing tests on all circuits that can be energized from two or more sources. All voltage and current phase angles shall be referenced to the same reference quantity for all readings on a specific scheme. The phasing shall be checked with phasing voltage probes where practical.

13.2.3.4.12. Corona Testing

For substations operating at or above 230 kV and for any substation that is operating with reduced phase-to-ground or reduced phase-to-phase clearances, that substation shall be tested for corona by use of "night vision" equipment.

Other means such as ultra-sonic equipment and time exposure photography shall also be used as needed to locate the sources of excess corona. The tester shall inspect all high voltage equipment, buses, leads, etc. for corona.

13.2.3.4.13. Substation Bus Protection

Perform current transformer (CT) Tests

Wire check AC circuit

Check bus VT's

Perform relay setting/calibrate relaying

Verify metering calibration

Check digital meter with analog mA output

Multifunction digital transducer/meter with MODBUS® plus output

Test function of control circuits

Perform bus differential upset test (if required)

Test alarms to annunciator and to RTU/PLC inputs

Test and document EMS analog, control, alarms and status

13.2.3.4.14. Current Transformers

Control Tests

Check that high voltage connections of transformers and breakers match the scheme

Verify high voltage phasing is correct

Verify phasing is correct

Verify that all documentation including, CT nameplates, M&R, relay test sheets, and schematics match (polarity marks and ratios).

All CT's used for revenue metering or interchange metering must have ratio correction test curves and phase angle correction test curves. All CT's in this service, which do not have these test curves available from the manufacturer or CT supplier, shall be tested and curves produced as outlined in the EEI "Handbook for Electricity Metering". Normally the ratio correction and phase angle correction curves are specified as part of the purchase specification and will be provided from the supplier.

Make sure CT connections are proper to give the desired protection.

Verify that actual tap connected will give the ratio on the scheme

Verify ratios and connections are correct for transformer differential relaying systems.

Fill out CT documentation

Polarity check – relative to polarity marks (physical), the bridging direction (electrical) and the drawings

Ratio/Taps check – all taps

Secondary injection (excitation)

Test and record CT voltage saturation

Wire checking – See Wire Checking below

Perform Meg Ohm test (500V scale) to ground

Make sure bushings are labeled with phase and bushing number

13.2.3.4.15. Voltage Transformers & Coupling Capacitor Voltage Transformers

VT and CCVT Physical Testing

Perform power factor tests

VT and CCVT Control Testing

Verify that actual tap connected will give the ratio on the scheme

Make sure VT nameplate, relay test sheets, and schematics match (polarity and ratios).

Perform wiring checks on CCVT

Perform ratio and polarity checks on wound VTs and distribution transformers used for metering or relaying

Wire checking – See Wire Checking below

13.2.3.4.16. Wire Checking

(CT and VT circuits only)

Perform continuity check of all current shorting switches

Perform continuity check of all CT wiring

Inject currents at the source of each current transformer string and check the string at each device with a clamp-on ammeter or current probe to verify that all current transformer strings are connected in accordance with schematics

Simulate the actual load current and fault current operation of the substation electrical systems by injecting appropriate currents into the CT strings to check the protective relay operation, the CT circuits, the meters, and the instruments.

Perform continuity check of all VT wiring (if required):

Pull the fuses from CVT. CCVT, PD, or VT junction boxes and apply the proper phase- to-phase and phase-to-ground voltages to the load side of the fuse blocks. Check for the proper voltages at all relays, instruments, switches, etc. to verify that the voltage circuit is connected in accordance with the schematics.

Verify tagging/labeling to standards

Verify proper fuse sizing of voltage circuits

Visually and mechanically (pull on wire) inspect terminations

Verify that all VT and CT circuits have one and only one ground (exception is for power/metering VT which are grounded at both transformer and at the first panel).

13.2.3.4.17. AC Circuits

Verify proper voltage rating of equipment before fusing up

Verify correct labeling and breaker size

Verify correct circuit feeds the equipment and that the scheme circuit number is correct

Verify that "wild leg" is not used on 120 V circuits.

13.2.3.4.18. DC Circuits

Verify proper voltage rating of equipment before fusing up

Verify correct labeling and fuse sizes as per the Design Documents

Verify that the scheme reflects the correct circuit number

Check for proper polarity at device

If possible, remove or turn off equipment power supplies before initial Energization then check polarity before turning on

Test for shorts, grounds and back-fed DC (cross-coupled voltage test) before initially installing DC fuses for the first time.

After each new circuit is fused up, check the battery for grounds

Make sure all unused fuse blocks have wooden dowels inserted

13.2.3.4.19. Metering

Check calibration of all metering including analog transducers, analog meters, and digital meters.

Apply standard configuration to programmable meters

Using a calibration standard, check the accuracy of the watt-hour meters and the pulse initiators (KYZ) according to ANSI C12 and as directed by the manufacturer.

Check and record the output at 0 percent and one non-zero point.

13.2.3.4.20. Relay Setting/Testing

Verify proper labeling of relay to match Design Documents. (Do not place labels on the removable covers of relays but rather on the panel or the relay itself)

Make sure that removable relays are tagged as well as the panel.

Relay testing

Perform acceptance tests in accordance with the manufacturer's instruction books.

Verify operation of all light emitting diode indicators on relays containing such features.

Set the contrast for liquid crystal display read-outs.

Check the electrical and mechanical continuity of all taps, jumpers, etc.

Verify that the electro-mechanical relay devices function at all tap settings (i.e., operable, not calibrated). Verify that the electro-mechanical relay devices are calibrated within the manufacturer's tolerance specifications at the relay settings provided by the Engineer.

Install settings on relays

Test all relays to the values provided.

Electro-mechanical relays shall be tested in a case. Cases shall not be pulled from the relay switchboards or unwired for this purpose. Relays can be tested in the case while mounted on the relay panel or in spare cases used for bench testing.

Solid state types of relays that are in a draw-out style case shall be tested as outlined above.

Microprocessor and solid state types of relays that cannot be removed from a case shall be tested, prior to being mounted or wired on the switchboard, by the use of test stabs or plugs into their access points.

If testing is required after the relay is wired, the relay may be unwired and tested using the relay's access termination points. However, if a relay is unwired, all circuits disrupted shall be retested to verify correct termination and operation.

All protective relay operating tolerances shall be set, at a maximum, to manufacturer's specification or +/- 5%, whichever is less.

Verify all of the inputs and outputs of the relay device for the correct internal functioning. Verify that the correct targets drop/show for each output.

Relays with no field settings, such as lockout and auxiliary tripping relays, shall be randomly tested for pickup and dropout voltages and times. Measure the coil impedance if required. Document and sign working copy of relay test sheets after calibration and logic testing are complete.

Label instruction book with date installed and equipment covered and write “substation copy” on the instruction book

Put label on back of relay with installed date and list communication parameters (cable, special interface software, passwords, etc.) if required

Provide as-left setting files for all devices including Relays, Meters, RTU’s, etc.

13.2.3.4.21. Demonstration Testing

Simulate real world tests with relaying systems by using AC quantities to operate the protective relays and then using the trip output to turn off the test set.

Trip and verify reclosing of breakers

Check MOD sectionalizing.

Trip lockouts from relays

Place all equipment in the condition it was found in at the beginning of the outage and place new equipment in service

13.2.3.4.22. Post-Energization Testing and Review

Review Design Documents to make sure all testing is documented or punch listed and that loose ends have been addressed.

Check all relaying is on and in service.

Make sure all equipment and control switches are in the position that they were switched out as.

Close all blocking bar switches/lockout switches if required

Check all panel grounds are landed.

Verify all unused CT's are shorted and grounded.

Verify all alarms and EMS points are in service.

Check for battery grounds.

Verify that switching request allows for parallel sources during load check of differential relaying before feeding radially.

Load check & in service checks.

Load check all new/modified CT circuits

Differential Relays: Compare restraint to operating quantities to ensure correct configuration. It is especially important on differential relays to verify correct operation under load when all inputs are energized.

Distance Relays: Measure the line power flow as seen by the relay inputs, and compare to line metered values to verify proper polarity and tap settings.

Overcurrent Relays: Compare input currents with other metered values, and verify polarity where applicable.

Phase check new/modified voltage circuits, verify all fuses are good.

Verify metering locally and at EMS.

Check rotation of transformer pumps and fans.

Check load on transformer pumps/fans with clamp on meter.

Check for proper operation of transformer/regulator LTC and paralleling operation.

Check for proper operation of transformer differential relaying.

Verify all relays have the proper voltages and current quantities present.

13.2.3.4.23. Cable Raceway Systems

Contractor shall accommodate inspection and testing activities by Owner. Before backfilling Contractor and Owner shall jointly inspect all trenches, conduit, cable placement, risers, and other construction not accessible after backfilling. If corrections are required, subsequent inspections will be made until all corrections are made and accepted by Owner.

The excavated trenches shall be maintained to be free of accumulated water and be maintained to the depths specified. Construction shall be arranged and marked so that trenches will be left open for the shortest practical time to trench collapse due to other construction activity, rain, or accumulation of water in the trench. Safety and traffic barriers shall be installed in accordance with local, State and Federal requirements.

All changes in routing of underground raceway systems shall be located exactly in the Design Documents.

13.2.3.4.24. Surface Coating Repair

Contractor shall accommodate inspection and testing activities by Owner. Contractor shall perform all surface coating repairs as required by this Section and as requested by Owner. All surface coating repairs to damaged equipment or structures occurring while in the possession of Contractor shall be made to the satisfaction of Owner and all costs to repair such surface coatings shall be borne by Contractor.

13.3. Wind Turbines

This section is for information purposes only if turbines are supplied by Owner.

13.3.1. All turbines will be commissioned and tested in strict compliance with wind turbine manufactures requirements and procedures.

13.3.2. Gearbox oil in each turbine shall be sampled and analyzed to confirm the oil meets all turbine and oil manufacture specifications.