## 1.0 PURPOSE

1.1 This standard defines responsibilities and requirements to meet certain requirements established by the following NERC Standards:

- PRC-019, "Coordination of Generating Unit or Plant Capabilities, Voltage Regulator Controls, and Protection"
- PRC-024, "Frequency and Voltage Protection Settings for Generating Resources"
- PRC-025, "Generator Relay Loadability"
- PRC-026, “Relay Performance During Stable Power Swings”
- PRC-027, “Coordination of Protection Systems for Performance During Faults”

## 2.0 APPLICABILITY

2.1 This standard is applicable to all Energy Supply Bulk Electric System (BES) generating facilities. Requirements of the various NERC Standards referenced above may have applicability to Protections Systems at these facilities for:

2.1.1 Generators

2.1.2 Synchronous condensers

2.1.3 Generator step up (GSU) transformers

2.1.4 Energy Supply owned Generator interconnection facilities that connect the GSU transformer to the transmission system.

2.1.5 Main or unit connected auxiliary transformers capable of feeding plant load when the unit is at power

2.1.6 Reserve or startup auxiliary transformers capable of feeding plant load when the unit is at power.

2.1.7 Aggregating systems and individual generating resources at dispersed generation facilities such as wind farms.

## 3.0 RESPONSIBILITIES

3.1 Performance Optimization Fleet Engineering personnel are responsible for the overall administration of the regional NERC Protection System Coordination and Relay Setting program. These responsibilities include maintaining coordination and settings studies for NERC related protection systems at BES generating facilities as well as performing and documenting all required communications with the other NERC Functional Entities concerning protection system coordination issues as required per Section 4.0 Requirements below.

3.2 The cognizant Performance Optimization Reliability Engineering personnel and/or ES Projects group Project Manager/Engineer are responsible:

3.2.1 To provide written notification to the Performance Optimization Fleet Engineering personnel of the installation of any new or planned installation of any NERC related protection systems; or any changes or planned changes to the existing NERC related protection systems as soon as the information becomes available.

3.2.2 To provide written notification to the Performance Optimization Fleet Engineering personnel of the installation of any new or planned installation of equipment, modification of the existing voltage regulating settings or planned modifications of existing voltage regulating settings at BES generating facilities as soon as the information becomes available.

3.2.3 To provide written notification to the Performance Optimization Fleet Engineering personnel of any change or planned changes in BES generator or synchronous condenser equipment capability as soon as the information becomes available.

3.2.4 To provide written notification to the Performance Optimization Fleet Engineering personnel of generator or synchronous condenser step up transformer, main or unit connected auxiliary transformer, or reserve or startup auxiliary transformer changes or replacements.

3.2.5 To provide an updated notification to Performance Optimization Fleet Engineering when previous notification is no longer valid for the changes described in paragraphs 3.2.1-3.2.4 above

3.2.6 As a result of any of the changes described in paragraphs 3.2.1-3.2.5 above, to work with Performance Optimization Fleet Engineering department to assure

that any required coordination studies are performed, and relay settings are established and communicated to other entities as required per Section 4.0 Requirements below.

## 4.0 REQUIREMENTS:

### 4.1 General

4.1.1 A Protection System Coordination and Relay Setting Study shall be developed for any new NERC related Protection System to be installed at a BES generating facility.

4.1.2 A Protection System Coordination and Relay Setting Study shall be developed or revised to address changes in a NERC related Protection System at a BES generating facility. Examples of changes which may necessitate development or revision of a study include, (but are not limited to), relay replacements, relay setpoint changes, excitation limiter and protection settings, or changes in current or voltage sensing devices.

4.1.3 A Protection System Coordination and Relay Setting Study shall be developed or revised to address replacement of generators or synchronous condensers, generator or synchronous condenser step-up transformers, main or unit connected auxiliary transformers, or reserve or startup auxiliary transformers when the replacement device ratings and/or impedance characteristics deviate from those utilized in the existing coordination study of the protection system for the component to be replaced.

4.1.4 For conventional synchronous machines, there should be only one Protection Coordination and Relay Setting study per NERC related Protection System that addresses PRC-027, PRC-019, PRC-024, PRC-025, and PRC-026 requirements applicable to that scheme or unit. This integrated approach will provide for greater clarity and consistency in documentation.

4.1.5 For dispersed generating facilities such as wind farms, the complex topography often requires use of dynamic simulations by vendors to prove compliance with some of the NERC standards. Coordination studies are often performed by architect/engineer firms during construction. As such, a collection of standard specific studies are often performed to address PRC-027, PRC-019, PRC-024, PRC-025, and PRC-026 as required.

4.1.6 Prior to performing a Protection System Coordination and Relay Setting Study, data to be used for generator and/or transformer ratings and impedances shall be verified against equipment test reports or design values for new equipment. The following engineering data should be included in the study for reference of report reviewers:

**Generator Parameters**
Generator MVA Rating
Generator kV Rating
Generator pf Rating
Generator $X_d$
Generator $X'_d$
Generator $X"_d$ (sat)
Generator $X_2$ (sat)
Gen Neut Gr Tr Ratio
Gen Neut Gr Resistance

**GSU Parameters**
GSU HV KV rating
GSU High Volt Tap
GSU LV KV Rating
GSU Impedance
GSU BASE MVA Rating
GSU Neutral Reactance
GSU Core Type

**System Parameters**
Assumed system available fault current

4.1.7 Prior to performing a Protection System Coordination and Relay Setting Study, updated transmission system fault current and impedance data shall be obtained. Updated transmission system fault current and impedance data shall be obtained at least annually or more frequently if significant changes are being implemented or have occurred which are anticipated to have a significant effect (>15% change) on system parameters for the substation associated with the generating unit to be analyzed.

4.1.8 All Protection System Coordination and Relay Setting Studies shall have a second engineering review to ensure adequacy of the developed protection system settings.

4.1.9 All Protection System Coordination and Relay Setting Studies shall be re-validated using updated data on a five-calendar year interval to ensure developed and applied settings remain valid for system and generating plant changes. This five-calendar year interval meets the periodic update requirements of both PRC-019 and PRC-027.

4.1.10 Protection system setting changes that do not affect fault coordination with separate interconnected entities can be processed as minor revisions and do not require review and approval by that separate entity prior to implementation. Nonetheless, a courtesy copy of the minor revision of the coordination study should be forwarded to the interconnected entity for documentation purposes.

Note that this does not eliminate the need for follow-up notifications such as those listed in Section 4.4.3 or 4.4.4 below.

4.2 PRC-027 Requirements

4.2.1 New or revised Protection System Coordination and Relay Setting studies for facilities that connect to the Xcel Energy Transmission System SHALL be provided to Transmission Operations - Protection System Engineering for review.

4.2.2 General requirements 4.1.6, 4.1.7, 4.1.8, and 4.1.9 above must be met to fulfill NERC PRC-027 program requirements for having an established relay setting process to assure accuracy of input data and output results.

4.2.3 For protection system settings applied on BES elements that electrically join the generating plant to equipment owned by a separate NERC functional entity (i.e. - Transmission Owner, Generator Owner, or Distribution Provider), the following PRC-027 requirements apply:

4.2.3.1 The proposed protections settings developed by the Protection System Coordination and Relay Setting study and applied on the BES Element that electrically joins the generating facility to that owned by a separate functional entity shall be provided to that entity for review. Performance Optimization Fleet Engineering should request that the Interconnecting Entity review the relay settings and associated coordination study within 30 days, or a mutually agreed upon timeframe.

4.2.3.2 That separate functional entity will either notify us of any identified coordination issues or will affirm that no coordination issues were identified.

4.2.3.3 When provided with protection system settings from a separate functional entity and applied on the BES element joining our generating facility to their system, the provided settings shall be reviewed within a mutually agreed to timeframe. Any identified coordination issues shall be communicated to that entity or the entity shall be notified that our review did not identify any coordination issues with the proposed settings.

4.2.3.4 Any identified coordination issues identified by the reviews described in 4.2.2.1 or 4.2.2.2 shall be addressed prior to the implementation of the proposed settings.

4.2.3.5 Any protection system settings revisions for protection applied on equipment that electrically joins the generating facility to that owned by a separate functional entity and which result from unforeseen circumstances that arise during implementation or commissioning, misoperation investigations, maintenance activities, or emergency replacements as a result of a protection system failure shall be communicated to the other owner of the electrically joined facility.

4.3 PRC-019 Requirements

4.3.1 Coordination studies for generators and synchronous condensers shall show coordination for the voltage regulating system controls, including in-service limiters and protection functions, with the applicable equipment capabilities and settings of the applicable Protection System devices and functions. Assuming normal automatic voltage regulator control loop and steady-state system operating conditions, the studies should show that:

4.3.1.1 In-service limiters are set to operate before the Protection System of the applicable Facility in order to avoid disconnecting the generator unnecessarily, and

4.3.1.2 The applicable in-service Protection System devices are set to operate to isolate or de-energize equipment in order to limit the extent of damage when operating conditions exceed equipment capabilities or stability limits.

4.3.2 The study described in Section 4.3.1 shall be reviewed and updated at a maximum of every 5 calendar years or within 90 days following the identification or implementation of systems, equipment, or settings changes that will affect the coordination of devices as described in Section 4.3.1. Possible systems, settings, or equipment changes which could affect this coordination include but are not limited to:

4.3.2.1 Voltage regulating settings or equipment changes;

4.3.2.2 Protection System settings or component changes;

4.3.2.3 Generator or synchronous condenser equipment capability changes;

4.3.2.4 Generator or synchronous condenser step up transformer changes.

4.3.3 Section G of NERC Reliability Standard PRC-019, "Coordination of Generating Unit or Plant Capabilities, Voltage Regulator Controls, and Protection" (Reference 6.1.5) provides a technical discussion of methods to show possible required coordination, but all voltage regulator settings, limiters and trips shall be reviewed for coordination with protective relays.

4.4 PRC-024 Requirements

4.4.1 Coordination and Relay Settings Studies shall document that BES generating resource frequency protection is set in accordance with PRC-024 Attachment 1 such that the applicable frequency protection does not cause the generating resource to trip or cease injecting current within the "no trip zone" during a frequency excursion of PRC-024 Attachment 1, subject to the following exceptions:

4.4.1.1 Applicable frequency protection may be set to trip or cease injecting current within a portion of the “no trip zone” for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.

4.4.2 Coordination and Relay Settings Studies shall document that applicable voltage protection is set in accordance with PRC-024 Attachment 2, such that the applicable protection does not cause the generating resource to trip or cease injecting current within the “no trip zone” during a voltage excursion at the high side of the GSU or MPT, subject to the following exceptions: [

4.4.2.1 If the Transmission Planner allows less stringent voltage protection settings than those required to meet PRC-024 Attachment 2, then the Generator Owner may set its protection within the voltage recovery characteristics of a location-specific Transmission Planner’s study. •

4.4.2.2 Applicable voltage protection may be set to trip or cease injecting current during a voltage excursion within a portion of the “no trip zone” for documented and communicated regulatory or equipment limitations in accordance with Requirement R3

4.4.3 If exceptions are applied in frequency protection settings per Section 4.4.1.1 or in voltage protection per Section 4.4.2.2 above because of known regulatory or equipment limitations, or when a previously documented regulatory or

equipment limitation is removed, the change shall be communicated to the Planning Coordinator and Transmission Planner within 30 calendar days of any of the following:

4.4.3.1 Identification of a regulatory or equipment limitation.

4.4.3.2 Repair of the equipment causing the limitation that removes the limitation.

4.4.3.3 Replacement of the equipment causing the limitation that removes the limitation.

4.4.3.4 Creation or adjustment of an equipment limitation caused by the consumption of the cumulative turbine life-time frequency excursion allowance.

4.4.4 Frequency and voltage protection settings established per Sections 4.4.1 and 4.4.2 shall be provided to the Planning Coordinator or Transmission Planner responsible for modeling the unit within 60 calendar days of receipt of a written request for the data or within 60 calendar days of any change of previously requested protection settings unless directed by the Planning Coordinator or Transmission Planner that the reporting of protection setting changes is not required.

4.5 PRC-025 Requirements

4.5.1 Coordination and Relay Settings Studies for BES facilities identified in Section 2.1 above shall document that all settings applied to load-responsive relays are made in accordance with PRC-025-2 Attachment 1 while maintaining reliable fault protection.

4.6 PRC-026 Requirements

4.6.1 For load-responsive protective relay functions as identified in PRC-026, Coordination and Relay Setting Studies for BES generators, transformers and transmission lines shall document applicability of PRC-026 requirements. In general, these requirements only apply to phase distance (21), phase overcurrent (51), out of step tripping (78), and loss of field (40) settings with time delays of less than 15 cycles. See PRC-026 Attachment A.

4.6.2 Within 12 months of notification from the Planning Coordinator of an ES owned BES element pursuant to Requirement R1 of PRC-026, the associated

Protection Coordination and Relay Setting study should be revised to determine and document whether the load responsive relay functions are applied per the criteria of PRC-026 Attachment B. This is only required if such an evaluation has not been performed in the last five years for the load responsive relay in question.

4.6.3 Within 12 months of becoming aware of an ES owned generator, transformer, or transmission line BES element that tripped in response to a stable or unstable power swing due to operation of its protective relays, the associated Protection Coordination and Relay Setting study should be revised to determine and document whether the load responsive relay functions are applied per the criteria of PRC-026 Attachment B.

4.6.4 If the evaluation performed per paragraph 4.6.2 or 4.6.3 above determines that the load responsive relay settings do not meet PRC-026 Appendix B criteria, a formal NERC Corrective Action Plan, CAP, shall be developed within six full calendar months to either:

4.6.4.1 Change settings to meet PRC-026 Attachment B criteria while maintaining dependable fault detection and, if applied, dependable out of step tripping.

Or

4.6.4.2 Modify the Protection System such that it is excluded from applicability to PRC-026 Attachment A criteria while maintaining dependable fault detection and, if applied, dependable out of step tripping.

4.6.5 Any CAP developed per paragraph 4.6.4 shall be implemented as planned. If CAP actions or timetables change, the CAP should be formally updated until all associated actions are complete.

4.7 Implementation Timelines – General Information

4.7.1 A Protection System Coordination and Relay Setting Study shall be developed to address all NERC related Protection Systems at a BES generating facility. All BES units shall have a Protection Coordination and Relay Setting study. Existing studies shall be reviewed and updated as needed per the requirements outlined in this document.

4.7.2 For PRC-026, studies performed in response to Planning Coordinator notifications per paragraph 4.6.2 or upon becoming aware that a BES element tripped because of a protective relay operation in response to a stable or unstable power swing per paragraph 4.6.3 must be completed by the later of 12 months after the notification from the Planning Coordinator, 12 months after awareness of a trip in response to a power swing or January 1, 2020.

4.7.3 For PRC-027, all initial studies for PRC-027 R2 compliance must be completed no later than 6 calendar years after the effective date of PRC-027-1. Based on PRC-027-1 effective date of 4/1/2021, the deadline for initial R2 compliance is 12/31/27.

## 5.0 REQUIRED RECORDS

5.1 Protection System Coordination and Relay Setting Studies written to address the requirements of this standard SHALL be stored in the regional Protection System Coordination and Relay Setting Study folder in Documentum or other approved regional data repository.

5.2 Copies of correspondence with Transmission Operators, Transmission Planners, Distribution Providers and/or Planning Coordinators concerning these Protection System Coordination and Relay Settings Studies SHALL be stored Documentum or in the regional specific data repository flagged for the applicable PRC-019, PRC-024, PRC-025, PRC-026, or PRC-027 standard. Note that dated sign-off blocks on Protection System Coordination and Relay Setting Study documents may be used as evidence of this communication.

5.3 Any Corrective Action Plan developed per paragraph 4.6.4 or revised Corrective Action Plant per paragraph 4.6.5 SHALL be stored in Documentum or in the regional specific data repository for PRC-026 documentation. The CAP SHALL be retained and available for review for a minimum of 12 months following completion of the implementation of the CAP.

## 6.0 REFERENCES AND DEFINITIONS

6.1 References

6.1.1 NERC System Protection and Control Subcommittee Technical Reference Document, "Power Plant and Transmission System Protection Coordination," Revision 2 - July 2010. It should be noted that this document does not contain the most up to date information concerning PRC-019, PRC-024, and PRC-025

requirements. The technical bases and guidelines for these specific standards supersede the information contained in the "Power Plant and Transmission System Protection Coordination," Revision 1 - July 2010 document for the affected settings.

6.1.2 IEEE Std C37.102, "IEEE Guide for AC Generator Protection"

6.1.3 IEEE Power System Relay Committee paper, "Coordination of Generator Protection with Generator Excitation Control and Generator Capability"

6.1.4 NERC Reliability Standard PRC-019, "Coordination of Generating Unit or Plant Capabilities, Voltage Regulator Controls, and Protection"

6.1.5 NERC Reliability Standard PRC-024, "Generator Frequency and Voltage Protective Relay Settings"

6.1.6 NERC Reliability Standard PRC-025, "Generator Relay Loadability."

6.1.7 NERC Reliability Standard PRC-025 "Guideline and Technical Basis"

6.1.8 NERC Reliability Standard PRC-026 “Relay Performance During Stable Power Swings”

6.1.9 NERC Reliability Standard PRC-027, “Coordination of Protection Systems for Performance During Faults”

6.2 Definitions

6.2.1 **BES** – Bulk Electric System

6.2.2 **BES Generating Facility** – in general, an individual generator of greater than 75 MVA and that connects to the system at a voltage level > 100 KV or a generating facility that aggregates to greater than 75MVA and that connects to the system at a voltage level >100 KV. See the NERC Glossary of Terms definition of Bulk Electric System for more details

6.2.3 **Frequency and Voltage Protection** - Frequency, voltage, and volts per hertz protection (whether provided by relaying or functions within associated control systems) that respond to electrical signals and: (i) directly trip the generating resource(s); or (ii) provide signals to the generating resource(s) to either trip or cease injecting current; and are applied to the following: BES generating resource(s), BES GSU transformer(s), High side of the generator-connected

unit auxiliary transformer (UAT) installed on BES generating resource(s),. Individual dispersed power producing resource(s) identified in the BES Definition, Inclusion I4, or Elements that are designed primarily for the delivery of capacity from the individual dispersed power producing resources identified in the BES Definition, Inclusion I4, to the point where those resources aggregate to greater than 75 MVA.

6.2.4 **GSU** – Generator Step Up

6.2.5 **NERC - North American Electric Reliability Corporation** – The organization charged with establishing standards for the reliable operation of the North American electric power grids.

6.2.6 **NERC related Protection System** – are located at BES generating facilities and consist of the relays, voltage and current sensing devices, DC control circuitry, DC power supply and communication systems used to protect generators, generator step up or main power transformers, synchronous condensers, reactive power sources such as capacitor banks or reactors, Unit Auxiliary or Main Station Auxiliary transformers, Startup or Reserve Station Auxiliary transformers and those portions of dispersed power facility aggregating systems where the power flow aggregates to >75 MVA.

## 7.0 REVISION HISTORY

| Date | Revision | Change |
|---|---|---|
| 07/21/2014 | 1.0 | Original Issue, supersedes *XES 7.410, "FERC PRC-001 System Protection Coordination"* |
| 05/23/2017 | 2.0 | Revised paragraph 3.2.6 and added paragraph 4.2.3 to clarify that a revised coordination study may be required for changes of the generator and/or GSU, MSA or UST, or RSA or SST transformers.<br>Added section 4.6 to document PRC-026 requirements.<br>Revised section 4.7 to document PRC-026 implementation requirements.<br>Revised section 5.0 to document PRC-026 record retention requirements. |
| 06/05/2018 | 2.1 | Corrected section references for PRC-024. |

| | | |
|---|---|---|
| 01/02/2019 | 2.2 | Corrected section 4.5 references to current version of applicable standard, PRC-025-2. |
| 06/09/2020 | 3.0 | Updated department names. Added requirements for PRC-027 including requirements for obtaining up to date input data for the performance of coordination studies and specific requirements for coordination of protection applied on equipment that joins the generating facility to that owned by other NERC functional entities. |
| 06/21/2022 | 3.1 | Updated to reflect minor changes to PRC-024 requirements as delineated in PRC-024-3. Deleted references to PRC-001. |
| 08/01/2023 | 3.2 | Minor revision to paragraph 4.7.3 to correct PRC-027 effective date and implementation requirements based on 6 month COVID extension by FERC Order. |