

Standard Development Roadmap

This section is maintained by the drafting team during the development of the standard and will be removed when the standard becomes effective.

Development Steps Completed:

1. The Standards Committee approved the SAR for posting on August 12, 2010.
2. SAR posted for formal comment on August 19, 2010.
3. Standard posted for informal comment period on August 19, 2010.

Proposed Action Plan and Description of Current Draft:

This is the first draft of the requirements developed to address the FERC directives in Order No. 733 and posted for an informal comment period.

Future Development Plan:

Anticipated Actions	Anticipated Date
1. Develop second draft of SAR and respond to comments.	September, 2010 – October, 2010
2. Post the standard for 45-day comment period with concurrent ballot	October , 2010
3. Develop second draft of the standard and respond to comments.	December, 2010 – January, 2011
4. Re-ballot the proposed standard	January, 2011
5. NERC Board approval	February, 2011
6. Submit standard to FERC for approval	March, 2011

A. Introduction

1. Title: Transmission Relay Loadability

2. Number: PRC-023-2

3. Purpose: Protective relay settings shall not limit transmission loadability; not interfere with system operators' ability to take remedial action to protect system reliability and; be set to reliably detect all fault conditions and protect the electrical network from these Faults.

4. Applicability:

4.1. Transmission Owners with load-responsive phase protection systems as described in Attachment A, applied to facilities defined below:

4.1.1 Transmission lines operated at 200 kV and above.

4.1.2 Transmission lines operated below 200 kV designated by the Planning Coordinator as critical to the reliability of the Bulk Electric System

4.1.3 Transformers with low voltage terminals connected at 200 kV and above.

4.1.4 Transformers with low voltage terminals connected below 200 kV as designated by the Planning Coordinator as critical to the reliability of the Bulk Electric System (BES).

The SDT will ensure that 4.1.2 and 4.1.4 are consistent with the applicability methodology once it is developed.

4.2. Generator Owners with load-responsive phase protection systems as described in Attachment A, applied to facilities defined in 4.1.1 through 4.1.4.

4.3. Distribution Providers with load-responsive phase protection systems as described in Attachment A, applied according to facilities defined in 4.1.1 through 4.1.4., provided that those facilities have bi-directional flow capabilities.

4.4. Planning Coordinators.

5. Effective Dates:

5.1. Requirement R1, Requirement R2, Requirement R3, Requirement R4:

5.1.1 For circuits described in 4.1.1 and 4.1.3 above (except for switch-on-to-fault schemes) —the beginning of the first calendar quarter following applicable regulatory approvals.

5.1.2 For circuits described in 4.1.2 and 4.1.4 above (including switch-on-to-fault schemes) — at the beginning of the first calendar quarter 39 months following applicable regulatory approvals.

5.1.3 Each Transmission Owner, Generator Owner, and Distribution Provider shall have 24 months after being notified by its Planning Coordinator pursuant to Requirement R5, Part 5.3 to comply with Requirement R1 (including all sub-requirements) for each facility that is added to the Planning Coordinator's critical facilities list determined pursuant to Requirement R5, Part 5.1.

5.2. Requirement R5: 18 months following applicable regulatory approvals.

B. Requirements

- R1.** Each Transmission Owner, Generator Owner, and Distribution Provider shall use any one of the following criteria (Requirement R1, Settings 1 through 13) for any specific circuit terminal to prevent its phase protective relay settings from limiting transmission system loadability while maintaining reliable protection of the BES for all fault conditions, and to prevent its out-of-step blocking schemes from blocking tripping for fault conditions. Each Transmission Owner, Generator Owner, and Distribution Provider shall evaluate relay loadability at 0.85 per unit voltage and a power factor angle of 30 degrees: [Violation Risk Factor: High] [Mitigation Time Horizon: Long Term Planning].

Settings:

1. Set transmission line relays so they do not operate at or below 150% of the highest seasonal Facility Rating of a circuit, for the available defined loading duration nearest 4 hours (expressed in amperes).
2. Set transmission line relays so they do not operate at or below 115% of the highest seasonal 15-minute Facility Rating¹ of a circuit (expressed in amperes).
3. Set transmission line relays so they do not operate at or below 115% of the maximum theoretical power transfer capability (using a 90-degree angle between the sending-end and receiving-end voltages and either reactance or complex impedance) of the circuit (expressed in amperes) using one of the following to perform the power transfer calculation:
 - An infinite source (zero source impedance) with a 1.00 per unit bus voltage at each end of the line.
 - An impedance at each end of the line, which reflects the actual system source impedance with a 1.05 per unit voltage behind each source impedance.
4. Set transmission line relays on series compensated transmission lines so they do not operate at or below the maximum power transfer capability of the line, determined as the greater of:
 - 115% of the highest emergency rating of the series capacitor.
 - 115% of the maximum power transfer capability of the circuit (expressed in amperes), calculated in accordance with Requirement R1, Setting 3, using the full line inductive reactance.
5. Set transmission line relays on weak source systems so they do not operate at or below 170% of the maximum end-of-line three-phase fault magnitude (expressed in amperes).
6. Set transmission line relays applied on transmission lines connected to generation stations remote to load so they do not operate at or below 230% of the aggregated generation nameplate capability.
7. Set transmission line relays applied at the load center terminal, remote from generation stations, so they do not operate at or below 115% of the maximum current flow from the load to the generation source under any system configuration.

¹ When a 15-minute rating has been calculated and published for use in real-time operations, the 15-minute rating can be used to establish the loadability requirement for the protective relays.

8. Set transmission line relays applied on the bulk system-end of transmission lines that serve load remote to the system so they do not operate at or below 115% of the maximum current flow from the system to the load under any system configuration.
 9. Set transmission line relays applied on the load-end of transmission lines that serve load remote to the bulk system so they do not operate at or below 115% of the maximum current flow from the to the under any system configuration.
 10. Set transformer fault protection relays and transmission line relays on transmission lines terminated only with a transformer such that the protection settings do not expose the limiting piece of equipment to fault level and duration that exceeds its capability and so that the relays do not operate at or below the greater of:
 - 150% of the applicable maximum transformer nameplate rating (expressed in amperes), including the forced cooled ratings corresponding to all installed supplemental cooling equipment.
 - 115% of the highest operator established emergency transformer rating.
 11. For transformer overload protection relays that do not comply with Requirement R1, Setting 10 set the relays according to one of the following:
 - Set the relays to allow the transformer to be operated at an overload level of at least 150% of the maximum applicable nameplate rating, or 115% of the highest operator established emergency transformer rating, whichever is greater, for at least 15 minutes to provide time for the operator to take controlled action to relieve the overload.
 - Install supervision for the relays using either a top oil or simulated winding hot spot temperature element set no less than 100° C for the top oil temperature or no less than 140° C for the winding hot spot temperature².
 12. When the desired transmission line capability is limited by the requirement to adequately protect the transmission line, set the transmission line distance relays to a maximum of 125% of the apparent impedance (at the impedance angle of the transmission line) subject to the following constraints:
 - a. Set the maximum torque angle (MTA) to 90 degrees or the highest supported by the manufacturer.
 - b. Evaluate the relay loadability in amperes at the relay trip point at 0.85 per unit voltage and a power factor angle of 30 degrees.
 - c. Include a relay setting component of 87% of the current calculated in Requirement R1, Setting 12 in the Facility Rating determination for the circuit.
 13. Where other situations present practical limitations on circuit capability, set the phase protection relays so they do not operate at or below 115% of such limitations.
- R2.** Each Transmission Owner, Generator Owner, and Distribution Provider that uses a circuit capability with the practical limitations described in Requirement R1, Settings.6,7, 8, 9, 12, or

FERC Order 733, ¶203:
Modify sub-requirement R1.10 to verify equipment is capable of sustaining the anticipated overload associated with the fault.

² IEEE standard C57.115, Table 3, specifies that transformers are to be designed to withstand a winding hot spot temperature of 180 degrees C, and cautions that bubble formation may occur above 140 degrees C.

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13 shall use the calculated circuit capability as the Facility Rating of the circuit and shall obtain the agreement of the Planning Coordinator, Transmission Operator, and Reliability Coordinator with the calculated circuit capability. [Violation Risk Factor: Medium] [Time Horizon: Long Term Planning]

- R3.** Each Transmission Owner, Generator Owner, and Distribution Provider that sets transmission line relays according to Requirement R1 Setting 2 shall provide its Planning Coordinator, Transmission Operator, Regional Entity, and Reliability Coordinator with a list of facilities associated with those transmission line relays at least once each calendar year, with no more than 15 months between reports [Violation Risk Factor: Lower] [Time Horizon: Long Term Planning]
- FERC Order 733, ¶186: Modify R1.2 to require that TOs, GOs, and DPs give their TOPs a list of transmission facilities that implement R1.2.
- R4.** Each Transmission Owner, Generator Owner, and Distribution Provider that sets transmission line relays according to Requirement R1 Setting 12 shall provide a list of the facilities associated with those relays to its Regional Entity at least once each calendar year, with no more than 15 months between reports. [Violation Risk Factor: Lower] [Time Horizon: Long Term Planning]
- FERC Order 733, ¶224: Make available for review to users, owners and operators of the Bulk-Power System, by request, a list of those facilities that have protective relays set pursuant sub-requirement R1.12.of anticipated overload.
- R5.** Each Planning Coordinator shall apply the criteria in Attachment B to determine which of the facilities (transmission lines operated below 200 kV and transformers with low voltage terminals connected below 200 kV) in its Planning Coordinator Area are critical to the reliability of the BES to identify the facilities below 200 kV that must meet Requirement R1 to prevent cascading when protective relay settings limit transmission loadability. [Violation Risk Factor: High] [Time Horizon: Long Term Planning]
- 5.1** The Planning Coordinator shall have a process to use the criteria established within Attachment B to determine the facilities that are critical to the reliability of the Bulk Electric System.
- 5.2** Each Planning Coordinator shall maintain a current list of facilities determined according to the process described in Requirement R5 Part 5.1.
- 5.3** Each Planning Coordinator shall provide a list of facilities to its Regional Entity, Reliability Coordinators, Transmission Owners, Generator Owners, and Distribution Providers within 30 calendar days of the establishment of the initial list and within 30 calendar days of any changes to that list.
- FERC Order 733, ¶237: Modify sub-requirement R3.3 to add the RE to list of entities that receive the critical facilities list.

PRC-023 — Attachment A

1. This standard includes any protective functions which could trip with or without time delay, on load current, including but not limited to:
 - 1.1. Phase distance.
 - 1.2. Out-of-step tripping.
 - 1.3. Switch-on-to-fault.
 - 1.4. Overcurrent relays.
 - 1.5. Communications aided protection schemes including but not limited to:
 - 1.5.1 Permissive overreach transfer trip (POTT).
 - 1.5.2 Permissive under-reach transfer trip (PUTT).
 - 1.5.3 Directional comparison blocking (DCB).
 - 1.5.4 Directional comparison unblocking (DCUB).
 - 1.6. Protective functions that supervise operation of other protective functions in 1.1 through 1.5.
2. The following protection systems are excluded from requirements of this standard:
 - 2.1. Relay elements that are only enabled when other relays or associated systems fail. For example:
 - Overcurrent elements that are only enabled during loss of potential conditions.
 - Elements that are only enabled during a loss of communications.
 - 2.2. Protection systems intended for the detection of ground fault conditions.
 - 2.3. Protection systems intended for protection during stable power swings.
 - 2.4. Generator protection relays that are susceptible to load.
 - 2.5. Relay elements used only for Special Protection Systems applied and approved in accordance with NERC Reliability Standards PRC-012 through PRC-017 or their successors.
 - 2.6. Protection systems that are designed only to respond in time periods which allow 15 minutes or greater to respond to overload conditions.
 - 2.7. Thermal emulation relays which are used in conjunction with dynamic Facility Ratings.
 - 2.8. Relay elements associated with dc lines.
 - 2.9. Relay elements associated with dc converter transformers.

FERC Order 733, ¶264: Revise section 1 of Attachment A to include supervising relay elements.