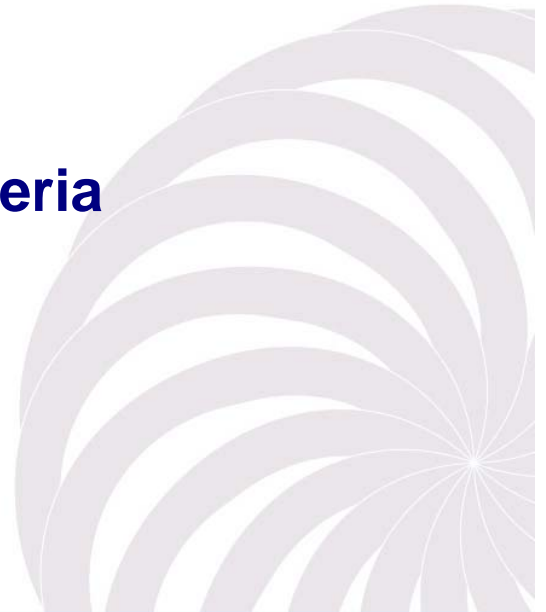




# **Transmission Reliability Criteria**

## **Part II**

### **System Planning**



---

**Version 0**

March 11, 2005

## TABLE OF CONTENTS

<b>1.0</b>	<b>INTRODUCTION</b> .....	<b>1</b>
<b>2.0</b>	<b>GENERAL APPROACH</b> .....	<b>1</b>
<b>3.0</b>	<b>TRANSMISSIONS ROLE AND ADEQUACY</b> .....	<b>2</b>
<b>3.1</b>	<b>Market Facilitation</b> .....	<b>2</b>
<b>3.2</b>	<b>Generation Dispatch</b> .....	<b>2</b>
<b>3.3</b>	<b>Transmission Must Run (TMR)</b> .....	<b>3</b>
<b>3.4</b>	<b>Interconnection with Other Jurisdictions</b> .....	<b>3</b>
<b>3.5</b>	<b>Opportunity Service</b> .....	<b>4</b>
<b>4.0</b>	<b>TRANSMISSION PLANNING RELIABILITY CRITERIA</b> .....	<b>5</b>
<b>4.1</b>	<b>Normal and Contingency Conditions</b> .....	<b>5</b>
<b>4.2</b>	<b>Maintenance Standard for Planning the ATS</b> .....	<b>9</b>
<b>4.3</b>	<b>Facility Design and Interconnection</b> .....	<b>9</b>
<b>4.4</b>	<b>System Protection and Controls</b> .....	<b>9</b>
<b>4.5</b>	<b>Point of Delivery (POD) Criteria</b> .....	<b>10</b>
<b>4.6</b>	<b>Point of Supply (POS) and Generation Surplus Area Criteria</b> .....	<b>10</b>
<b>5.0</b>	<b>PERFORMANCE STANDARDS</b> .....	<b>11</b>
<b>5.1</b>	<b>Voltage Standards</b> .....	<b>11</b>
<b>5.2</b>	<b>Voltage Stability Criteria</b> .....	<b>14</b>
<b>5.3</b>	<b>Voltage Swing Criteria</b> .....	<b>16</b>
<b>5.4</b>	<b>Thermal Loading</b> .....	<b>19</b>
<b>5.5</b>	<b>Off-Nominal Frequency</b> .....	<b>19</b>
<b>5.6</b>	<b>Short Circuit Levels and Circuit Breaker Capacities</b> .....	<b>19</b>
<b>6.0</b>	<b>POWER SYSTEM MODELING</b> .....	<b>20</b>
<b>6.1</b>	<b>System Model</b> .....	<b>20</b>
<b>6.2</b>	<b>System Load</b> .....	<b>20</b>
<b>6.3</b>	<b>Load Model</b> .....	<b>20</b>
<b>6.4</b>	<b>Clearing Times</b> .....	<b>21</b>
	<b>APPENDIX A APPLICABLE CRITERIA AND GUIDES</b> .....	<b>1</b>

## 1.0 Introduction

This document presents the reliability criteria, which will be used as the basis for planning the Alberta Transmission System (**ATS**).

As Part 2 of the AESO Reliability Criteria (**Reliability Criteria**), this document must be read in the context of the whole. The definitions in the WECC Reliability Criteria are the bases for the terms used in this document unless otherwise defined. Definitions of terms and acronyms can be found in the appendices of Part I.

## 2.0 General Approach

The ATS is comprised of transmission facilities with several owners, including regulated and non-regulated transmission facility owners (**TFO**'s). As well, there are many loads and generators directly connected to the ATS. Market participants, end use customers, landowners, the general public and other stakeholders all have an interest in the reliability and development requirements of the ATS.

The AESO's role is to ensure that there are adequate transmission facilities available so that the ATS can operate in a safe, reliable and efficient manner and to promote a fair, efficient and openly competitive market for electricity taking into account the interest of all stakeholders.

The objective of the Reliability Criteria is to provide a basis for planning a reliable transmission system taking into account the need for continuity of service, operating costs, capital investments and the need to facilitate the electric market in Alberta. Although not considered in the Reliability Criteria, other impacts such as social, land use and environmental must also be considered when establishing a system development plan. The system will normally be designed to meet or exceed the Reliability Criteria under credible worst-case loading and generation conditions unless stated otherwise. However, if extraordinary expenditures are required or a proposed plan does not meet the Reliability Criteria, the reasons, related costs, and risks involved must be evaluated on an individual basis. Conversely, if studies show that certain very unlikely contingencies will result in extraordinary consequences; projects may be initiated to mitigate such consequences. Each decision must stand the test of good engineering and business judgment.

### 3.0 Transmissions Role and Adequacy

Given the role and importance of the transmission system, the Government of Alberta, through the Electric Utilities Act (**EU Act**) and the associated Transmission Regulation (**Transmission Regulation**) has identified several requirements related to system reliability and adequacy. The Regulation requires the AESO to forecast future needs of market participants and create 10 and 20 year long term plans to fulfill these needs. Further, the AESO must plan the ATS to meet NERC and WECC reliability standards and provide adequate transmission capability under normal and abnormal conditions. The AESO must also report to the Alberta Energy and Utilities Board (**EUB**) regarding development plans and compliance with reliability standards periodically.

The following standards are important aspects central to planning adequate resources for the ATS.

#### 3.1 Market Facilitation

The market facilitation standards for the AIES are established in the EU Act Transmission Regulation. The following paragraphs are a summary of the market facilitation requirements, for the complete context and text refer to the Regulation.

The ATS shall be planned sufficiently robust to allow for transmission of 100% of anticipated **in-merit** electric energy referred to in section 17(c) of the EU Act when all transmission facilities are in service<sup>1</sup>. That is, all anticipated in-merit generation must be able to deliver energy to the Alberta market recognizing the ATS must be operated in a manner that anticipates single contingency events as defined by the AESO's Transmission Operating Criteria, the AESO's operating procedures and WECC's **MORC** (Minimum Operating Reliability Criteria).

The ATS shall be planned so that on an annual basis, at least 95% of all anticipated in-merit electric energy referred to in section 17(c) of the EU Act can be traded when operating under abnormal operating conditions<sup>2</sup>. Abnormal operating conditions include conditions where transmission facilities are out of service, emergency conditions exist, construction or commissioning of transmission facilities occur or situations when transmission facility maintenance cannot be coordinated with generation outages.<sup>3</sup>

#### 3.2 Generation Dispatch

For the purpose of determining ATS adequacy, generation will be **dispatched** according to the forecast **merit order** for the period of study. Non-dispatchable generation such as wind or run of river hydro will be assumed at its minimum or maximum seasonal output whichever is more onerous.

---

<sup>1</sup> Electric Utilities Act, Transmission Regulation, s8(1), (e), (i)

<sup>2</sup> Ibid., s8(1), (e), (ii)

<sup>3</sup> Ibid., s1(1), (a)

The transmission supply to each predominantly load area will be planned so that a Category B event will result in acceptable performance with the most critical generator out of service, for commercial or maintenance reasons, and with the system readjusted after re-dispatching the remaining generation according to the forecast merit order. The most critical generator out of service is the generation dispatch approach utilized in Alberta to assess the most onerous loading into any particular load area in an open market. This is often referred to as the N-G-1 criteria, where the system is normal, the most critical generator is out of service, the system is adjusted and a WECC defined Category B event occurs.

The most critical generator is the unit that will cause the greatest stress on the component of the ATS being studied. The most critical generator could include more than one generator if a second generator is dependent on the first to operate or if one system element (including a generator component) could result in more than one generator being unable to operate. The critical generating unit may be different under different study conditions and for different study areas.

Category C and D events will be assessed with all generation available and dispatched according to the forecast merit order.

The transmission capability out of predominately generation surplus areas will be planned so that a Category B or C event will result in acceptable performance with maximum reasonable generation dispatch and with coincident minimum local load. Assessing the maximum reasonable generation dispatch shall take into account the maximum forecast coincident combination of maximum continuous rating (**MCR**), peak continuous rating (**PCR**) and contract levels.

### 3.3 Transmission Must Run (TMR)

The AESO will consider specific and limited application of non-wires solutions to provide transmission capacity where<sup>4</sup>:

- a) in areas where there is limited potential for growth of load, and the cost of the non-wires solution is materially less than the life-cycle cost of the transmission wires solution, compared over an equivalent study period, or
- b) on a temporary basis, if the non-wires solution is required to ensure reliable service due to the shorter lead time of the non-wires solution.

### 3.4 Interconnection with Other Jurisdictions

The ATS will be planned so that, under normal operating conditions, the transmission system interconnections with jurisdictions outside Alberta can import and export electricity on a continuous basis, at or near the transmission facility's **path rating**.<sup>5</sup>

---

<sup>4</sup> EU Act Transmission Regulation, s8(4)

<sup>5</sup> Ibid., s8(1), (g)

The ATS will be planned so that imports over interconnections are not required in order to meet performance standards. See NERC/WECC Planning Standard Table 1 presented in Figure 4.1-1.

For assessing firm transmission capacity ratings, non-dispatchable generation such as wind or run of river hydro will be assumed at its most adverse seasonal output.

### **3.5 Opportunity Service**

The ATS will not be planned to provide for opportunity service.

The capability to enter into opportunity energy transactions will be measured with all generation available and dispatched in merit. Non-dispatchable generation such as wind or run of river hydro will be assumed at their most advantageous seasonal output. The system shall be capable of withstanding a Category B or C event with opportunity load shedding allowed.

It is recognizing that opportunity service capability may be increased as a result of restoring transfer capability of the interties to their path ratings as described in Section 3.4.

## 4.0 Transmission Planning Reliability Criteria

The ATS will be planned to meet the WECC Reliability Criteria and more specifically the NERC/WECC Planning Standards contained therein. Specific WECC guides and AESO standards also apply to planning the ATS. A summary of applicable documents can be found in Appendix B.

The WECC's planning reliability criteria is titled the NERC/WECC Planning Standards as they are the NERC Planning Standards with additional requirements specific to the WECC. Many of the additional requirements result from the long distances between generation and load centers in the WECC as compared with other NERC regions.

The NERC Planning Standards apply to internal systems, while the WECC extensions to the NERC Planning Standards are only applied to external systems by the WECC unless otherwise stated either in the NERC/WECC Reliability Standards or herein.

The goal of the NERC/WECC Planning Standards is to ensure that there is an adequate transmission system where adequate is defined as "The ability of the electric systems to supply the aggregate electrical demand and energy requirements of their customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements."<sup>6</sup>

For convenience, key aspects of the NERC/WECC Planning Standards are summarized in this document. For a full presentation of these criteria, refer to the full WECC Reliability Criteria.

### 4.1 Normal and Contingency Conditions

Transmission systems are subject to a wide variety of conditions and events. Load, generation and interchanges are constantly changing in response to customer needs and the need for load and generation to balance instantaneously. The ATS extends over a wide geographic area and must operate through a wide variety of market, weather, maintenance and equipment outage conditions.

The NERC/WECC's Reliability Standard Table 1 below titled "Transmission System Standards – Normal and Contingency Conditions" provides a definition of the categories of system events and acceptable response to these events. For convenience a summary of the four categories of events follows. For full details see Table 1.

Category A represents a normal system with no contingencies and all facilities in service. This is often referred to as the N-0 condition. The system must be able to supply all firm load and firm transfers to other areas. All equipment must operate

---

<sup>6</sup> WECC NERC/WECC Planning Standards and Minimum Operating Reliability Criteria Definitions,

within its applicable rating, voltages must be within their applicable ratings and the system must be stable with no cascading outages.

Category B events result in the loss of any single specified system element under specified fault conditions and normal clearing. The specified elements are a generator, a transmission circuit, a transformer or a single pole of a DC transmission line. This is often referred to as an N-1 event or with the most critical generator out of service, an N-G-1 event. The acceptable impact on the system is the same as Category A. Radial customers, including loads or generators, are allowed to disconnect from the system. The loss of opportunity load or opportunity interchanges is allowed.

Category C events result in the loss of one or more specified system elements under specified fault conditions and include both normal and delayed fault clearing events. When any two specified system elements are lost simultaneously, this is referred to as an N-2 event. All of the system limits for Category A and B events apply with the exception that planned, controlled loss of either firm load, firm transfers and/or certain generation is acceptable provided there is no cascading.

Category D represents a wide variety of extreme, rare and unpredictable events, which may result in the loss of customer demand (firm load) and generation in widespread areas. The system may not be able to reach a new **stable** state. These events need to be evaluated for risk and consequences. The WECC is currently drafting the "Extreme Contingency Guide" to provide additional guidance around this class of event.

This criteria applies to the system or path at its maximum load or loading condition based on the average MW flow over the highest load or path loading hour. "Planned or controlled interruption of electric supply to radial customers or some local network customers, connected to or supplied by the faulted element or by the affected area, may occur in certain areas without impacting the overall security or the interconnected transmission system."<sup>7</sup>

---

<sup>7</sup> NERC/WECC Planning Standards Table 1 page 25. footnote b)

Figure 4.1-1

NERC/WECC Planning Standards

I. System Adequacy and Security

A. Transmission Systems

Table I. Transmission Systems Standards — Normal and Contingency Conditions

Category	Contingencies		System Limits or Impacts				
	Initiating Event(s) and Contingency Element(s)	Elements Out of Service	Thermal Limits	Voltage Limits	System Stable	Loss of Demand or Curtailed Firm Transfers	Cascading <sup>e</sup> Outages
A - No Contingencies	All Facilities in Service	None	Applicable Rating <sup>a</sup> (A/R)	Applicable Rating <sup>a</sup> (A/R)	Yes	No	No
B – Event resulting in the loss of a single element.	Single Line Ground (SLG) or 3-Phase (3Ø) Fault, with Normal Clearing: 1. Generator 2. Transmission Circuit 3. Transformer Loss of an Element without a Fault. Single Pole Block, Normal Clearing : 4. Single Pole (dc) Line	Single	A/R	A/R	Yes	No <sup>b</sup>	No
		Single	A/R	A/R	Yes	No <sup>b</sup>	No
		Single	A/R	A/R	Yes	No <sup>b</sup>	No
		Single	A/R	A/R	Yes	No <sup>b</sup>	No
C – Event(s) resulting in the loss of two or more (multiple) elements.	SLG Fault, with Normal Clearing : 1. Bus Section 2. Breaker (failure or internal fault) SLG or 3Ø Fault, with Normal Clearing <sup>f</sup> , Manual System Adjustments, followed by another SLG or 3Ø Fault, with Normal Clearing : 3. Category B (B1, B2, B3, or B4) contingency, manual system adjustments, followed by another Category B (B1, B2, B3, or B4) contingency Bipolar Block, with Normal Clearing : 4. Bipolar (dc) Line Fault (non 3Ø), with Normal Clearing : 5. Any two circuits of a multiple Circuit towerline <sup>g</sup>	Single	A/R	A/R	Yes	No <sup>b</sup>	No
		Multiple	A/R	A/R	Yes	Planned/Controlled <sup>d</sup>	No
		Multiple	A/R	A/R	Yes	Planned/Controlled <sup>d</sup>	No
SLG Fault, with Delayed Clearing <sup>f</sup> (stuck breaker or protection system failure): 6. Generator 7. Transmission Circuit 8. Transformer 9. Bus Section	Multiple	Multiple	A/R	A/R	Yes	Planned/Controlled <sup>d</sup>	No
		Multiple	A/R	A/R	Yes	Planned/Controlled <sup>d</sup>	No
		Multiple	A/R	A/R	Yes	Planned/Controlled <sup>d</sup>	No

Figure 4.1-2

**NERC/WECC Planning Standards**

**I. System Adequacy and Security**

**A. Transmission Systems**

<p>D<sup>2</sup> - Extreme event resulting in two or more (multiple) elements removed or cascading out of service</p>	<p>30 Fault, with Delayed Clearing (stuck breaker or protection system failure)</p> <ol style="list-style-type: none"> <li>1. Generator</li> <li>2. Transmission Circuit</li> <li>3. Transformer</li> <li>4. Bus Section</li> </ol> <p>30 Fault, with Normal Clearing:</p> <ol style="list-style-type: none"> <li>5. Breaker (failure or internal fault)</li> </ol> <p>Other:</p> <ol style="list-style-type: none"> <li>6. Loss of towertline with three or more circuits</li> <li>7. All transmission lines on a common right-of-way</li> <li>8. Loss of a substation (one voltage level plus transformers)</li> <li>9. Loss of a switching station (one voltage level plus transformers)</li> <li>10. Loss of all generating units at a station</li> <li>11. Loss of a large load or major load center</li> <li>12. Failure of a fully redundant special protection system (or remedial action scheme) to operate when required</li> <li>13. Operation, partial operation, or misoperation of a fully redundant special protection system (or remedial action scheme) in response to an event or abnormal system condition for which it was not intended to operate</li> <li>14. Impact of severe power swings or oscillations from disturbances in another Regional Council</li> </ol>	<p>Evaluate for risks and consequences.</p> <ul style="list-style-type: none"> <li>• May involve substantial loss of customer demand and generation in a widespread area or areas.</li> <li>• Portions or all of the interconnected systems may or may not achieve a new, stable operating point.</li> <li>• Evaluation of these events may require joint studies with neighboring systems.</li> </ul>
---	--	--

**Footnotes to Table I.**

- a) Applicable rating (A/R) refers to the applicable normal and emergency facility thermal rating or system voltage limit as determined and consistently applied by the system or facility owner. Applicable ratings may include emergency ratings applicable for short durations as required to permit operating steps necessary to maintain system control. All ratings must be established consistent with applicable NERC Planning Standards addressing facility ratings.
- b) Planned or controlled interruption of electric supply to radial customers or some local network customers, connected to or supplied by the faulted element or by the affected area, may occur in certain areas without impacting the overall security of the interconnected transmission systems. To prepare for the next contingency, system adjustments are permitted, including curtailments of contracted firm (non-recallable reserved) electric power transfers.
- c) Cascading is the uncontrolled successive loss of system elements triggered by an incident at any location. Cascading results in widespread service interruption which cannot be restrained from sequentially spreading beyond an area predetermined by appropriate studies.
- d) Depending on system design and expected system impacts, the controlled interruption of electric supply to customers (load shedding), the planned removal from service of certain generators, and/or the curtailment of contracted firm (non-recallable reserved) electric power transfers may be necessary to maintain the overall security of the interconnected transmission systems.
- e) A number of extreme contingencies that are listed under Category D and judged to be critical by the transmission planning entity(ies) will be selected for evaluation. It is not expected that all possible facility outages under each listed contingency of Category D will be evaluated.
- f) Normal clearing is when the protection system operates as designed and the fault is cleared in the time normally expected with proper functioning of the installed protection systems. Delayed clearing of a fault is due to failure of any protection system component such as a relay, circuit breaker, or current transformer (CT), and not because of an intentional design delay.
- g) System assessments may exclude these events where multiple circuit towers are used over short distances (e.g., station entrance, river crossings) in accordance with Regional exemption criteria

## 4.2 Maintenance Standard for Planning the ATS

The NERC/WECC Planning Standard<sup>8</sup> requires that "... systems must be capable of meeting Category B requirements while accommodating the planned (including maintenance) outage of any bulk electric equipment (including protection systems or their components) at those demand levels for which planned (including maintenance) outages are performed." The AESO intends to meet the above standard with the exception of **Local Networks**. Due regard will be given to the ability to reduce the area load by running generation out of merit or moving distribution connected load to adjacent supply sources. The bulk electric equipment considered is limited to transmission circuits, transformers and protection systems.

## 4.3 Facility Design and Interconnection

The AESO has established and posted standards for the interconnection of load and generation facilities. With time the range of facility design and other technical standards will increase and evolve. Appendix A summarizes the current standards and will be updated as new standards emerge.

## 4.4 System Protection and Controls

**Remedial Action Schemes (RAS)** or **Special Protection Schemes (SPS)** are designed for specific foreseen events and shed load or generation to preserve system integrity. They may be used when the cost of additional facilities are not warranted on a cost versus benefit evaluation, when facilities can not be built in time, to shed opportunity loads or transactions, to increase operating limits beyond planning limits of system capacity, or when the frequency of the RAS triggering event is very low. The consequence of RAS failure must also be considered.

A RAS may be acceptable for an interim period to allow for generation or load interconnection pending completion of required transmission developments. Alternately, system conditions may be in transition whereby a transmission development may not be required in the longer term. The required system performance could be provided through the application of a RAS. Interim period, in this context, could be as long as it takes to complete the proposed transmission development. Good engineering and business judgment must be used when considering the benefits and risks of a RAS.

**Safety net systems** should be used to protect the system from events which are more critical than Category B. They have a characteristic of protecting the system from many different events by sacrificing some firm load to protect the system from uncontrolled outages over wider areas and promote faster restoration of the system. It is recognized that safety nets will not effectively protect the ATS from all Category D events. Safety net systems may well protect the system in the event of a Category B or greater event under abnormal or emergency conditions. Underfrequency and undervoltage load shedding schemes are examples of safety nets.

---

<sup>8</sup> Page 16

**Automatic reclosing systems** can have a positive impact on system reliability and are widely applied. System studies must pay due regard for existing or proposed reclosing systems.

**Single Pole Trip and Reclose (SPT&R)** is used within Alberta and on the B.C. Tie to enhance availability of transmission circuits. Application of SPT&R may be used to enhance reliability but does not increase system capabilities to withstand Category B events as these events include three phase faults.

**240 and 500 kV protections systems**, in Alberta, are designed to higher standards with the view to increasing the speed of fault clearing, reducing protection failures and preserving security of the ATS and its inerties.

#### 4.5 Point of Delivery (POD) Criteria

The WECC Reliability Criteria accepts that individual PODs may be supplied via a single radial transmission circuit and single transformers. Outages of radial elements will result in the loss of firm and/or opportunity load.

The customer may make arrangements with the AESO for additional supply facilities, such as second transformers, additional supply transmission lines or additional distribution supply circuit breakers as desired by the customer for reliability, financial or other reasons. Commercial arrangements for these additions will be those that apply from time to time.

The parts of the system upstream from the dedicated supply facilities will be designed to meet the Reliability Criteria.

Refer to the AESO's load interconnection standard for related design standards at [www.aeso.ca](http://www.aeso.ca).

#### 4.6 Point of Supply (POS) and Generation Surplus Area Criteria

NERC and the WECC do not have a standard regarding the loss of generation other than the impacts they would have on the remainder of the system such as overloads, voltage stability and loss of firm load including non-recallable transfers.

Loss of generation is acceptable for outages to the radial elements of the ATS interconnecting the generator. New radial generator interconnections that will exceed the MW equivalent of the existing or planned **largest single generation contingency** shall be evaluated for impact on the ATS. Consideration shall be given to, but not be limited to, impact on interchange capacities, generation reserve requirements and system dynamic response.

In generation rich areas, RASs designed to achieve full generation output are not acceptable in the long term for Category B events. Due consideration shall be given to light load conditions.

Refer to the AESO's generator interconnection standard for related design standards at [www.aeso.ca](http://www.aeso.ca).

## 5.0 Performance Standards

Performance standards relate to how the system responds to normal or contingency events and are measured in voltage or voltage change, thermal loading, stability or off frequency Voltage Limits.

### 5.1 Voltage Standards

The ATS must be capable of steady state operation within acceptable voltage ranges during normal and abnormal conditions. In areas where there are concerns such as voltage stability or over voltages, more restrictive voltage ranges may apply. Table 5.1-1 below summarizes the acceptable ranges of steady state voltage for each nominal voltage class. These classes are established to ensure that equipment in each nominal voltage range is specified according to a standard that allows for equipment standardization and interchangeability.

**Table 5.1-1 Acceptable Range of Steady State Voltage (kV)**

Nominal	Extreme Minimum	Normal Minimum	Normal Maximum	Extreme Maximum
500	500	510	540	550
240	220	240	264	264
240 Ft. McMurray, Northwest	220	250	269	275
144	130	137	151	155
138	124	135	145	150
72	65	71	75	78
69	62	65	72	74

Extreme maximum voltages are voltages above which TFO's become concerned with exceeding maximum equipment ratings and high supply voltages to end use customers. The ATS must be capable of operating below the extreme maximum voltage following a Category B event on a reasonably expected system precondition.

Extreme minimum voltages are voltages below which TFO's may not be able to supply adequate voltages to end use customers. The ATS must be capable of operating above the extreme minimum voltage following a Category B event on a reasonably expected system precondition.

The ATS must be capable of operating within the extreme maximum and extreme minimum voltages as described above after adjustment have been made to generators, on load tap changer transformers and reactive compensation devices.

The normal maximum to minimum voltage range represent desired or typical operating voltages taking into account over and under voltage conditions at remote busses under normal and post contingency conditions.

The Fort McMurray and Northwest areas of the ATS were interconnected via long, lightly loaded 240 kV lines. The areas operated at higher voltages than the remainder of the 240 kV system and equipment was installed with higher voltage capability. These areas will continue to operate at higher level into the foreseeable future.

The standard summarized in Table 5.1-1, will not be applied retroactively. Equipment ratings must be respected by planning and operating the system to avoid overstressing legacy equipment. Legacy equipment may limit the ability to plan or operate the ATS to the extreme voltage limits.

While Table 5.1.1 presents acceptable steady state voltages after automatic and manual adjustments, Table 5.1-2 below, presents the acceptable post contingency voltage change limits for three defined post event time frames. This standard is used in conjunction with the “NERC/WECC Planning Standard Table 1.”

The “Low Voltage Bus” in Table 5.1-2 refers to the interface point between the ATS and load customers including distribution system supply points which are generally 25 kV or less. The voltage drop standards apply to Category B events while the voltage rise standards apply to events such as switching single system elements or Category B events.

**Table 5.1-2 Acceptable Post Contingency Voltages**

Parameter and Reference Point	Time Period		
	Post Transient (Up to 30s)	Post Auto Control (30 sec to 5 min)	Post Manual Control (Steady State)
Voltage Deviation from Steady State at POD Low Voltage Bus	± 10%	± 7%	± 5%

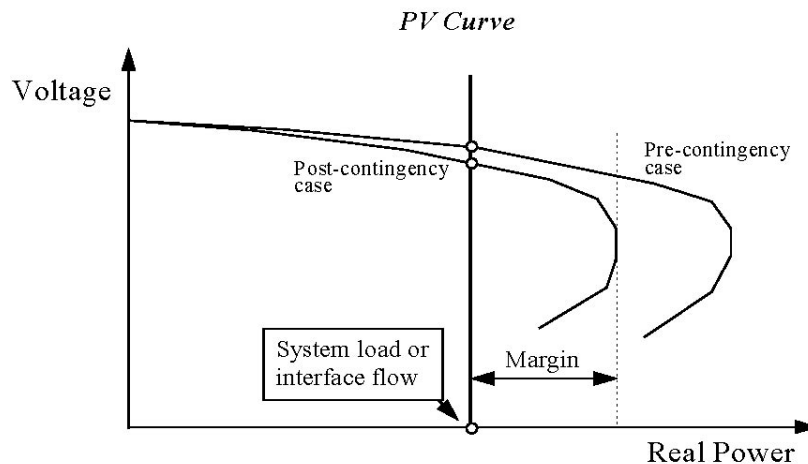
For the purpose of this standard, the post transient period is the time up to 30 seconds after an event and generally prior to the automatic tap changing or switching operations. The post automatic control period is the time after the post transient period and before manual control and adjustments to the system are made. Post manual control is the period of time after system operators have been able to make manual adjustments to the system.

Following a Category B or C event, and after manual control adjustments, the ATS must be able to operate within the voltages defined in Table 5.1-2. In some cases variations from Table 5.1-2 are allowed and defined in AESO operating procedures or system design specifications.

## 5.2 Voltage Stability Criteria

Figure 5.2.1 below shows the power voltage curves for pre and post-contingency system conditions. This figure can be used as a guide to understanding and measuring the WECC voltage stability criteria.

Figure 5.2-1 Voltage Stability – PV Analysis



The WECC voltage stability criteria states, "for load areas, post-transient voltage stability is required for the area modeled at a minimum of 105% of the reference load level for system normal conditions (Category A) and for single contingencies (Category B). For multiple contingencies (Category C), post-transient voltage stability is required with the area modeled at a minimum of 102.5% of the reference load level. For this standard, the reference load level is the maximum established planned load. Table 5.2-1 below is taken from the WECC Voltage Stability Criteria, Undervoltage Load Shedding Strategy, and Reactive Power Reserve Monitoring Methodology dated May 1998 and summarizes the Power Voltage (P-V) and Reactive Power (V-Q) margin requirements.

Table 5.2-1 Voltage Stability Criteria

Table 1

WSCC VOLTAGE STABILITY CRITERIA<sup>(\*)</sup>

Performance Level	Disturbance (1)(2)(3)(4) Initiated By: Fault or No Fault DC Disturbance	MW Margin  (P-V Method)  (5)(6)(7)	MVAR Margin  (V-Q Method)  (6)(7)
A	Any element such as: One Generator One Circuit One Transformer One Reactive Power Source One DC Monopole	≥ 5%	Worst Case Scenario (8)
B	Bus Section	≥ 2.5%	50% of Margin Requirement in Level A
C	Any combination of two elements such as:  A Line and a Generator A Line and a Reactive Power Source Two Generators Two Circuits Two Transformers Two Reactive Power Sources DC Bipole	≥ 2.5%	50% of Margin Requirement in Level A
D	Any combination of three or more elements such as: Three or More Circuits on ROW Entire Substation Entire Plant Including Switchyard	> 0	> 0

- (1) This table applies equally to the system with all elements in service and the system with one element removed and the system readjusted (see Section 2.2).
- (2) For application of this criteria within a member system, controlled load shedding is allowed to meet Performance Level A (see Section 2.2 for a description of provisions for application of this criteria within a member system).
- (3) The list of element outages in each Performance Level is not intended to be different than the Disturbance Performance Table in the WECC Reliability Criteria. Additional element outages have been added to this table to show more examples of contingencies. Determination of credibility for contingencies for each Performance Level is based on the definitions used in the existing WECC Reliability Criteria.
- (4) Margin for N-0 (base case) conditions must be greater than the margin for Performance Level A.
- (5) Maximum operating point on the P axis must have a MW margin equal to or greater than the values in this table as measured from the nose point of the P-V curve for each Performance Level.
- (6) Post-transient analysis techniques shall be utilized in applying the criteria.
- (7) Each member system should consider, as appropriate, the uncertainties in Section 2.3 to determine the required margin for its system.
- (8) The most reactive deficient bus must have adequate reactive power margin for the worst single contingency to satisfy either of the following conditions, whichever is worse: (i) a 5% increase beyond maximum forecasted loads or (ii) a 5% increase beyond maximum allowable interface flows. The worst single contingency is the one that causes the largest decrease in the reactive power margin.
- (\*) Table 1 is an excerpt from the WSCC Reliability Criteria for Transmission System Planning in effect at the time of this document's approval. The most current version of the Council's Table of Allowable Effects on Other Systems should be referred to when conducting studies.

### 5.3 Voltage Swing Criteria

The Voltage Swing Criteria as presented in the NERC/WECC Reliability Standard<sup>9</sup>, shall apply at both ends of the interconnections between the WECC and Alberta for Category B events. This criteria does not apply to other parts of the ATS.

The WECC voltage dip criteria require that “a single element outage in one system shall not cause a transient voltage dip in another system that is greater than 20% for more than 20 cycles at load buses, or exceed 25% at load buses or 30% at non-load buses at any time other than during the fault.” Figure 5.3-1 shows the typical voltage performance that manifests on interconnections between major systems such as the B.C. Tie. This figure provides guidance around interpreting the magnitude and duration of voltage swings in comparison to the criteria.

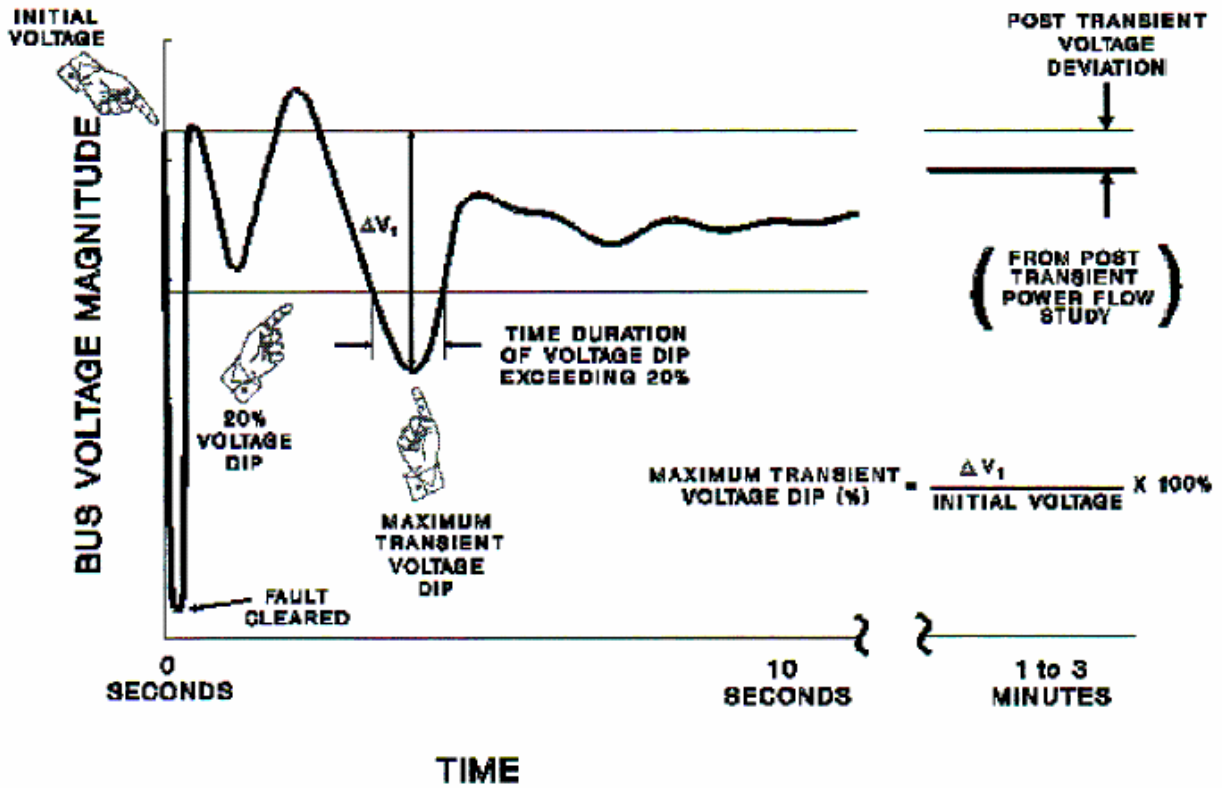
For faults on either system there is a voltage drop during the fault followed by a power and voltage swing on the path after the fault is cleared. In the extreme the swing will grow and the two systems will go out of synchronism. The protective relaying will monitor the condition and take the intertie out of service to prevent equipment damage or cascading outages of other system elements. This phenomenon, if not controlled, can lead to wide spread system failures.

Table W-1 titled WECC Disturbance-Performance Table of Allowable Effects on Other Systems is included below in Figure 5.3-2. It summarizes the voltage swing effects that a system may have on another system for single contingency events.

---

<sup>9</sup> Table W-1 WECC Disturbance –Performance Table of Allowable Effects on Other Systems

Figure 5.3-1 Voltage Performance Parameters



**Figure 5.3-2 WECC Disturbance-Performance Standard**

**NERC/WECC Planning Standards**

**I. System Adequacy and Security**

**A. Transmission Systems**

**WECC DISTURBANCE-PERFORMANCE TABLE  
OF ALLOWABLE EFFECTS ON OTHER SYSTEMS**

NERC and WECC Categories	Outage Frequency Associated with the Performance Category (outage/year)	Transient Voltage Dip Standard	Minimum Transient Frequency Standard	Post Transient Voltage Deviation Standard (See Note 2)
A	Not Applicable	Nothing in addition to NERC		
B	≥ 0.33	Not to exceed <b>25%</b> at load buses or <b>30%</b> at non-load buses.  Not to exceed <b>20% for more than 20 cycles</b> at load buses	Not below <b>59.6</b> Hz for 6 cycles or more at a load bus.	Not to exceed <b>5%</b> at any bus.
C	0.033 – 0.33	Not to exceed <b>30%</b> at any bus.  Not to exceed <b>20% for more than 40 cycles</b> at load buses.	Not below <b>59.0</b> Hz for 6 cycles or more at a load bus.	Not to exceed <b>10%</b> at any bus.
D	< 0.033	Nothing in addition to NERC		

**Notes:**

- The WECC Disturbance-Performance Table applies equally to either a system with all elements in service, or a system with one element removed and the system adjusted.*
- As an example in applying the WECC Disturbance-Performance Table, a Category B disturbance in one system shall not cause a transient voltage dip in another system that is greater than 20% for more than 20 cycles at load buses, or exceed 25% at load buses or 30% at non-load buses at any time other than during the fault.*
- Additional voltage requirements associated with voltage stability are specified in Standard I-D. If it can be demonstrated that post transient voltage deviations that are less than the values in the table will result in voltage instability, the system in which the disturbance originated and the affected system(s) should cooperate in mutually resolving the problem.*

**Table W-1**

## 5.4 Thermal Loading

The continuous thermal rating of any transmission element shall not be exceeded under normal operating conditions.

The emergency overload rating of any transmission element shall not be exceeded for a loss of one transmission element. The system shall be capable of returning to normal equipment load levels without the loss of load.

TFOs have the accountability for identifying the maximum loading that their equipment can safely withstand for various conditions.

## 5.5 Off-Nominal Frequency

Alberta complies with the WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Plan.

The WECC plan may be supplemented with additional load subject to underfrequency tripping to achieve specific performance goals.

Category B and C events or the loss of the B.C. Tie shall not result in a system frequency over 61.0 HZ. The overfrequency must settle to less than 60.3 Hz quickly enough to avoid uncoordinated generator tripping in Alberta.

## 5.6 Short Circuit Levels and Circuit Breaker Capacities

Circuit Breakers shall be capable of interrupting 100% of maximum short circuit duty that a circuit breaker could experience with all generation on and all system available.

## 6.0 Power System Modeling

The AESO sponsors the Alberta Transmission Data Committee (TDC) whose role is to continuously improve the AIES model and validate the models against system performance. The TDC document titled "Transmission Modeling Data Requirements" is posted at [www.aeso.ca](http://www.aeso.ca).

### 6.1 System Model

The ATS shall be modeled with as much accuracy as necessary to ensure that the response of the ATS to disturbances can be accurately determined and current and future short circuit levels can be assessed. The model shall include, but not be limited to, representations of generators, transmission lines, transformers, capacitors, reactors, power control equipment, control systems, loads and interconnections.

### 6.2 System Load

The ATS will be designed to supply forecast peak load and peak flows based on a forecast of MWh/hour in a normal weather year.

There are elements or paths of the system that may need to be designed to accommodate peak loads that are substantially higher when measured over shorter durations.

The loads to be used for specific geographic areas are the expected forecast coincident peak loads for load areas.

The loads to be used for generation surplus areas may be the light or peak loads. The system shall be planned for the most onerous reasonable load and generation conditions.

The system will be planned to accommodate long term firm contracts for interchanges to other jurisdictions.

Operational loads will be based on one-minute values unless otherwise stated.

### 6.3 Load Model

Individual motors over 10 MW are modeled. Where an aggregate of motor loads are deemed to effect system performance the aggregated motors are modeled.

For dynamic studies, the remainder of the load is modeled using the WECC default model of 20% induction motor load with the remaining load of 100% constant current and 100% constant impedance for real and reactive components of AB load respectively. When a more accurate model is developed and correlated with system experience, the new model may be used for either the ATS or parts of the ATS.

For load flow studies a constant MVA model shall be used.

## 6.4 Clearing Times

Studies shall be done with the actual or specified clearing times of existing systems whichever is slower. No intentional safety margins or time delays will be added. Table 6.4-1 presents a set of maximum clearing times for each voltage level. Systems where clearing times are slower than this standard shall be examined to ensure system security is not compromised.

Faster clearing times can be employed provided they are achievable and verified

**Table 6.4-1 Standard New System Clearing Times**

Nominal kV	Fast End Cycles	Slow End Cycles
500	4	5 to 6
240	5	6 to 7
144	6	7 to 8
138	6	7 to 8
72 & 69	No established standard	

The intent of Table 6.4-1 is to indicate the maximum clearing times to be employed on additions to the system. Actual equipment ratings are used in system studies unless experience indicates otherwise.

These clearing times are intended to represent periods when short circuit levels are high due to generation dispatch patterns along with near to station bolted three phase or single phase faults.

## Appendix A Applicable Criteria and Guides

The following is a list of documents the AESO complies with or is guided by when planning developments to the ATS.

### AESO complies with:

- EU Act and Transmission Regulation (The Government of Alberta, Queen's Printer at [www.qp.gov.ab.ca](http://www.qp.gov.ab.ca))
- HEE Act and regulations(The Government of Alberta, Queen's Printer at [www.qp.gov.ab.ca](http://www.qp.gov.ab.ca))
- WECC Reliability Criteria, including the NERC/WECC Planning Standard (The WECC at [www.wecc.biz](http://www.wecc.biz))
- WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Plan (Contact the WECC or AESO)
- ISO Rules and Operating Policies (The AESO at [www.aeso.ca](http://www.aeso.ca))
- Reliability Management System Agreement with the WECC (The AESO at [www.aeso.ca](http://www.aeso.ca))

### AESO uses the following guides:

- Undervoltage Load Shedding Guide (The WECC at [www.wecc.biz](http://www.wecc.biz))
- Voltage Stability Criteria, Undervoltage Load Shedding and Reactive Reserve Monitoring Methodology (The WECC at [www.wecc.biz](http://www.wecc.biz))
- WECC Policy Regarding Extreme Contingencies and Unplanned Events (The WECC at [www.wecc.biz](http://www.wecc.biz))
- Transmission Data Committee - Transmission Modeling Data Requirements

### AESO applicable standards:

- Technical Requirements for Connecting to the Alberta Interconnected Electric System (IES) Transmission System Part 1 Technical Requirements for Connecting Generators, Part 2 Technical Requirements for Connecting Loads, Part 3 Technical Requirements for Connecting Transmission Facilities and are available at [www.aeso.ca](http://www.aeso.ca). The title of this standard will be updated in Section 4.5 and Appendix A. (at [www.aeso.ca](http://www.aeso.ca))
- Alberta Interconnected Electric System Protection Standard (at [www.aeso.ca](http://www.aeso.ca))