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.

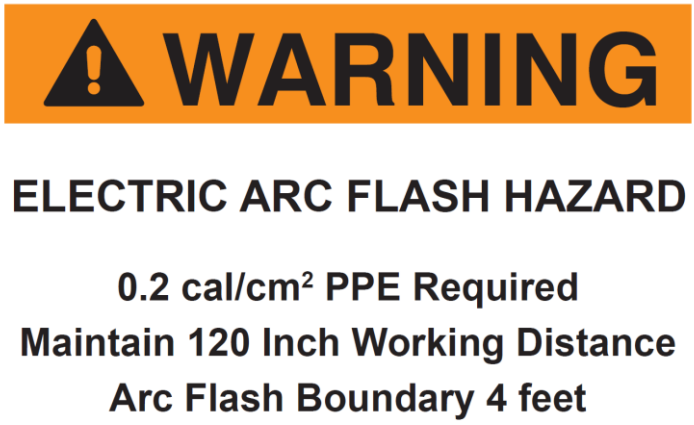
7.5.6.7. Reactive Power Flow – The purpose of the reactive power flow study is to calculate the power factor over a range of plant outputs to ensure the power factor of the wind farm meets the Generator Interconnection Agreement required power factor range while staying within the power factor limitations 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.

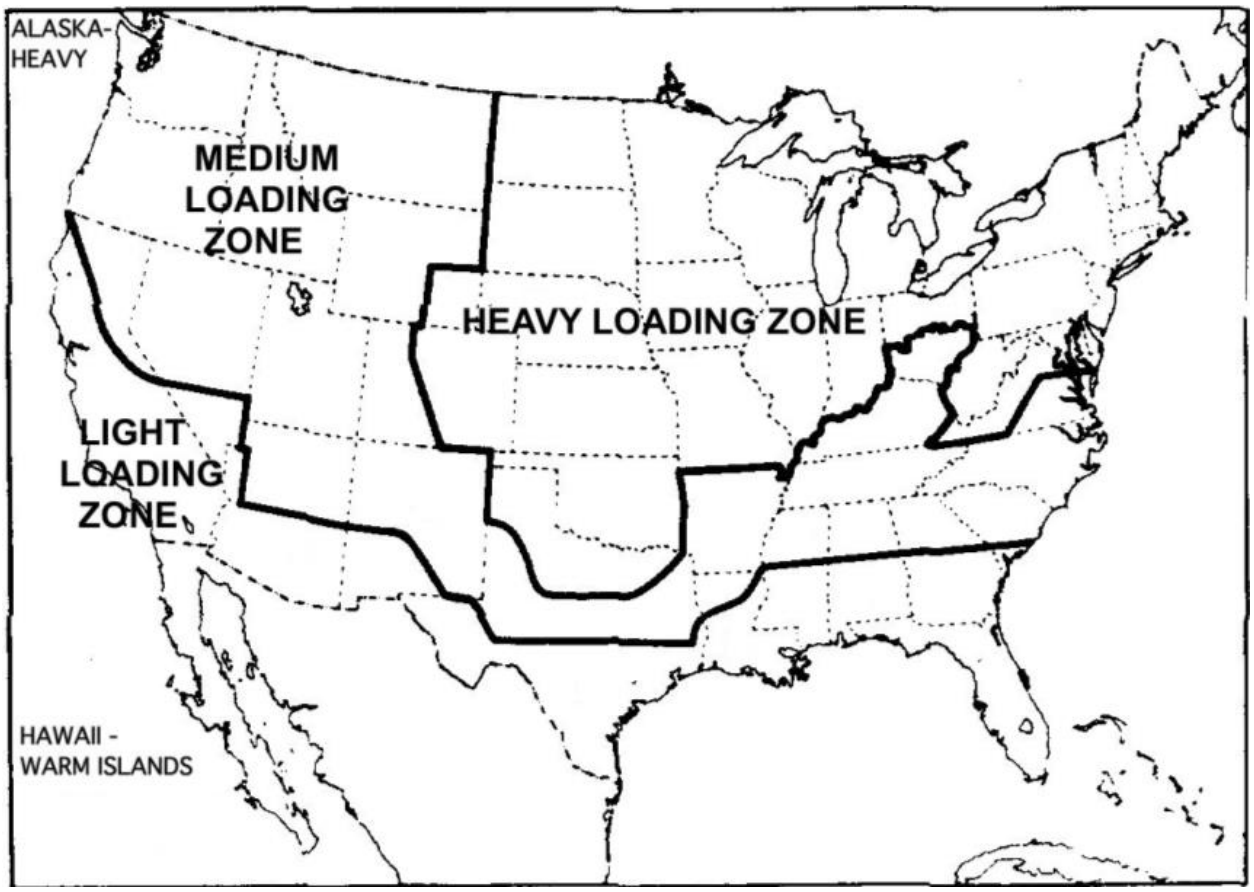


Figure 2: NESC Rule 250 B Loading Zones

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.

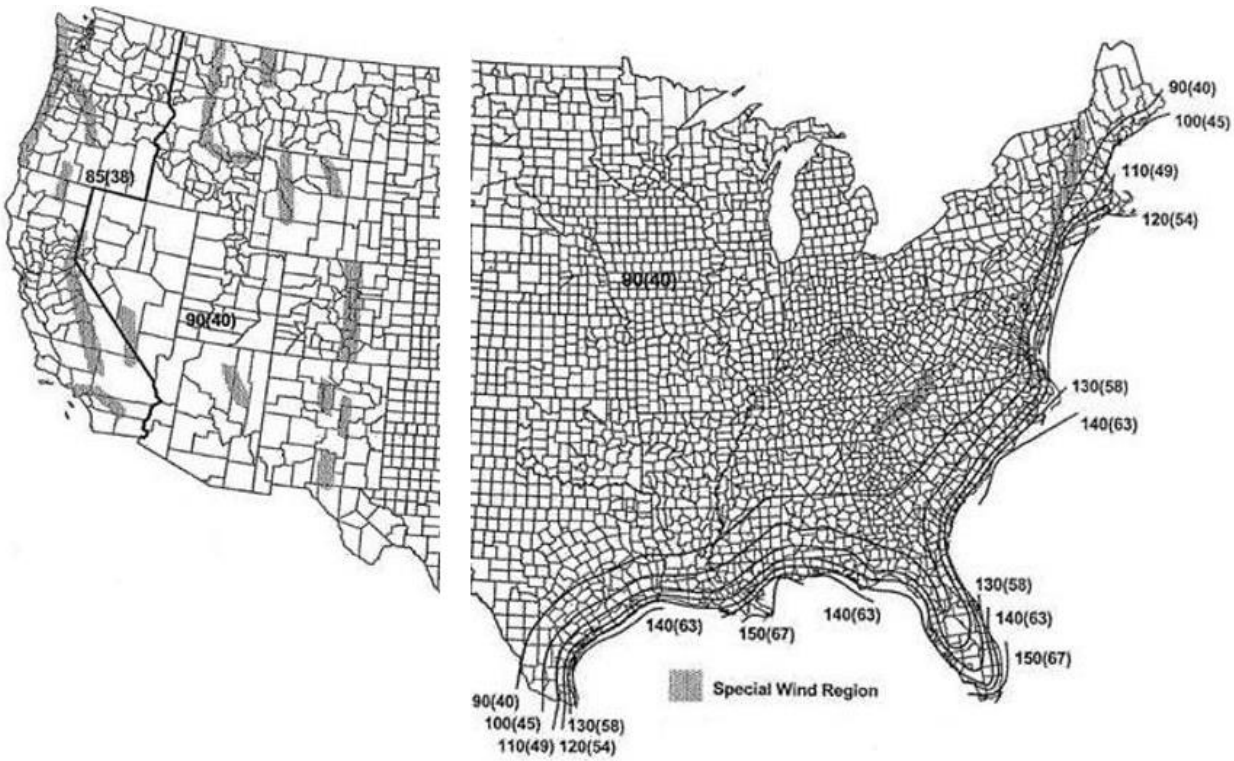


Figure 3: NESC Rule 250C extreme wind map.

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.

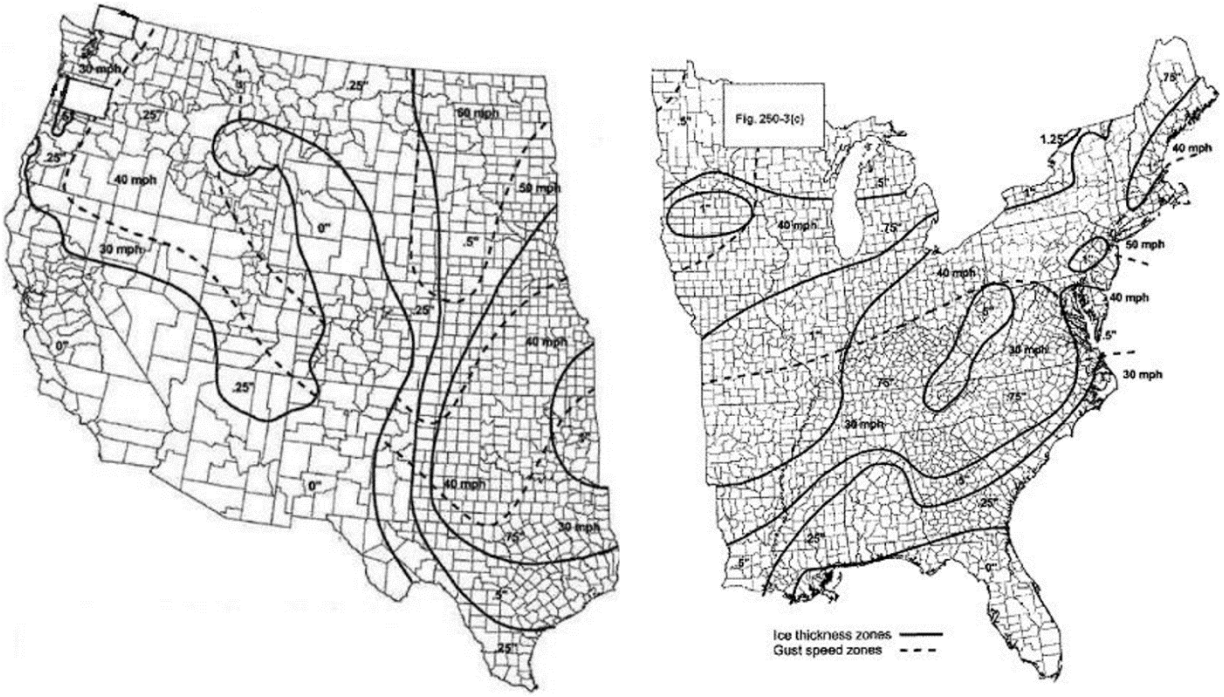


Figure 4: NESC Rule 250D combined ice and wind map.

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:

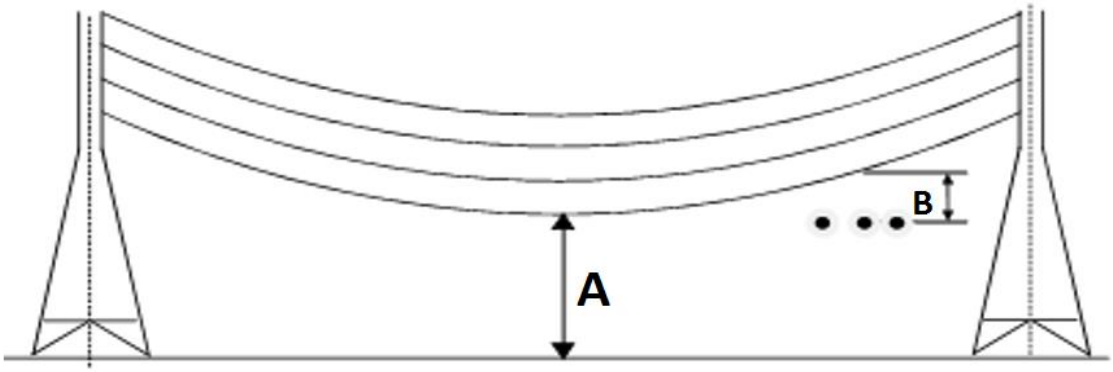
Under NESC Rule 250C (special wind zone regions apply), and conductors at final sag, the structure deflection should be limited to 8% of the structure height, assumed linear for conductor attachments below the top of pole.

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″)

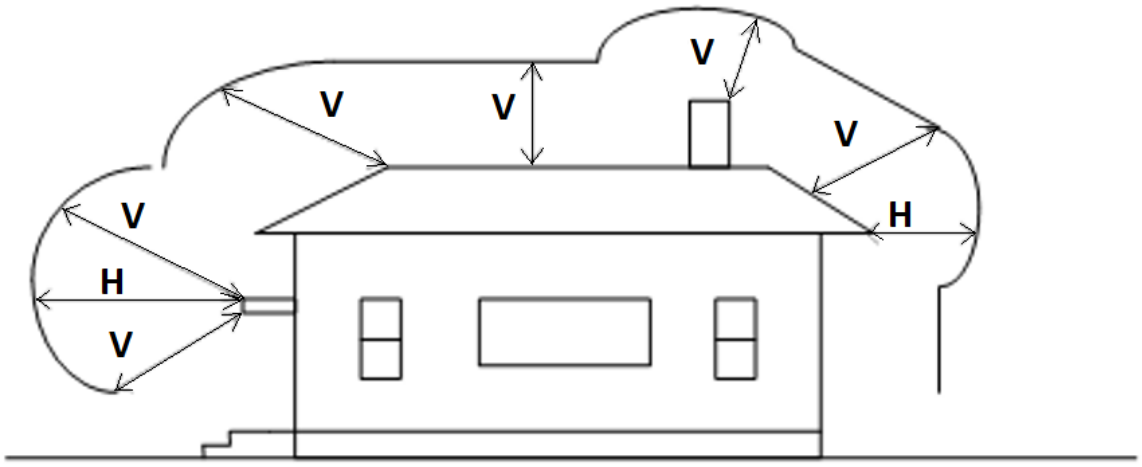
		KV	**34.5kV**	**69kV**	**88kV**	**115kV**	**161kV**	**230kV**	**345kV**	**500kV**
B	**The clearance between two different circuit crossings (NESC Section 233)**	**34.5kV**	4′-0″ (2′-0″)	4′-0″ (2′-8″)	5′-0″ (3′-1″)	5′-0″ (3′-7″)	6′-0″ (4′-6″)	7′-0″ (5′-11″)	10′-0″ (8′-3″)	13′-0″ (11′-4″)
		69kV		5′-0″ (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 *(These clearances apply to working near energized lines)*	**WORKING CLEARANCE AT HIGHEST OPERATING TEMPERATURE OF CONDUCTOR**							
	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”

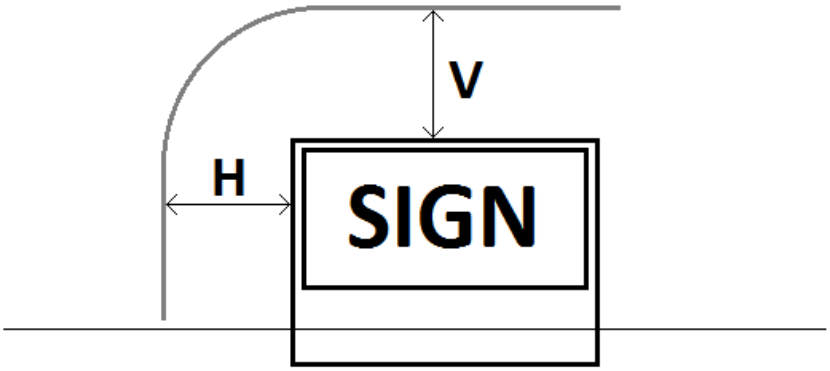
NOTES
1. Clearances are from NFPA 70E, Table 130.2(C), “Approach boundaries to live parts for shock protection”
2. Qualified workers have skills and knowledge related to the construction and operation of the electrical equipment and installations and have received safety training on the hazards involved.
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″)

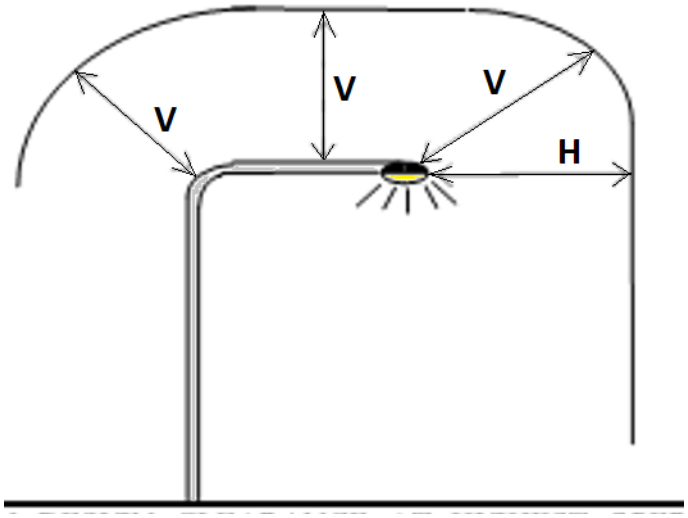
Figure 6: Building clearance.



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”)

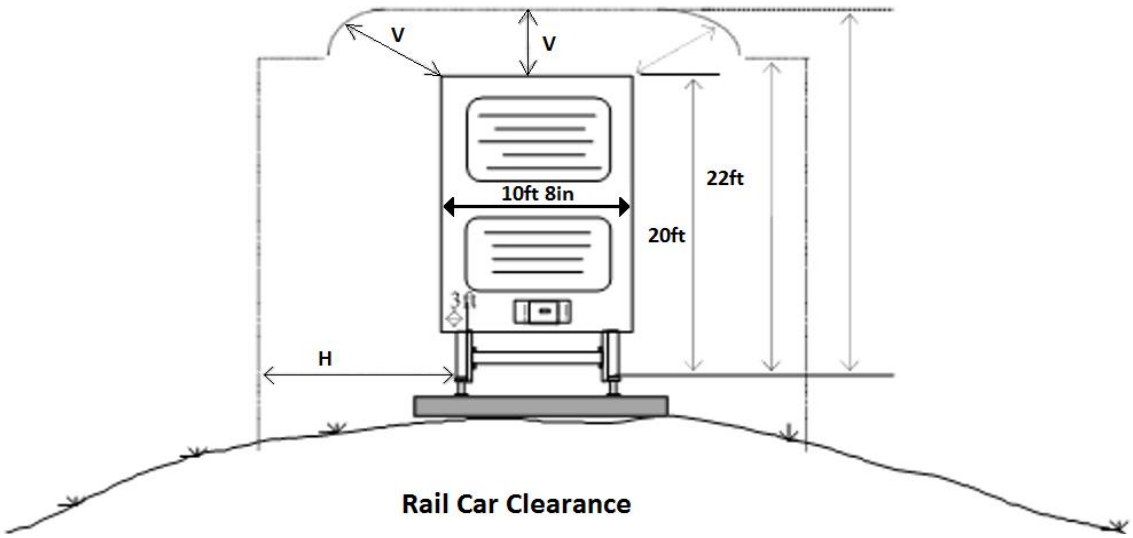
V	Vertical clearance	10’ (10’-0”)	14’ (12’-6”)	14’ (13’-3”)	15’ (13’-6”)	15’ (14’-1”)	15’ (15’-0”)	17’ (16’-5”)	19’ (18’-9”)	22’ (21’-11”)
NOTE: During installation and maintenance of signs, billboards etc., compliance with the working clearances for booms cranes and workers listed on Figure 6 of this 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.



Rail Car 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

Pentachlorophenol (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.

Creosote 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.

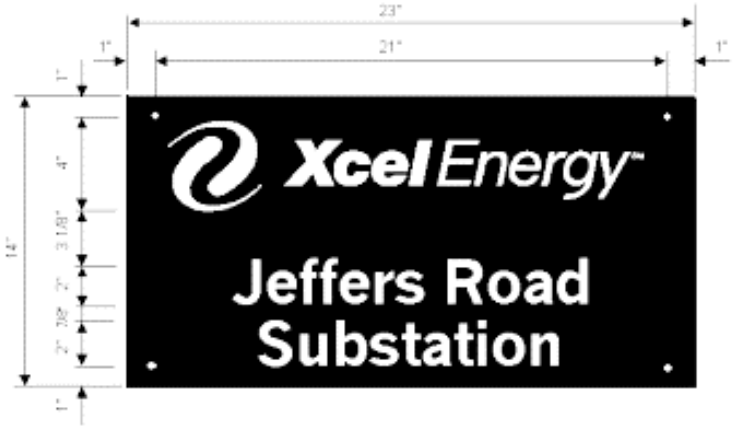
9.1.9.2. Cables within the substation shall be routed through a cable trench system extending from the Electrical Equipment Enclosure (EEE) to equipment located within the substation. The final route from the cable trench to the device shall be in schedule 40 PVC conduit for below grade portions of the 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

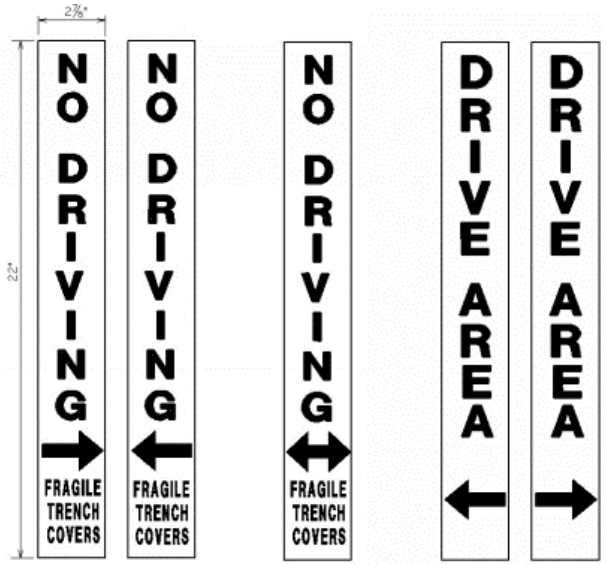
9.1.10.6.1. The sign should be placed at substations where cables are in the area and need to be marked to prevent accidental digging.

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



Sign #1 Decals Mounted Back-to-Back

Sign #2 Decals Mounted Back-to-Back

Sign #3 Decals Mounted Back-to-Back

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.

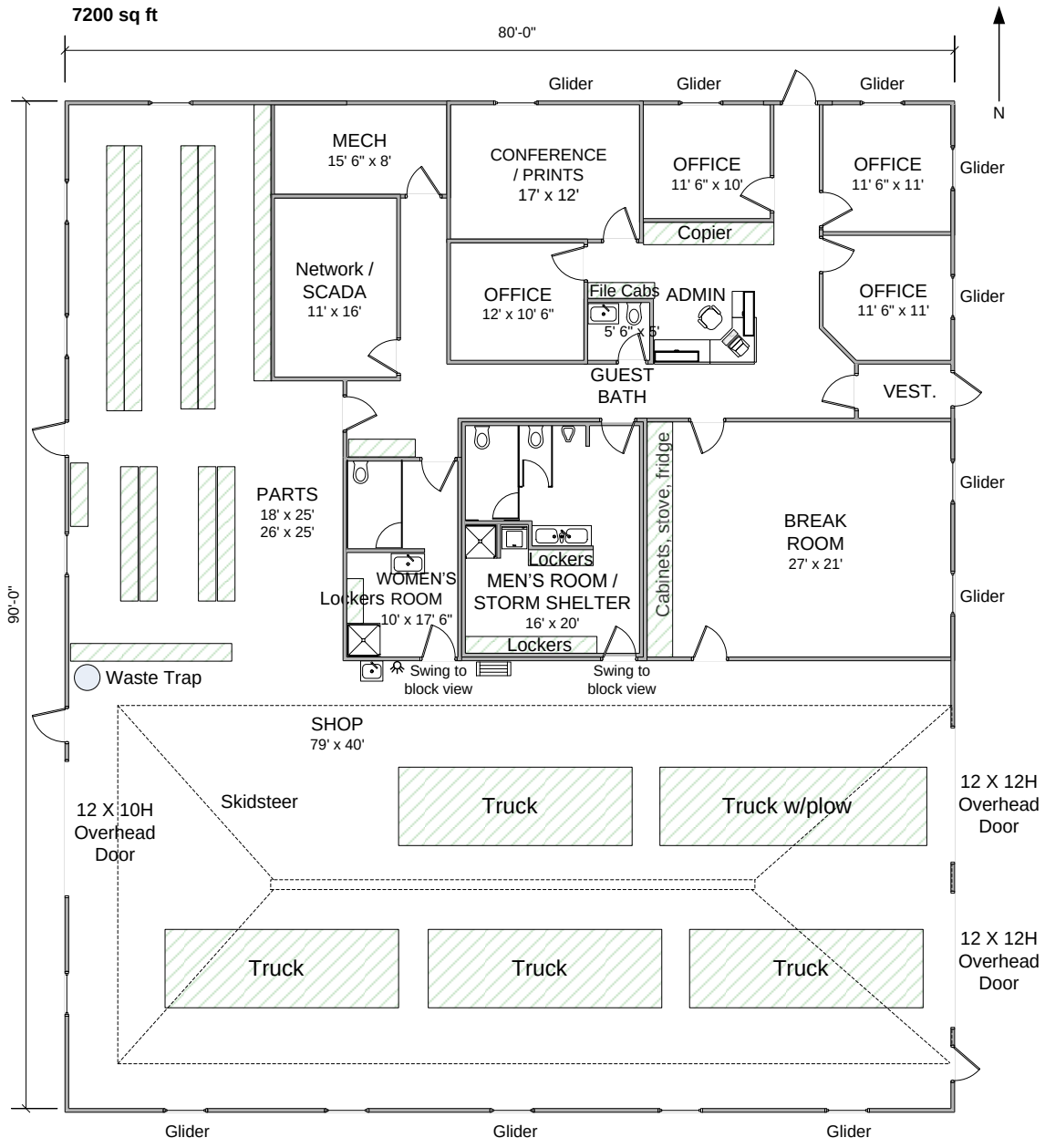


Figure 10: O&M building interior layout - 7,200 sq. ft.

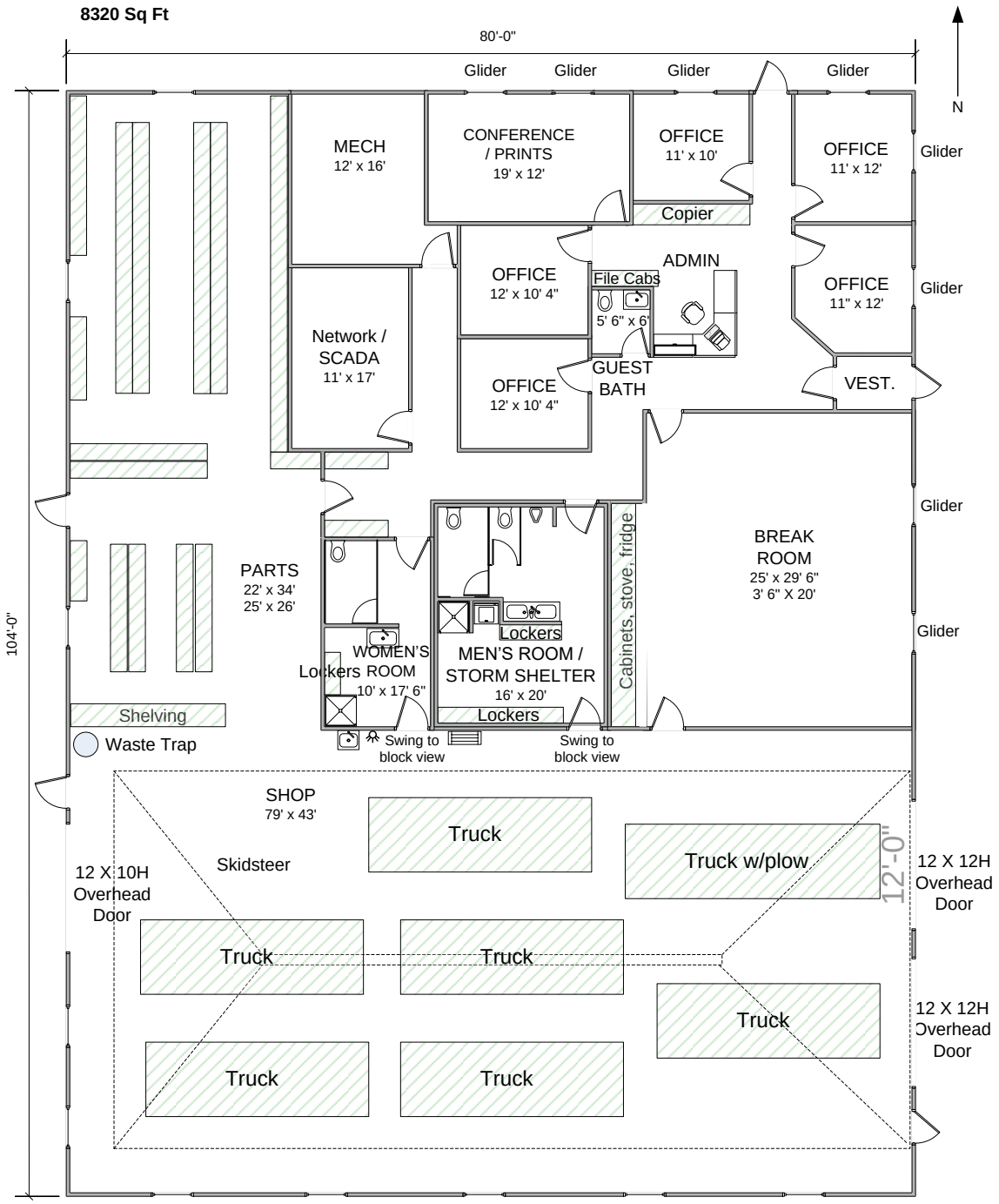


Figure 11: O&M building interior layout - 8,300 sq. ft.

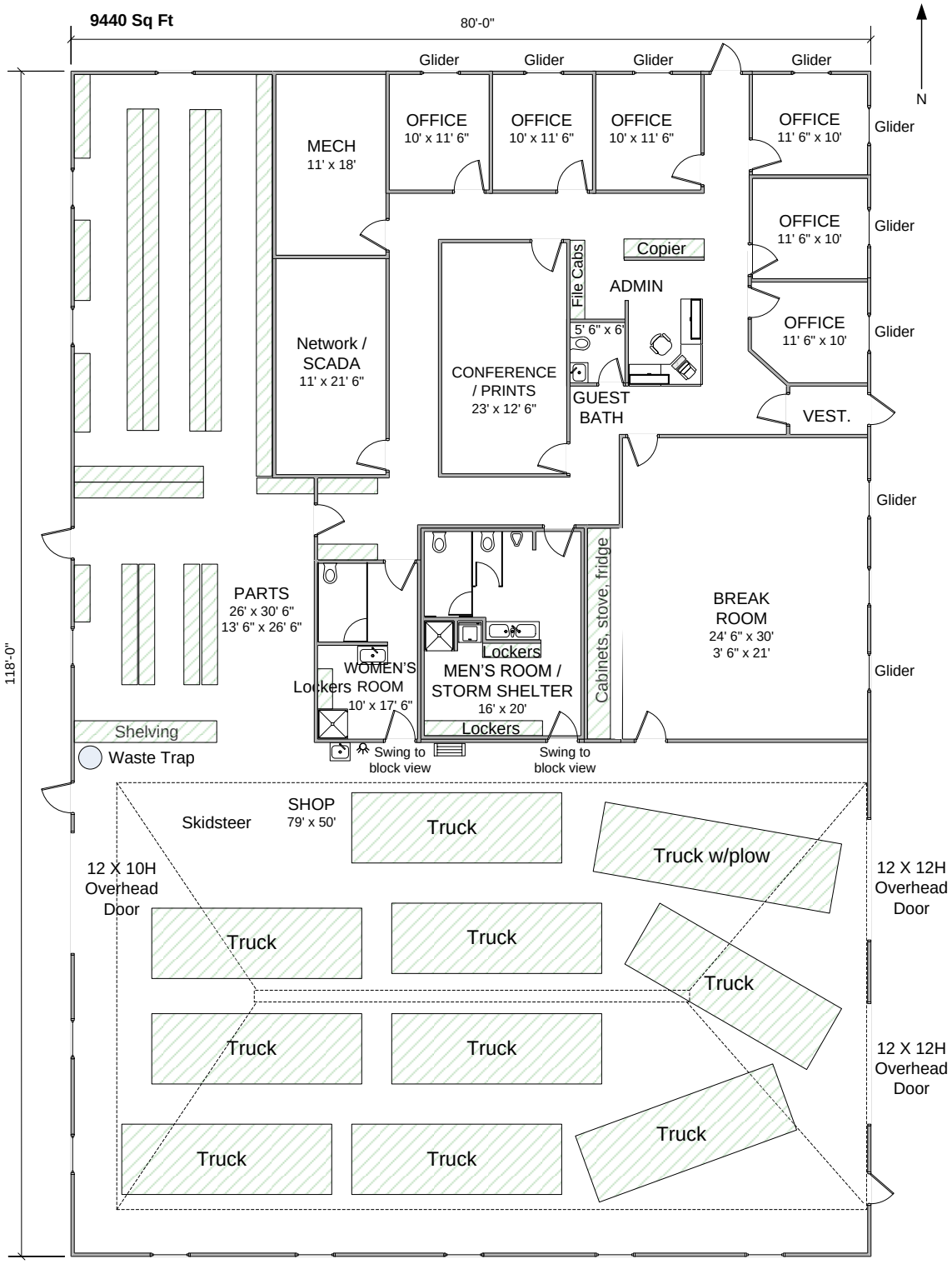


Figure 12: O&M building interior layout - 9,400 sq. ft.

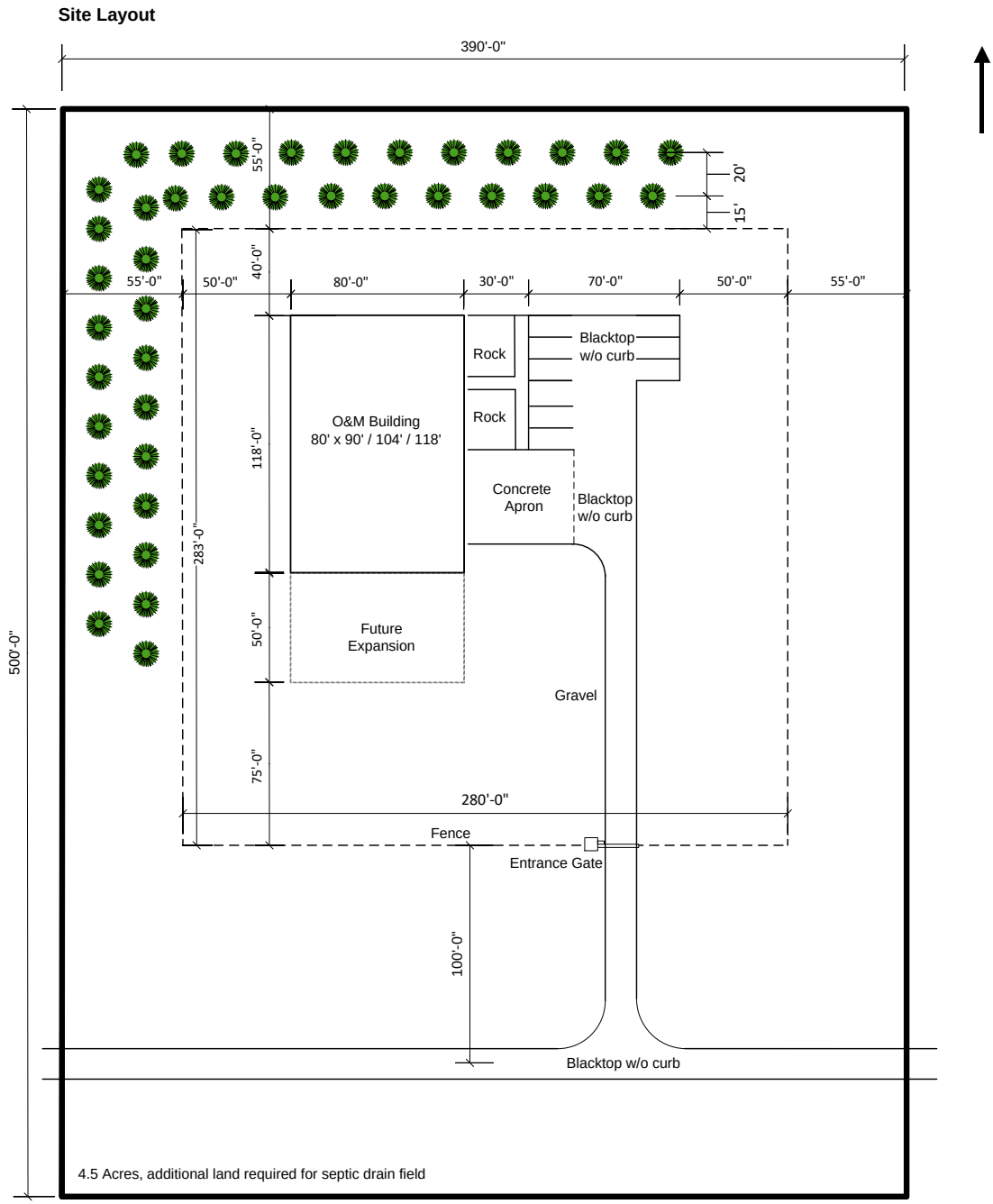


Figure 13: Typical O&M building exterior layout.

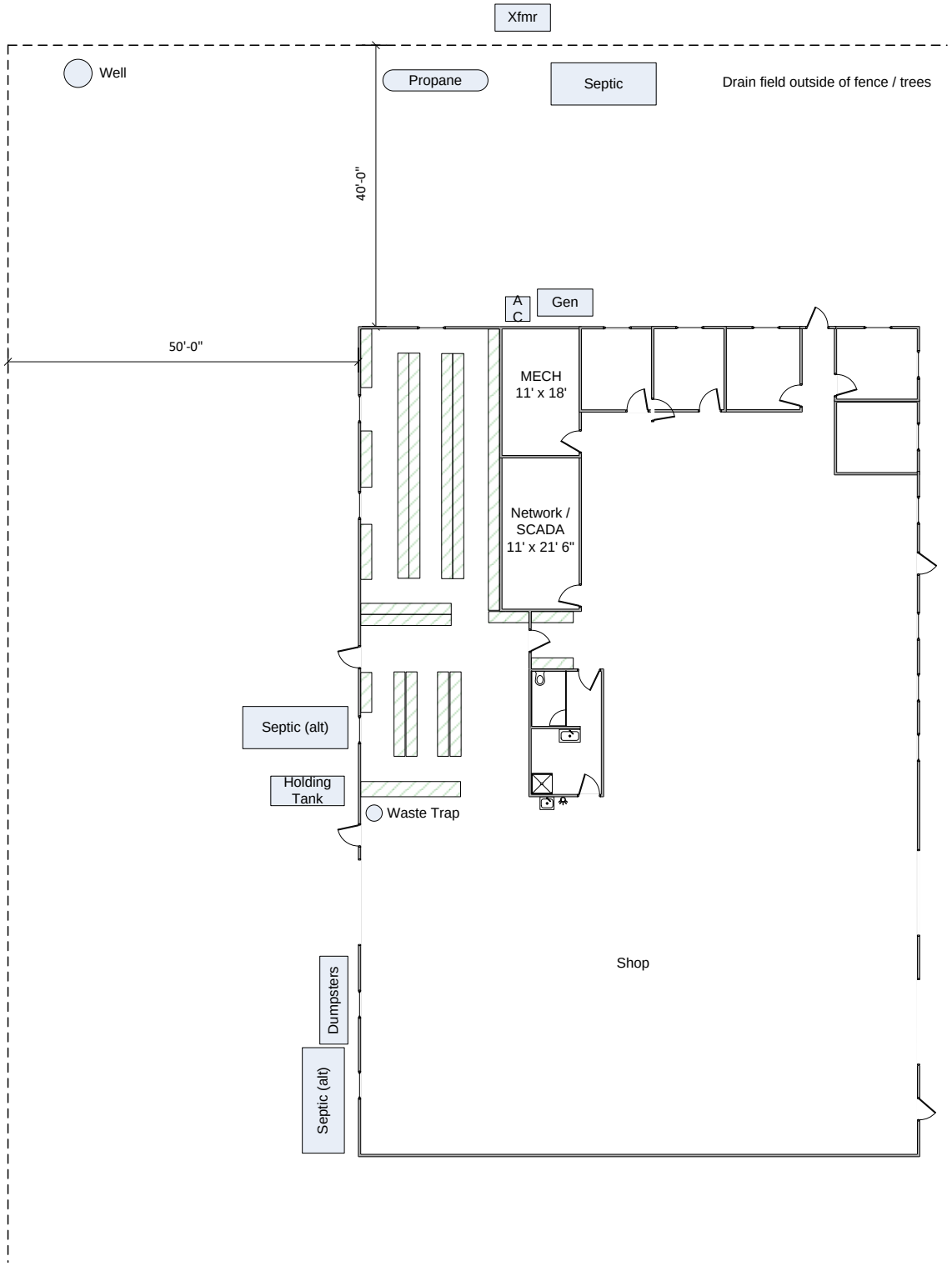


Figure 144: O&M building exterior utility layout.

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

13.2.3.3.2.1. 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.