
Project QC-2020-03

PRC-025-2 – Generator Relay Loadability

1. OVERVIEW OF THE STANDARD

1.1. Applicability

Functions covered:

The standard applies to the following functions that apply a load-responsive protection relay¹ at the terminals of the Elements listed in the Facilities section below:

- Generator Owner (GO)
- Transmission Owner (TO)
- Distribution Provider (DP)

Facilities covered:

The following Elements associated with Main Transmission System (RTP) generating units and generating plants, including those generating units and generating plants identified as Blackstart Resources in the Transmission Operator's system restoration plan:

- Generating unit
- Generator step-up transformer (GSU)
- Unit auxiliary transformer(s) (UAT) that supply overall auxiliary power necessary to keep generating unit(s) online
- Elements that connect the GSU transformer(s) to the Transmission system that are used exclusively to export energy directly from a RTP generating unit or generating plant, except that Elements may also supply generating plant loads.
- Element utilized in the aggregation of dispersed power producing resources.

Exemptions: The generating facilities that are not connected to the RTP are exempted from the application of this standard.

1.2. Purpose of the Reliability Standard

The currently effective PRC-025-1 standard addresses setting 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. During implementation of the PRC-025-1 standard, NERC and the industry identified the need to revise the standard to address certain relay applications and to clarify the language to advance the reliability goals of the standard. The purpose of the PRC-025-2 standard is to enhance the currently-effective PRC-025-1 standard by better addressing the risk of unnecessary generator tripping when voltage is depressed and the generator is capable of increased Reactive Power output and voltage support during the voltage disturbance. Changes made to the PRC-025-2 standard are described in detail in Section 2 below.

¹ Relays include low voltage protection devices that have adjustable settings.

1.3. Regulatory Context

The Régie de l'énergie (hereinafter "the Régie") adopted PRC-025-1 in Decision D-2017-110² and has been in effect since October 1st, 2017. Adopted by the NERC Board of Trustees on February 8, 2018 and subsequently approved by FERC on May 2, 2018³ the PRC-025-2 standard came into effect in the United States on July 1st, 2018, two months after being approved by FERC.

North American Electric Reliability Corporation (NERC) submitted a "Notice of Filing of the North American Electric Reliability Corporation of Proposed Reliability Standard PRC-025-2"⁴ on March 22, 2018.

1.4. Specific Provisions for Québec

The Reliability Coordinator (hereinafter called "the Coordinator") is proposing to renew the Québec specific provisions, particularly in the applicability of the standard to the facilities of the Main Transmission System (RTP) and specific provisions already adopted by the Régie in its ruling D-2017-110 pertaining to the exemption of generating facilities that are not connected to the RTP.

1.5. Proposed Effective Dates

In the United-States, PRC-025-1 came into effect on October 1, 2014 under a phased implementation plan based on two time frames. In the case where replacement or removal of the load responsive relays is not necessary, entities had 60 months (October 1, 2019) to comply with the standard. Where replacement or removal of the load responsive relays is necessary, entities had 84 months (October 1, 2021) to come into compliance. In Québec, standard PRC-025-1 came into effect October 1, 2017 with an implementation plan of 48 months (October 1, 2021) where replacement or removal of the load responsive relays was not necessary or 72 months (October 1, 2023) where replacement or removal of the load responsive relays was necessary. NERC's PRC-025-2 standard implementation plan is the continuity of PRC-025-1 implementation plan.

In the United-States, PRC-025-2 came into effect on July 1, 2018. The PRC-025-2 implementation plan⁵ recognizes that entities are in the process of implementing the PRC-025-1 standard to meet these dates, but that certain revisions in PRC-025-2 may give reason for entities to re-evaluate their settings for load-responsive protective relays or require further time for implementation. The PRC-025-2 implementation plan provides a new phased compliance schedule that is intended to supersede the phased compliance schedule provided in the currently-effective PRC-025-1 implementation plan. For existing Options in Table 1 "Relay Loadability Evaluation Criteria", entities would have at least as much time to come into compliance with the PRC-025-2 standard as they would have under the PRC-025-1 implementation plan. New phased compliance dates are provided for new and revised Table 1 Options, including:

² Régie de l'Énergie, Decision D-2017-110, consulted on July 9, 2020, at: http://publicsde.regie-energie.qc.ca/projets/332/DocPrj/R-3944-2015-A-0083-Dec-Dec-2017_09_27.pdf

³ FERC, Docket No. RD18-4-000, consulted on July 9, 2020, at

https://www.nerc.com/FilingsOrders/us/FERCOrdersRules/Delegated%20Order%20Approving%20PRC-025-2_RD18-4.pdf

⁴ Notice of Filing of the North American Electric Reliability Corporation of Proposed Reliability Standard PRC-025-2, consulted on July 9, 2020 at : <https://www.nerc.com/FilingsOrders/ca/Canadian%20Filings%20and%20Orders%20DL/Quebec%20PRC-025-2%20filing.pdf>

⁵ NERC PRC-025-2 Implementation Plan, consulted on July 9, 2020, at:

https://www.nerc.com/pa/Stand/Project%20201604%20Modifications%20to%20PRC0251%20DL/Project_2016_04_Implementation_Plan_Clean_01092018.pdf

- New Option⁶ 5b: 24 or 48 months, depending on whether replacement or removal is necessary;
- For the 50 element only in Options 2a, 2b, 2c, 5a, 5b, 8a, 8b, 8c, 11, 13a, and 13b: 60 or 84 months, depending on whether replacement or removal is necessary;
- Revised Options 14b, 15b and 16b: 24 or 48 months, depending on whether replacement or removal is necessary.

For load-responsive relays that become applicable to the PRC-025-2 standard, entities would continue to have 60 or 84 months to come into compliance, depending on whether replacement or removal is necessary.

The implementation plan provides additional timing for new Option 5b due to the number of dispersed power generating resources that may have been unable to apply the existing 130% threshold.

The implementation plan also provides a full 60 and 84 month implementation timeline to address the newly-added 50 element in certain Options. This timeline accounts for engineering review, potential equipment procurement, and outage coordination to commission the equipment and apply the appropriate settings.

Additionally, the implementation plan allows entities sufficient time to address newly-revised Options addressing Transmission lines interconnecting the generating unit or plant to the Transmission system. The timeframe allows entities to re-evaluate their settings to account for line impedance effects and to make appropriate modifications to the settings.

The following tables summarize the effective dates in the United States as well as the proposed implementation dates in Québec of the requirements and their associated violation risk factors and violation severity levels.

Load responsive protective relays subject to the standard			
Requirements	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
R1	Each GO, TO and DP shall apply settings that are in accordance with PRC-025-2 – Attachment 1 : Relay Settings, on each load-responsive protection relay while maintaining reliable fault protection.	Where determined by the GO, TO or DP that replacement or removal is not necessary, the later of October 1, 2019 or 12 months after the effective date of Reliability Standard PRC-025-2, except as noted for the PRC-025-2 – Attachment 1, Table 1 Relay Loadability Evaluation Criteria, Options listed below	Where determined by the GO, TO, or DP that replacement or removal is not necessary, the later of October 1, 2021 or 12 months after adoption by the Régie of Reliability Standard PRC-025-2, except as noted for the PRC-025-2 – Attachment 1, Table 1 Relay Loadability Evaluation Criteria, Options listed below

⁶ The Application Guidelines section explains the functionality of the elements and its options.

Load responsive protective relays subject to the standard			
Requirements	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
		Where determined by the GO, TO or DP that replacement or removal is necessary, the later of October 1, 2021 or 36 months after the effective date of Reliability Standard PRC-025-2, except as noted for the Table 1 Relay Loadability Evaluation Criteria Options listed below	Where determined by the GO, TO or DP that replacement or removal is necessary, the later of October 1, 2023 or 36 months after the effective date of Reliability Standard PRC-025-2, except as noted for the Table 1 Relay Loadability Evaluation Criteria Options listed below

Load-responsive protective relays which become applicable to the standard			
Requirements	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
R1	Each GO, TO and DP shall apply settings that are in accordance with PRC-025-2 – Attachment 1: Relay Settings, on each load-responsive protective relay while maintaining reliable fault protection.	<p>Where determined by the GO, TO or DP that replacement or removal is not necessary, 60 months beyond the date the load-responsive protective relays become applicable to the standard.</p> <p>Where determined by the GO, TO or DP that replacement or removal is necessary, 84 months beyond the date the load-responsive protective relays become applicable to the standard.</p>	<p>Where determined by the GO, TO, or DP that replacement or removal is not necessary, 60 months beyond the date the load-responsive protective relays become applicable to the standard.</p> <p>Where determined by the GO, TO or DP that replacement or removal is necessary, 84 months beyond the date the load-responsive protective relays become applicable to the standard.</p>

Phased-In Implementation of specific Table 1 Relay Loadability Evaluation Criteria Options			
Option	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
5b	Asynchronous generating unit(s) (including inverter-based installations,) including Element utilized in the aggregation of dispersed power producing resources applying any phase overcurrent relay (e.g., 51, or 51V-R – voltage restrained) ⁷ .	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after the effective date of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after the effective date of Reliability Standard PRC-025-2.	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after adoption by the Régie of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after adoption by the Régie of Reliability Standard PRC-025-2.
2a, 2b and 2c (50 element only)	Synchronous generating units(s) (including inverter-based installations), including Elements utilized in the aggregation of dispersed power producing resources applying specifically the phase overcurrent relay 50 element.	Where determined GO, TO or DP, that replacement or removal is not necessary, 60 months after the effective date of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 84 months after the effective date of Reliability Standard PRC-025-2.	Where determined GO, TO or DP, that replacement or removal is not necessary, 60 months after adoption by the Régie of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 84 months after adoption by the Régie of Reliability Standard PRC-025-2.
Options 5a and 5b (50 element only)	Asynchronous generating unit(s), including Elements utilized in the aggregation of dispersed power producing resources applying specifically the	Where determined GO, TO or DP, that replacement or removal is not necessary, 60 months after the effective date of Reliability Standard PRC-025-2.	Where determined GO, TO or DP, that replacement or removal is not necessary, 60 months after adoption by the Régie of Reliability Standard PRC-025-2.

⁷ Phased-in implementation of the phase overcurrent relay 50 element is provided under Options 5a and 5b.

Phased-In Implementation of specific Table 1 Relay Loadability Evaluation Criteria Options			
Option	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
	phase overcurrent relay 50 element.	Where determined by the GO, TO, or DP that replacement or removal is necessary, 84 months after the effective date of Reliability Standard PRC-025-2.	Where determined by the GO, TO, or DP that replacement or removal is necessary, 84 months after adoption by the Régie of Reliability Standard PRC-025-2.
Options 8a, 8b, and 8c (50 element only)	Generator step-up transformer(s) connected to synchronous generators applying, specifically the phase overcurrent relay 50 element installed on generator-side of the GSU transformer.	Where determined GO, TO or DP, that replacement or removal is not necessary, 60 months after the effective date of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 84 months after the effective date of Reliability Standard PRC-025-2.	Where determined GO, TO or DP, that replacement or removal is not necessary, 60 months after adoption by the Régie of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 84 months after adoption by the Régie of Reliability Standard PRC-025-2.
Option 11 (50 element only)	Generator step-up transformer(s) connected to asynchronous generators only (including inverter-based installations) apply, specifically the phase overcurrent 50 element installed on the generator side of the GSU transformer	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after the effective date of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after the effective date of Reliability Standard PRC-025-2.	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after adoption by the Régie of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after adoption by the Régie of Reliability Standard PRC-025-2.
Option 13a and 3b (50 element only)	Unit auxiliary transformer(s) (UAT) applying, specifically the	Where determined GO, TO or DP, that replacement or removal is not necessary,	Where determined GO, TO or DP, that replacement or removal is not necessary,

Phased-In Implementation of specific Table 1 Relay Loadability Evaluation Criteria Options			
Option	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
	phase overcurrent 50 element applied at the high-side terminals of the UAT, for which operation of the relay will cause the associated generator to trip.	24 months after the effective date of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after the effective date of Reliability Standard PRC-025-2.	24 months after adoption by the Régie of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after adoption by the Régie of Reliability Standard PRC-025-2.
Option 14b	Relays installed on the high-side of the GSU transformer, including relays installed on the remote end of line, for Elements that connect the GSU transformer(s) to the Transmission system that are used exclusively to export energy directly from a BES generating unit or generating plant (except that Elements may also supply generating plant loads) – connected to synchronous generators applying a phase distance relay (e.g., 21) – directional toward the Transmission system.	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after the effective date of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after the effective date of Reliability Standard PRC-025-2.	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after adoption by the Régie of Reliability Standard PRC-025-2. Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after adoption by the Régie of Reliability Standard PRC-025-2.
Option 15b	Relays installed on the high-side of the GSU transformer, including relays installed at the remote end of the line, for Elements that connect the GSU	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after the effective date of Reliability Standard PRC-025-2.	Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after adoption by the Régie of Reliability Standard PRC-025-2.

Phased-In Implementation of specific Table 1 Relay Loadability Evaluation Criteria Options			
Option	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
	transformer(s) to the Transmission system that are used exclusively to export energy directly from a BES generating unit or generating plant (except that Elements may also supply generating plant loads) –connected to synchronous generators applying a phase instantaneous overcurrent supervisory element (e.g., 50) – associated with current-based, communication-assisted schemes where the scheme is capable of tripping for loss of communications and/or phase time overcurrent relay (e.g., 51)	Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after the effective date of Reliability Standard PRC-025-2.	Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after adoption by the Régie of Reliability Standard PRC-025-2.
Option 16b	Relays installed on the high-side of the GSU transformer, including relays installed at the remote end of the line, for Elements that connect the GSU transformer(s) to the Transmission system that are used exclusively to export energy directly from a BES generating unit or generating plant (except that Elements may also supply generating plant load.) – connected to synchronous generators	<p>Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after the effective date of Reliability Standard PRC-025-2.</p> <p>Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after the effective date of Reliability Standard PRC-025-2.</p>	<p>Where determined GO, TO or DP, that replacement or removal is not necessary, 24 months after adoption by the Régie of Reliability Standard PRC-025-2.</p> <p>Where determined by the GO, TO, or DP that replacement or removal is necessary, 48 months after adoption by the Régie of Reliability Standard PRC-025-2.</p>

Phased-In Implementation of specific Table 1 Relay Loadability Evaluation Criteria Options			
Option	Applicability	Effective Date in the United States	Proposed Implementation Date in Québec
	applying Phase directional instantaneous overcurrent supervisory element (e.g., 67) – associated with current-based, communication assisted schemes where the scheme is capable of tripping for loss of communications directional toward the Transmission system and/or phase directional time overcurrent relay (e.g., 67) –directional toward the Transmission system		

1.6. Standards or Requirements to Retire

The standard PRC-025-1 is to be retired when PRC-025-2 comes into effect.

1.7. Modifications to the Glossary

None.

2. ASSESSMENT OF RELEVANCE

With the objective of advancing the reliability goals of the standard, the NERC project “2016-04 Modifications to PRC-025-1” considered revisions to the standard that would address the following issues:

A. Dispersed Power Producing Resources

To prevent instances of non-compliance for conditions where the Generator Owner may be prevented from achieving the margin specified by the standard for dispersed power producing resources, PRC-025-2 Table 1 Option 5 requires setting the overcurrent relay of a Protection System applied to an asynchronous generating unit or an Element utilized in the aggregation of dispersed power producing resources to a margin greater than 130% of the calculated current derived from the maximum aggregate nameplate megavolt-ampere (MVA) output at rated power factor. In some cases, manufacturer requirements or the physical limitations of dispersed power producing resources may prevent the entity from being able to achieve the 130% threshold. To ensure that the load-responsive protective relays associated with

asynchronous generation Facilities may be set at a level to prevent unnecessary tripping during a system disturbance, PRC-025-2 Table 1 adds an alternative setting option, Option 5b⁸.

B. Non-Standard Relay Element Applications

To prevent potential non-compliance where the Generator Owner might apply a non-standard relay element application and undermine the goal of the standard, PRC-025-2 improves upon the PRC-025-1 standard by addressing the inclusion of the IEEE 50 device element and other similar instantaneous (i.e., without intentional delay) overcurrent elements for the various overcurrent applications within Table 1. In practice, a 50 element is generally set with a very high pick up setting and well above the loadability levels determined by the standard. With the inclusion of the 50 element and the addition of a definite time characteristic in Table 1, the standard clarifies that the 50 element must also achieve the same or greater level of loadability as the 51 element (i.e., with intentional delay) thereby avoiding the potential for setting the 50 element inconsistently with the objectives of the standard as well as unknowingly creating a 51 element⁹, which is applicable to the standard.

In addition, revisions are made in Attachment 1 to clarify that IEEE device numbering convention varies by manufacturer and that not all protective relays are designated by an IEEE device number.

C. Application Column of Table 1

To prevent a lowering of reliability where the Generator Owner might only apply part of the Table 1 application(s), thereby misapplying the loadability margins to relays for the stated application(s), PRC-025-2 reflects several revisions to clarify the Application column of Table 1 where it was not clear whether applicable protective relays associated with all listed Elements are to be set using the setting criteria of Table 1 or just one of the multiple listed Elements. Other clarifications were made to Options 7 through 12 and 14 through 19 of Table 1 to remove the described location of the relay from the “Relay Type” column to the “Application” column.

D. Dependability of Protective Relays that Interconnect Generating Facilities to the Transmission System

To prevent a lowering of dependability of protective relays directional toward the Transmission system at generating facilities that are remote to the transmission network, PRC-025-2 contains revisions to Table 1 Options 14b, 15b, and 16b to address cases where the interconnecting Transmission line impedance impacts the maximum Reactive Power capability of the generator or plant. Where a generating Facility is generally small and remote to the Transmission network, the maximum Reactive Power output capability can be significantly lower than the capability determined by the specific Table 1 Options. For these Facilities, setting load-responsive protective relays using the maximum resource capability without considering the effects of line impedance could result in an overly conservative loadability setting which could reduce relay dependability for clearing faults, create substantive difficulty in coordinating backup protection schemes, or result in the application of more complex and costly protective schemes (e.g., transfer-trip). These revisions move the point of the system disturbance (i.e., 0.85 per unit nominal voltage) from the terminals of the generator step-up transformer to the remote end of the line to account for the effects of line impedance and enhances

⁸ Current Option 5 remains in Table 1 as Option 5a for entities that have implemented the 130% setting.

⁹ Any 50 element being applied with a definite time characteristic is, by the IEEE definition, a 51 element and applicable to the standard.

reliability by improving dependability of load-responsive protective relays for clearing faults, reducing difficulty in coordinating backup protection schemes, and potentially eliminating the need for more complex and costly protective schemes

E. Use of Term “Pickup Setting”

Elimination of the use of the term “pickup setting” and other terms or phrases that relate to initial measurements and specific detection methods, and instead, use a term or phrase that clearly aligns with the intent of the standard for relays to “not trip” based on the criteria in Table 1.. The term “pickup” is eliminated from the fifth column of PRC-025-2 Table 1 as well as in Attachment 1 so that it reads “Setting Criteria.

F. Miscellaneous Revisions

To clarify miscellaneous aspects of the standard, Attachment 1, and/or the Application Guidelines, revisions in PRC-025-2 Attachment 1 under the “Generators” heading clarify that the phrase regarding unit capability “reported to the Transmission Planner” is a minimum criterion and that a greater unit capability is acceptable. Additionally, low voltage protection devices that do not have adjustable settings are now specifically listed under the list of Exclusions in Attachment 1. This change is consistent with the addition of the new footnote 1 in the Applicability section of the standard Revisions are also made to the Guidelines and Technical Basis section to add supporting information regarding the above-described standard changes as well as provide clarification in several areas.

In accordance with the agreement made in 2009 between the Régie, NERC and the NPCC and with the authorization of the Québec government,¹⁰ these standards were developed and approved by external agencies for North America, including Québec. In the opinion of the Reliability Coordinator, these standards are relevant for system reliability in Québec and the standards contribute to harmonization with neighboring systems.

It should be noted that all the revision to the PRC-025 standard are relevant to Québec entities and that the revisions described in Section 2D above are particularly relevant for Québec as they provide an alternative option where the integration of generation facilities to the transmission network with long transmission and where line impedance may be a factor. The revisions address cases where generating facilities are remote to the transmission network by allowing setting criteria based on the simulation of field forcing in response to a 0.85 per unit voltage at the remote end of the line and not at the high-side terminal of the GSU transformer.

3. PRELIMINARY IMPACT ASSESSMENT

This section presents the Reliability Coordinator’s preliminary impact assessment.

PRC-025-2	Low	Moderate	High
Implementation of the standard		X	
Enforcement of the standard		X	

¹⁰ Agreement entered into in accordance with Order-in-Council 443-21009 dated April 8, 2019.

Compliance monitoring		X	
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Legend:

Low: Normal industry practice that only requires minor adjustments to existing processes or practices.

Moderate: Change that requires allocation of some physical, human or financial resources to implement the proposed standard, maintain it or monitor its compliance.

High: Change that requires allocation of significant physical, human or financial resources to plan and implement the proposed standard, maintain it or monitor its compliance.

4. FINAL IMPACT ASSESSMENT

This section shall be completed upon receipt of the impact assessment forms and at the conclusion of the consultation process prior to filing of reliability standards with the Régie de l'énergie.