# PRC-023-AB-4

# Transmission Relay Loadability

# Standard Effective Date: July 1, 2020

## Audit Summary

|  |  |
| --- | --- |
| **Registered Entity:** | [Registered Entity name as it appears in the AESO ARS Registry] |
| **Functional Entity:** | [Functional entities for which the Registered Entity above was registered throughout the audit period] |
| **Audit Period:** | From: [Audit start date or standard effective date, whichever comes later]  To: [Audit end date or standard withdrawal/supersede date, whichever comes first] |
| **Audit:** | [Scheduled (YYYY-QX) or Spot Check YYYY-MM-DD] |
| **Compliance Monitoring Entity:** | Alberta Electric System Operator (AESO) |
| **Suspected Non-Compliance to the standard?** | |  |  | | --- | --- | |  |  | |  | [If **Yes**, list the requirements with suspected contravention findings e.g. R1, R2, R5] | |
| **Date of Completion** | [Use YYYY-MM-DD format] |

## Assessment Commentary

[Information (if any) relevant to audit findings below]

## Findings

R1 [Summary of Findings]

R2 [Summary of Findings]

R3 [Summary of Findings]

R4 [Summary of Findings]

R5 [Summary of Findings]

## Contact Information

| **Audited Entity** | |
| --- | --- |
| **Compliance Primary** | Name:  Title:  Phone:  Email: |
| **Subject Matter Expert** | Name:  Title:  Phone:  Email: |

| **AESO Team** | |
| --- | --- |
| **Lead Auditor** | Name:  Title:  Phone:  Email: |
| **Auditor** | Name:  Title:  Phone:  Email: |
| **Compliance Manager** | Name:  Title:  Phone:  Email: |
| **Standard Owner** | Name:  Title:  Phone:  Email: |

## 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**.

## Compliance Assessment

| **Requirement and Measure** | **Evidence Submission** | **Evidence Description** | **Evidence** | **Assessment Approach** | **Auditor Notes** |
| --- | --- | --- | --- | --- | --- |
| **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 unit**s 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.  **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. | **AR1** Please provide:   1. The list of protection relays that implement the protection functions specified in Appendix 1 of PRC-023-AB-4 including the in-service date for new applicable protection relays, if any, during the audit period.   The ID document and associated template posted on the AESO web site (currently [PRC-023-4-AB R1.1 template for ID](https://www.aeso.ca/rules-standards-and-tariff/alberta-reliability-standards/prc-023-transmission-relay-loadability/)) could be considered when providing the evidence. | Provide descriptions for AR1(i) evidence. | Embed file, link to evidence or file name(s). | Review AR1(i) list for appropriateness and completeness. | *For AESO use only* |
| 1. Evidence demonstrating that each applicable protection relay is set in accordance with one of the criteria set out in requirements R1.1 through R1.14. such as dated protection relay setting files. | Provide descriptions for AR1(ii) evidence. | Embed file, link to evidence or file name(s). | Review AR1(ii) evidence to verify that one of the criteria (R1.1 to R1.14) was used and implemented. | *For AESO use only* |
| 1. The dated evidence for evaluating the phase protection relay’s loadability at 0.85 per unit voltage and a power factor angle of 30°.   The ID document and associated template posted on the AESO web site (currently [PRC-023-4-AB R1.1 template for ID](https://www.aeso.ca/rules-standards-and-tariff/alberta-reliability-standards/prc-023-transmission-relay-loadability/)) could be considered when providing the evidence. | Provide descriptions for AR1(iii) evidence. | Embed file, link to evidence or file name(s). | Review AR1(iii) to verify that the phase protection relay’s loadability was evaluated at 0.85 per unit voltage and a power factor angle of 30°. | *For AESO use only* |
| 1. For each protection relay set per the criterion in R1.11, evidence demonstrating its protection setting does not expose the transformer to fault levels and durations beyond those indicated in the reliability standard. | Provide descriptions for AR1(iii) evidence. | Embed file, link to evidence or file name(s). | Review AR(iv) to verify that for each protection relay set per the criterion in R1.11, its protection setting did not expose the transformer to fault levels and durations beyond those indicated in the reliability standard. | *For AESO use only* |
| *Note: Evidence may be provided for the entire population in the initial evidence submission at the Entity’s discretion. Otherwise, the AESO will request specific samples.* |  |  |  |  |
| or any other evidence to demonstrate compliance with R1. | Provide descriptions for other evidence. | Embed file, link to evidence or file name(s). | Review additional evidence provided. | *For AESO use only* |
| **Findings** | | | | | |
| *For AESO use only* | | | | | |

| **Requirement and Measure** | **Evidence Submission** | **Evidence Description** | **Evidence** | **Assessment Approach** | **Auditor Notes** |
| --- | --- | --- | --- | --- | --- |
| **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.  **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. | **AR2** Please provide:   1. A list of applicable protection relays with out-of-step blocking elements. | Provide descriptions for AR2(i) evidence. | Embed file, link to evidence or file name(s). | Review AR2(i) list for appropriateness and completeness. | *For AESO use only* |
| 1. Evidence to demonstrate that the out-of-step blocking elements are set to allow tripping of phase protective relays for **fault**  that occur during the loading conditions used to verify transmission line protection relay loadability per requirement R1. | Provide descriptions for AR2(ii) evidence. | Embed file, link to evidence or file name(s). | Review AR2(ii) to verify the out-of-step blocking elements were set to allow tripping of phase protective relays for **faults** that occur during the loading conditions used to verify transmission line relay loadability per requirement R1. | *For AESO use only* |
| *Note: Evidence may be provided for the entire population in the initial evidence submission at the Entity’s discretion. Otherwise, the AESO will request specific samples.* |  |  |  |  |
| or any other evidence to demonstrate compliance with R2. | Provide descriptions for other evidence. | Embed file, link to evidence or file name(s). | Review additional evidence provided. | *For AESO use only* |
| **Findings** | | | | | |
| *For AESO use only* | | | | | |

| **Requirement and Measure** | **Evidence Submission** | **Evidence Description** | **Evidence** | **Assessment Approach** | **Auditor Notes** |
| --- | --- | --- | --- | --- | --- |
| **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.  **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. | **AR3** Please provide:   1. The list of protection relays using a circuit capability with the practical limitations described in requirements R1.7, R1.8, R1.9, R1.13, or R1.14 during the audit period.   If none of the above requirements were used, an attestation letter to this effect. | Provide descriptions for AR3(i) evidence. | Embed file, link to evidence or file name(s). | Review AR3(i) list for appropriateness and completeness. | *For AESO use only* |
| 1. For each of the protective relays included in AR3(i), evidence that the calculated circuit capability was used as the facility rating of the circuit. | Provide descriptions for AR3(ii) evidence. | Embed file, link to evidence or file name(s). | Review the AR3(ii) to determine whether the audited entity used the calculated circuit capability as the facility rating. | *For AESO use only* |
| 1. The dated written correspondence showing that the **ISO** agreed to the calculated circuit capability. | Provide descriptions for AR3(iii) evidence | Embed file, link to evidence or file name(s). | Review the AR3(iii) to determine whether the audited entity obtained the agreement of the ISO to use the calculated circuit capability. | *For AESO use only* |
| or any other evidence to demonstrate compliance with R3. | Provide descriptions for other evidence. | Embed file, link to evidence or file name(s). | Review additional evidence provided. | *For AESO use only* |
| **Findings** | | | | | |
| *For AESO use only* | | | | | |

| **Requirement and Measure** | **Evidence Submission** | **Evidence Description** | **Evidence** | **Assessment Approach** | **Auditor Notes** |
| --- | --- | --- | --- | --- | --- |
| **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.  **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. | **AR4** Please provide:   1. The list of protection relays and their associated transmission lines using R1.2 as the basis for verifying transmission line protection relay loadability during the audit period.   If R1.2 was not used, an attestation letter to this effect. | Provide descriptions for AR4 (i) evidence. | Embed file, link to evidence or file name(s). | Review AR4(i) list for appropriateness and completeness. | *For AESO use only* |
| 1. The dated correspondence with the ISO as required by R4. | Provide descriptions for AR4 (ii) evidence. | Embed file, link to evidence or file name(s). | Review AR4(ii) evidence to verify that the entity provided the ISO with the updated list at least once each calendar year, with no more than 15 months between reports. | *For AESO use only* |
| or any other evidence to demonstrate compliance with R4. | Provide descriptions for other evidence | Embed file, link to evidence or file name(s). | Review additional evidence provided. | *For AESO use only* |
| **Findings** | | | | | |
| *For AESO use only* | | | | | |

| **Requirement and Measure** | **Evidence Submission** | **Evidence Description** | **Evidence** | **Assessment Approach** | **Auditor Notes** |
| --- | --- | --- | --- | --- | --- |
| **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.  **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. | **AR5** Please provide:   1. The list of protection relays and their associated transmission lines using R1.13 as the basis for verifying transmission line protection relay loadability during the audit period.   If R1.13 was not used, an attestation letter to this effect. | Provide descriptions for AR5 (i) evidence. | Embed file, link to evidence or file name(s). | Review AR5(i) list for appropriateness and completeness. | *For AESO use only* |
| 1. The dated correspondence with ISOas required by R5. | Provide descriptions for AR5 (ii) evidence. | Embed file, link to evidence or file name(s). | Review AR5(ii) evidence to verify that the entity provided the ISO with the updated list at least once each calendar year, with no more than 15 months between reports. | *For AESO use only* |
| or any other evidence to demonstrate compliance with R5. | Provide descriptions for other submitted evidence. | Embed file, link to evidence or file name(s). | Review additional evidence provided. | *For AESO use only* |
| **Findings** | | | | | |
| *For AESO use only* | | | | | |

## General Notes

The AESO developed this Reliability Standard Audit Worksheet (RSAW) to add clarity and consistency to the audit team’s assessment of compliance with this reliability standard, including the approach elected to assess requirements.

Additionally, the RSAW provides a non-exclusive list of examples of the types of evidence a market participant may produce or may be asked to produce to demonstrate compliance with this reliability standard. A market participant’s adherence to the examples contained within this RSAW does not constitute compliance with the reliability standard.

This document is not an AESO authoritative document and revisions to it may be made from time to time by the AESO. Market participants are notified of revisions through the stakeholder update process.

## Notes to File

[For AESO use only: any observations, remarks or action items for future audits]

## Revision History

| **Version** | **Issue Date** | **Description** |
| --- | --- | --- |
| 1.0 | September 9, 2020 | Initial version |
|  |  |  |