

Alberta Reliability Standard

Transmission Relay Loadability

PRC-023-AB-4



1. Purpose

The purpose of this **reliability standard** is to ensure the protection relay settings do not limit transmission loadability, do not interfere with an **operator's** ability to take remedial action to protect the **reliability** of the **transmission system**, and are set to reliably detect all **fault** conditions and protect the electrical network from these **faults**.

2. Applicability

This **reliability standard** applies to:

- (a) the **legal owner** of a **transmission facility** with load-responsive phase **protection systems**, as described in Appendix 1, applied at the terminals of any one or more of the following facilities:
 - (i) transmission lines operated at 200 kV and above, except **system elements** that are part of a radial circuit, including transmission step-up transformers and lines, that are only used to export energy directly from a **generating unit** or **aggregated generating facility** to a single **system element** on the networked **transmission system**;
 - (ii) transmission lines operated below 200 kV which the **ISO** identifies, as required in requirement R6.2, as essential to the **reliability** of the **bulk electric system**, except transmission lines that are part of a radial circuit that are only used to export energy directly from a **generating unit** or **aggregated generating facility** to a single **system element** on the networked **transmission system**;
 - (iii) transformers with low voltage terminals connected at 200 kV and above; or
 - (iv) transformers with low voltage terminals connected below 200 kV, which the **ISO** identifies in accordance with requirement R6.2, except transformers that are part of a radial circuit that are only used to export energy directly from a **generating unit** or **aggregated generating facility** to a single **system element** on the networked **transmission system**;
- (b) the **legal owner** of a **generating unit**, that also owns the associated switch yard, with load-responsive phase **protection systems**, as described in Appendix 1, applied at the terminals of any one or more of the following facilities:
 - (i) transmission lines operated at 200 kV and above, except transmission lines that are part of a radial circuit that are only used to export energy directly from a **generating unit** to a single **system element** on the networked **transmission system**;
 - (ii) transmission lines operated below 200 kV which the **ISO** identifies, as required in requirement R6.2, as essential to the **reliability** of the **bulk electric system**, except transmission lines that are part of a radial circuit that are only used to export energy directly from a **generating unit** to a single **system element** on the networked **transmission system**;
 - (iii) transformers with low voltage terminals connected at 200 kV and above; or
 - (iv) transformers with low voltage terminals connected below 200 kV which the **ISO** identifies in accordance with requirement R6.2, except transformers that are part of a radial circuit that are only used to export energy directly from a **generating unit** to a single **system element** on the networked **transmission system**;
- (c) the **legal owner** of an **aggregated generating facility**, that also owns the associated switch yard, with load-responsive phase **protection systems**, as described in Appendix 1, applied at the terminals of any one or more of the following facilities:

- (i) transmission lines operated at 200 kV and above, except transmission lines that are part of a radial circuit that are only used to export energy directly from an **aggregated generating facility** to a single **system element** on the networked **transmission system**;
 - (ii) transmission lines operated below 200 kV which the **ISO** identifies, as required in requirement R6.2, as essential to the **reliability** of the **bulk electric system**, except transmission lines that are part of a radial circuit that are only used to export energy directly from an **aggregated generating facility** to a single **system element** on the networked **transmission system**; or
 - (iii) transformers with low voltage terminals connected below 200 kV which the **ISO** identifies in accordance with requirement R6.2, except transformers that are part of a radial circuit that are only used to export energy directly from an **aggregated generating facility** to a single **system element** on the networked **transmission system**; and
- (d) the **ISO**.

3. Requirements

R1 Each **legal owner** of a **transmission facility**, **legal owner** of a **generating unit**, and **legal owner** of an **aggregated generating facility** must:

- (a) use one of the criteria set out in requirements R1.1 through R1.14, inclusive, for each specific circuit terminal, being either a transmission line or a transformer, to prevent its phase protection relay settings from limiting **transmission system** loadability; and
- (b) for R1.1 through R1.14 evaluate the phase protection relay's loadability at 0.85 per unit voltage and a **power factor** angle of 30°.

A load encroachment function within protection relays may be used to meet (a) and (b).

R1.1 Set transmission line protection 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 to 4 hours, expressed in amperes;

R1.2 Set transmission line protection relays so they do not operate at or below 115% of the 10-minute emergency facility rating of a circuit, expressed in amperes;

R1.3 Set transmission line protection relays so they do not operate at or below 115% of the maximum theoretical power transfer capability, using a 90° 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:

R1.3.1 an infinite source, i.e. zero source impedance, with a 1.00 per unit bus voltage at each end of the transmission line; or

R1.3.2 an impedance at each end of the transmission line, which reflects the actual system source impedance with a 1.05 per unit voltage behind each source impedance;

R1.4 Set transmission line protection relays on series compensated transmission lines so they do not operate at or below the maximum power transfer capability of the transmission line, determined as the greater of:

- (a) 115% of the highest emergency rating of the series capacitor, or
- (b) 115% of the maximum power transfer capability of the circuit, expressed in amperes, calculated in accordance with requirement R1.3, using the full transmission line inductive

reactance;

- R1.5** Set transmission line protection 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;
- R1.6** Set transmission line relays applied on transmission lines connected to a **generating unit** or **aggregated generating facility** remote to load so they do not operate at or below 230% of the total nameplate capability of all the **generating units** at the facility;
- R1.7** Set transmission line protection relays applied at the load center terminal, remote from a **generating unit** or **aggregated generating facility**, 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;
- R1.8** Set transmission line protection relays applied on the 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;
- R1.9** Set transmission line protection relays applied on the load-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 load to the system under any system configuration;
- R1.10** Set transformer **fault** protection relays and transmission line protection relays on transmission lines terminated only with a transformer so that they do not operate at or below the greater of:
- (a) 150% of the applicable maximum transformer nameplate rating, expressed in amperes, including the forced cooled ratings corresponding to all installed supplemental cooling equipment; or
 - (b) 115% of the highest established emergency transformer rating;
- R1.11** Set load responsive transformer **fault** protection relays, if used, such that the protection settings do not expose the transformer to a **fault** level and duration that exceeds the transformer's mechanical withstand capability;
- R1.12** For transformer overload protection relays that do not comply with requirement R1.10:
- (a) set the protection 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 emergency transformer rating, whichever is greater;
 - (b) the protection relay must allow overload in requirement R1.12(a) for at least 30 minutes to allow the **ISO** to take controlled action to relieve the overload;
 - (c) install supervision for the protection relays using either a top oil or simulated winding hot spot temperature element; and
 - (d) the protection relay setting should be no less than 100°C for the top oil or 140°C for the winding hot spot temperature;
- R1.13** When the desired transmission line capability is limited by the requirement to adequately protect the transmission line and a load encroachment function is not available within the protection relay, set the transmission line distance protection relays to a maximum of 125% of the apparent impedance, at the impedance angle of the transmission line, subject to the following constraints:
- R1.13.1** set the maximum torque angle to 90° or the highest setting supported by the manufacturer;

- R1.13.2** evaluate the protection relay loadability in amperes at the protection relay trip point 0.85 per unit voltage and a **power factor** angle of 30°; and
- R1.13.3** include a protection relay setting component of 87% of the current calculated in requirement R1.13.2 in the facility rating determination for the circuit; and
- R1.14** Where other extraordinary situations present practical limitations on circuit capability, as the **ISO** approves in writing, set the phase protection relays and associated current transformer ratios so they do not operate at or below 115% of such limitations.
- R2** Each **legal owner** of a **transmission facility**, **legal owner** of a **generating unit**, and **legal owner** of an **aggregated generating facility** must set its out-of-step blocking elements to allow tripping of phase protection relays for **faults** that occur during the loading conditions used to verify transmission line protection relay loadability per requirement R1.
- R3** Each **legal owner** of a **transmission facility**, **legal owner** of a **generating unit**, or **legal owner** of an **aggregated generating facility** that uses a circuit capability with the practical limitations described in requirements R1.7, R1.8, R1.9, R1.13, or R1.14 must use the calculated circuit capability as the facility rating of the circuit and must obtain the **ISO's** written agreement to use the calculated circuit capability.
- R4** Each **legal owner** of a **transmission facility**, **legal owner** of a **generating unit**, or **legal owner** of an **aggregated generating facility** that uses requirement R1.2 as the basis for verifying transmission line protection relay loadability must provide the **ISO** with an updated list of circuits associated with those transmission line protection relays at least once each calendar year, with no more than **15 months** between reports.
- R5** Each **legal owner** of a **transmission facility**, **legal owner** of a **generating unit**, or **legal owner** of an **aggregated generating facility** that uses requirement R1.13 as the basis for verifying transmission line protection relay loadability must provide the **ISO** with an updated list of circuits associated with those transmission line protection relays at least once each calendar year, with no more than **15 months** between reports.
- R6** The **ISO** must conduct an assessment at least once each calendar year, with no more than 15 months between assessments, by applying the criteria in Appendix 2, to identify the circuits in its planning area for which the **legal owner** of a **transmission facility**, **legal owner** of a **generating unit**, and **legal owner** of an **aggregated generating facility** must comply with requirements R1 through R5. The **ISO** must:
- R6.1** maintain a list of circuits per the application of Appendix 2, including an effective date that is no earlier than **24 months** from identification of the circuits; and
- R6.2** provide the list of circuits to the **legal owner** of a **transmission facility**, **legal owner** of a **generating unit**, and **legal owner** of an **aggregated generating facility** within its planning area within **30 days** of the establishment of the initial list and within **30 days** of any changes to that list.

2. Measures

The following measures correspond to the requirements identified in section 3 of this **reliability standard**. For example, MR1 is the measure for R1.

MR1 Evidence of using one of the criteria set out in requirements R1.1 through R1.14, evaluating the phase protection relay's loadability, and implement transmission line protection relays settings, all as required in requirement R1 exists. Evidence may include:

- (a) spreadsheets or summaries of calculations to show that each of its transmission line protection

relays is set in accordance with one of the criteria set out in requirements R1.1 through R1.14;

- (b) coordination curves or summaries of calculations that show that protection relays set per criterion set out in requirement R1.11 do not expose the transformer to **fault** levels and durations beyond those indicated in the **reliability standard**;
- (c) evidence to demonstrate settings implementation, or
- (d) other equivalent evidence.

MR2 Evidence of setting its out-of-step blocking elements as required in requirement R2 exists. Evidence may include spreadsheets or summaries of calculations, or other equivalent evidence.

MR3 Evidence of using, and obtaining the **ISO**'s written agreement to use, the calculated circuit capability as required in requirement R3 exists. Evidence may include:

- (a) facility rating spreadsheets or facility rating database to show that the calculated circuit capability was used as the facility rating of the circuit;
- (b) dated correspondence to show that the **ISO** agreed to the calculated circuit capability; or
- (c) other equivalent evidence.

MR4 Evidence of providing the **ISO** with an updated list of circuits as required in requirement R4 exists. Evidence may include dated correspondence to the appropriate **ISO** recipient with the updated list which may either be a full list, a list of incremental changes to the previous list, a statement that there are no changes to the previous list, or other equivalent evidence.

MR5 Evidence of providing the **ISO** with an updated list of circuits as required in requirement R5 exists. Evidence may include dated correspondence to the appropriate **ISO** recipient with the updated list which may either be a full list, a list of incremental changes to the previous list, a statement that there are no changes to the previous list, or other equivalent evidence.

MR6 Evidence of conducting an assessment as required in requirement R6 exists. Evidence may include power flow results, calculation summaries or study reports that the **ISO** used the criteria established within Appendix 2 to identify the circuits in its planning area, or other equivalent evidence.

MR6.1 Evidence of maintaining the list of circuits as required in requirement R6.1 exists. Evidence may include a documented list of circuits with the effective date and the revision history captured, or other equivalent evidence.

MR6.2 Evidence of providing the list of circuits as required in requirement R6.2 exists. Evidence may include dated correspondence to the applicable entities, or other equivalent evidence.

3. Appendices

Appendix 1 – *Associated Switch Yard with Load-Responsive Phase Protection Systems*

Appendix 2 – *Criteria for Identifying Circuits and Establishing a List*

Appendix 3 – *Retirement of Requirement R1.6*

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Revision History

Effective	Description
2019-xx-xx	<p>Overlapping content removed:</p> <ul style="list-style-type: none"> • generator protection relays that are susceptible to load; and • the application of PRC-023-AB-4 to phase protection relays on transmission lines that are part of a radial circuit that are only used to export energy directly from a generating unit or aggregated generating facility to a single system element on the networked transmission system. <p>R1 was amended for clarity.</p> <p>Appendix 3 was added to remove requirement R1.6 when PRC-025-AB-2 becomes effective.</p> <p>Additional amendments to ensure consistent use of defined terms as included in the AESO's Consolidated Authoritative Document Glossary; formatting and grammatical corrections; the deletion of the following sections:</p> <p>(a) "Definitions";</p> <p>(b) "Processes and Procedures"; and</p> <p>(c) "Appendices".</p>
April 1, 2016	<p>This is the date the following requirements R1, R2, R3, R4 and R5 became effective for:</p> <p>(a) transmission lines operated below two hundred (200) kV which the ISO identifies as essential to the reliability of the bulk electric system; and</p> <p>(b) transformers with low voltage terminals connected below two hundred (200) kV the ISO identifies as essential to the reliability of the bulk electric system.</p>
April 1, 2015	<p>This is the date the following for requirements R1, R2, R3, R4 and R5 became effective for:</p> <p>(a) transmission lines operated at two hundred (200) kV and above; and</p> <p>transformers with low voltage terminals connected at two hundred (200) kV and above.</p>
April 1, 2014	Initial Release

Appendix 1

Associated Switch Yard with Load-Responsive Phase Protection Systems

1. This **reliability standard** includes any protection functions which could trip with or without time delay, on load current, including:
 - (a) phase distance;
 - (b) out-of-step tripping;
 - (c) switch-on-to-**fault**;
 - (d) overcurrent relays;
 - (e) communications aided **protection system** including:
 - (i) permissive overreach transfer trip;
 - (ii) permissive under-reach transfer trip;
 - (iii) directional comparison blocking;
 - (iv) directional comparison unblocking; and
 - (f) phase overcurrent supervisory elements (i.e. phase **fault** detectors) associated with current-based, communication-assisted schemes (i.e. pilot wire, phase comparison, and line current differential) where the scheme is capable of tripping for loss of communications.
2. The following **protection systems** are excluded from the requirements of this **reliability standard**:
 - (a) relay elements that are only enabled when other relays or associated systems fail, including:
 - (i) overcurrent elements that are only enabled during loss of potential conditions; and
 - (ii) relay elements that are only enabled during a loss of communications except as noted in subsection 1(f) above;
 - (b) **protection systems** intended for the detection of ground **fault** conditions;
 - (c) **protection systems** intended for protection during stable power swings;
 - (d) Not used;
 - (e) relay elements used only for **remedial action scheme** purposes;
 - (f) **protection systems** that are designed only to respond in time periods which allow 15 minutes or greater to respond to overload conditions;
 - (g) thermal emulation relays which are used in conjunction with dynamic facility ratings; and
 - (h) relay elements associated with direct current lines.

Appendix 2

Criteria for Identifying Circuits and Establishing a List

The **ISO** must evaluate the following circuits:

- (a) transmission lines operated at 100 kV to 200 kV and transformers with low voltage terminals connected at 100 kV to 200 kV; and
- (b) transmission lines operated below 100 kV and transformers with low voltage terminals connected below 100 kV that are essential to the **reliability** of the **bulk electric system**.

Criteria

If any of the following criteria apply to a circuit, the **ISO** must identify the circuit as required in requirement R6.

- 1 A major transfer path within the Western **Interconnection** as defined by the Regional Entity.
- 2 The circuit is a monitored facility of an **interconnection reliability operating limit**, where the **interconnection reliability operating limit** was determined in the planning horizon pursuant to **reliability standard** FAC-010-AB.
- 3 The circuit is identified through the following sequence of power flow analyses:
 - (a) simulate double **contingency** combinations selected by engineering judgment, without manual system adjustments in between the 2 **contingencies** (reflects a situation where real time operating personnel may not have time between the 2 **contingencies** to make appropriate system adjustments), performed by the **ISO** for the one-to-five-year planning horizon;
 - (b) for circuits operated between 100 kV and 200 kV, evaluate the post-**contingency** loading, in consultation with the **legal owner**, against a threshold based on the facility rating assigned for that circuit and used in the power flow case by the **ISO**;
 - (c) when more than one facility rating for that circuit is available in the power flow case, the **ISO** must base the threshold for selection on the facility rating for the loading duration nearest 4 hours;
 - (d) the threshold for selection of the circuit will vary based on the loading duration assumed in the development of the facility rating:
 - (i) if the facility rating is based on a loading duration of up to and including 4 hours, the circuit must comply with this **reliability standard** if the loading exceeds 115% of the facility rating;
 - (ii) if the facility rating is based on a loading duration greater than 4 and up to and including 8 hours, the circuit must comply with this **reliability standard** if the loading exceeds 120% of the facility rating; or
 - (iii) if the facility rating is based on a loading duration of greater than 8 hours, the circuit must comply with this **reliability standard** if the loading exceeds 130% of the facility rating; and
 - (e) radially operated circuits serving only load are excluded.
- 4 The **ISO** must select the circuit based on technical studies or assessments, other than

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those specified in criteria 1 through 3, in consultation with the **legal owner**.

- 5 The **ISO** and the **legal owner** must mutually agree upon the circuit for inclusion.

Appendix 3

Appendix 3 – Retirement of Requirement R1.6

Requirement R1.6 will be retired as of midnight the **day** before the effective date of **reliability standard** PRC-025-AB-2, *Generator Load Reliability*.