

702 VOLTAGE CONTROL

1. Purpose

To provide consistent voltage control guidelines for the Alberta Interconnected Electric System (AIES) and operating policy for all parties concerned with voltage control, including the transmission facility owners (TFOs), generation facility owners (GFOs) and the system controller (SC).

2. Background

Several different TFOs own and operate transmission facilities, including voltage control devices, in the AIES. GFOs throughout the province participate in voltage stability and control. The SC is responsible for the overall reliability of the AIES and TFOs and GFOs are responsible for their equipment. Therefore, voltage control must be a cooperative and coordinated effort, under the overall direction of the SC.

The AIES voltage is controlled through various methods including:

- Adjusting generator terminal voltage.
- Switching capacitor banks and reactors.
- Transformer tap changes.
- Static VAR compensators.
- Adjusting transmission must run (TMR) levels.
- Line switching.

Nominal transmission operating voltage levels across the province include 500 kV, 240 kV, 144 kV and 138 kV, and , 72 kV and 69 kV.

2.1 Operating voltage definitions

The definitions of minimum operating voltage, desired operating voltage range and maximum operating voltage are provided here for easy reference.

Minimum operating voltage

Minimum operating voltage at a substation bus is defined as the lowest voltage at which the bus can be operated on a continuous basis and meet the reliability criteria.

Minimum operating voltages listed in [Table 1](#) are determined by engineering studies using the AESO Transmission Reliability Criteria (<http://www.aeso.ca/rulesprocedures/8677.html>) to ensure B type (loss of single element) and C type (loss of two or more elements) contingency criteria of voltage deviation and voltage stability limits are met in real-time operation at peak load conditions.

Maximum operating voltage

Maximum operating voltage at a substation bus is the highest voltage level at which the substation bus can be operated on a continuous basis without violating equipment voltage ratings of the substation.

Desired Operating Voltage

Desired operating voltage at a substation bus is the optimum voltage range that will reduce system losses and improve system stability.

3. Policy

3.1 General

- The AIES must have sufficient reactive resources within its boundaries to protect the voltage levels under first contingency conditions.
- Maximum voltage violations must be removed immediately.
- Capacitive and inductive reactive resources will be operated to maintain system and interconnection voltages within established limits.
- When reactive resources are insufficient to prevent voltage collapse, necessary corrective action will be taken, including load reduction.
- Voltage adjustments in one area may have effects throughout the system and therefore must be coordinated by the SC with GFOs and TFOs affected by the adjustment.
- Voltage adjustments on a weak or lightly loaded system have greater impact than on a strong or normally loaded system.
- To reduce the risk of system instability, minimize line losses and be best prepared for contingencies, voltage levels are preferred to be in the upper end of the desired operating voltage ranges during heavy load periods.
- Voltages should be raised before system load pick up for most effective use of reactive resources.
- If voltages fall below the desired range, the following actions will be taken:
 - Dispatch capacitor banks on and/or reactors off in the area.
 - Dispatch transformer taps.
 - Direct GFOs in the area to raise voltage set points.
 - Cancel outages that would impact the low voltages.

After taking the above steps but the voltages still fall below the minimum operating limit, real-time action should follow immediately to restore voltages above the minimum and within the desired range through:

- Curtailing opportunity services, export and/or DOS.
- Issuing TMR.
- Shedding firm load.
- Accepting the operation of UVLS in post contingency.

- If voltage rises above the desired range or the maximum operating limit, real-time action must follow immediately to bring the voltage within the desired range. Possible actions may be:
 - Dispatching capacitor banks off and/or reactors in service in the area.
 - Directing GFOs in the area to lower their voltage set points.
 - Dispatching transformer taps down.

3.2 Voltage adjustment methods

Generator voltage adjustment

Generators must be capable of operating continuously in automatic voltage regulation mode between the generating unit's lagging and leading reactive power obligations.

Generator automatic voltage regulators must be capable of maintaining voltage at the generator interface as prescribed in the AESO Generation and Load Interconnection Standards.(the "interface" is the generator terminals for synchronous generators and low voltage side of the system step-up transformer for wind power facilities) The transmission connected generating units must operate with their excitation system in voltage regulation mode and must not adjust their voltage settings without first advising the SC. Note that control modes such as Power Factor control or Constant VAr control are not permitted.

To adjust system voltages the SC will direct GFOs to raise or lower their voltage by a specific amount using either the generator transformer OLTC (On-Load Tap Changer) or adjusting the generator interface voltage. This action will result in a change in VAr output from the generator. The SC will ensure the desired voltage level is attained. It is also desirable to balance VAr's proportionately, based on MCR, between generators located in close electrical proximity. To achieve this balance, generator terminal voltages should be adjusted simultaneously so that increasing VAr output on one generator does not cause an adjacent generator to reduce VAr output and vice versa.

Under normal operating conditions and subject to any operating agreements with the AESO, the SC will direct voltage such that reactive power is within the unit obligation or within 0.9 power factor lagging and 0.95 power factor leading based on gross MW output of generating units.

During disturbances or emergencies that cause system voltage to change, the automatic voltage regulators (AVR) will cause generators to respond and this may mean providing VAr's up to the generating units reactive power capability. The GFO must not adjust the AVR setting without first advising the SC. The SC will assess system conditions before approving or denying the adjustment.

System voltage adjustment can be accomplished through a coordinated change in generation plant voltage levels. For example, the Wabamun area generators and the Battle River-Sheerness generators are adjusted in relation to the system load curves in each of their areas.

Local voltage adjustments can be accomplished by adjusting smaller generators connected in the area. Adjusting these generator voltage levels for short-term voltage requirements helps to reduce switching transients created by reactor or capacitor switching devices by minimizing switching operations. However, it is important that the generators are still able to supply dynamic reactive reserves and this must be considered when adjusting these units for voltage control.

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The SC will issue directives for generator voltage adjustments directly to the generator operator. It is preferred that the SC directs generators to adjust their voltage level rather than their VAR output so that confusion about the generator control modes is avoided.

Reactor and capacitor switching

The SC will request the TFO to switch a capacitor or reactor in or out to adjust the area voltage. The TFO will initiate discussion with the SC if the TFO identifies a need for voltage adjustment on its or an adjacent system. The SC will assess the need based on the overall system voltage and immediate or upcoming events of which the SC is aware. If the SC does not agree with the need for the adjustment the SC will provide an explanation to the TFO.

Closing capacitors can cause switching transients. Some capacitor banks have zero crossing breakers or pre-insertion reactors to minimize switching transients so they are the preferred capacitors to use to control voltages.

To reduce reactive power circulation, reactors and capacitors in the same vicinity or in adjacent substations should not be put on at the same time.

Avoiding situations where reactors or capacitors are countering the VAR output of a generator helps to reduce VAR circulation and line losses.

It is desirable to allow time between reactor-capacitor switching for the distribution tap changers to adjust. This helps to avoid voltages that are too high or too low on the distribution systems.

Minimizing the number of operations on a reactor or capacitor breaker reduces the system exposure to switching transients.

Tap changer adjustments

Generally, the raising of taps on a transmission tie transformer will raise the voltage on the low side and lower the voltage on the high side of a transformer. Lowering taps will do the opposite.

Transmission must run levels

TMR generators are usually dispatched to minimum TMR levels for area reliability. However, if voltages cannot be maintained within acceptable limits and generator VAR adjustments, reactor and capacitor switching and tap changer adjustments have all been exhausted, then TMR levels can be increased to help support the voltage.

Langdon static VAR compensator (SVC)

The reactive capability of the SVC to provide reactive power into the T102s Langdon 240 kV bus is +200 MVAR to -300 MVAR. (The SVC reactive equipment is installed at 20 kV and its actual capability at the 20 kV is ± 250 MVAR) In order to maintain reliable operation in the Calgary area, dynamic reactive reserves are required as identified in OPP 510. To provide the required dynamic reactive reserves and minimize internal losses, the SVC is to be operated within an operating range of 0 MVAR and -50 MVAR during normal system operating conditions.

The SVC voltage set point is normally to be set to 253 kV to maintain the Langdon (T102S) 240 kV voltages within the desired range.

When the SVC is out of service the Calgary Area 240kV voltages are to be kept close to the high limit of the operating voltage range, refer to [Table 1](#). This will help to reduce the MVAR output from the Calgary area generators and increase the available dynamic reserve capability.

Emergency response and voltage limit violation

In emergency situations, such as transmission or generation contingencies, when personnel safety or system reliability are at risk, the TFO may take necessary voltage control action to return the voltage to within limits without contacting the SC. The SC must be notified as soon as possible after the action is taken.

Following a contingency or other event that results in a voltage limit violation, the voltage must be returned to within the desired range as soon as practical. If the minimum or maximum voltage limit is violated, it must be returned to within the operating range as soon as possible.

3.3 Voltage adjustment areas

Voltage control devices that have unique operating characteristics or that are required to be switched in a specific order are discussed in the subsequent paragraphs. All voltage control devices are listed in [Table 2](#).

To facilitate description of voltage control, the AIES has been divided into the geographic and electrical areas listed in the subsequent sections. These areas are not independent of each other. Operations in one area can affect voltage in one or more of the other areas.

Southern area

The voltage in Southern Alberta is influenced by several factors. They include a comparatively weak transmission system, consisting of mainly 138 kV and 69 kV lines. There is very little synchronous generation in the area. Heavy irrigation loads in the summer also contribute to lower voltage. For these reasons, capacitor bank installations are predominant throughout the southern area. AltaLink controls all of the capacitors and reactors in the southern area except for the Medicine Hat capacitors, which are controlled by the City of Medicine Hat.

The following guidelines are for switching capacitor banks in the Southeast area:

- Switch on the Taber T83S capacitor bank 83S61 before 83S67 as 83S61 is not equipped to control transients. Do not close 83S61, if 83S67 is already closed.
- Switch on Burdett T368S capacitor bank 368S35 before 368S44 as 368S35 is not equipped to control transients. Do not close 368S35, if 368S44 is already closed.
- During summer, one capacitor bank at Taber T83S and one at Burdett T368S may be required at all times.
- Switch capacitor bank 523S33 as required at Bullshead T523S.
- Medicine Hat 41S capacitor banks can be switched in service to support Medicine Hat 41S 138 kV bus depending on City of Medicine Hat (CMH) load.

If different switching order is required in real-time for Southeast cap banks, SC will consult AltaLink operator and develop a joint strategy for managing voltages in the area.

The 27 MVar capacitors at Blackie (T253S) and Canmore (T118S) have pre-insertion reactors for transient control.

To prevent 727L line from reclosing on a trapped charge, the Magcan (T142S) capacitor has an under voltage trip setting of 55 kV for two seconds. If the capacitor is tripped due to under voltage, it will be locked out for 10 minutes.

If both Sheerness units are off line it may be necessary to switch on the West Brooks (28S) reactor.

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The City of Medicine Hat has one 9 MVAR and two 7.2 MVAR capacitors available for voltage control. They are typically used during the summer to support the voltage during the irrigation season.

ATCO Electric can adjust the McNeill converter station voltage set point so that VARs are either absorbed from or sent to Amoco Empress (T163S).

Refer to [OPP 503](#) for guidelines on when the Amoco Empress T163S capacitor banks are to be put into service.

BC Transmission Corporation (BCTC) has the capability to adjust both 500 kV at Cranbrook and 138 kV at Natal. The Burnaby dispatch centre must be called for 500 kV adjustments and the South Interior Control Centre for 138 kV adjustments. In abnormal situations, such as transmission outages in the southern portion of Alberta, the SC may choose to call on BCTC for voltage support.

Wind farms are becoming more common throughout the southern area. The wind generators have a significant effect on voltage due to their tendency to absorb VARs and the high variance in MW output. Refer to [OPP 515](#) for detailed operating policies and procedures on the issues of voltage control in this area.

A Wind Voltage-Amp-Reactive (WindVAR) electronic device has been installed at the Garden City substation 226S which sends a signal to the Magrath wind turbines to supply or absorb reactive power to and from the grid, as when needed. Through the WindVAR, the voltage is controlled and regulated in real-time.

To maintain voltage fluctuations within tolerance for the Summerview wind farm collector bus, six 6.6 MVAR independently switched capacitor banks and an 8 MVAR Dynamic VAR (D-VAR) voltage regulation system have been installed at the Summerview substation 354S for voltage control.

Calgary area

The Calgary area voltage is influenced by several system factors, such as city and area load, imports and exports and area generation MW output. The voltage is adjusted by the Langdon (T102S) SVC, switching AltaLink and ENMAX capacitor banks, adjusting transmission tie transformer tap settings and adjusting area generator MVAR output.

Janet (T74S) has two 138 kV 81 MVAR capacitor banks controlled by circuit switchers 74S54 and 74S56. There is an interlock that prevents 74S56 closure if 74S54 is already closed. Circuit switcher 74S54 has a pre-insertion reactor to prevent switching transients.

There are generators in the Calgary area that can help control voltage by adjusting their VAR output. These include Balzac, Cavalier, Carseland and Calpine. VARs on the Bow Hydro can also impact the Calgary area voltage. Except for Bow Hydro, the SC will issue voltage support directives directly to these plants. Voltage support directives for Bow Hydro must be issued to the TransAlta generation operator.

Calpine is an LBC SO (Location Based Credits Standing Offer) generator (see OPP 513 LBC SO Generator Utilization for Transmission Reliability). LBC SO generators must be capable of 0.85 lagging to 0.95 leading power factor.

Adjusting local generation voltage levels and/or the SVC for short term voltage requirements instead of switching capacitors or reactors is preferred as this minimizes breaker maintenance. For example, if a voltage adjustment is required in the Calgary area while the interchange with BC is ramping, adjustment of a local generator voltage level could save switching a capacitor in for a short period before switching it out.

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The capacitor at Strathmore T151S is required when 765L (Janet T74S – Strathmore T151S) is out of service and the generation at Cavalier is off. Switching the capacitor under these conditions will cause an 8.5% voltage change at Strathmore T151S. The capacitor should therefore be switched on prior to removing 765L from service for a planned outage.

There are two 130 MVAR capacitor banks at Janet and two 100 MVAR capacitor banks at Sarcee. Guidelines for switching these 240 kV capacitor banks are listed below:

Guidelines for switching 240 kV capacitor banks:

1. Under normal system operating conditions, one 240 kV capacitor bank at Sarcee (T42S) should be switched on before either of the 240kV banks at Janet (T74S). After the first capacitor is switched on at Sarcee (T42S), then a capacitor at either Janet (T74S) or a second capacitor at Sarcee (T42S) can be switched on as operating conditions require.
2. The following are general guidelines for determining when to switch a Calgary area capacitor bank:
 - Maintain SVC within the operating range, refer to section on SVC.
 - Maintain voltage levels at substations in the Calgary area within the desired range as listed in [Table 1](#).
 - If there are high MVAR flows between the 240 kV and 138 kV systems at a substation in the Calgary area, then consider switching capacitor bank(s) to reduce this flow when system conditions allow. For example, to reduce high MVAR flows from the 240 kV system into the 138 kV system at E. Calgary (T5S) consider switching on the 138 kV capacitor(s) at E. Calgary (T5S).
3. In general, if a voltage adjustment is required on the 240 kV system, then switch a 240 kV capacitor bank and if a voltage adjustment is required on the 138 kV system, then switch a 138 kV capacitor bank. Further system adjustments may be necessary after either one 240 kV or one 138 kV cap bank is switched on.
4. If a 240 kV capacitor bank needs to be switched on, first switch off a minimum of 50 MVAR of 138 kV capacitor banks in the Calgary area and then switch on a 240 kV capacitor bank.
5. If a 240 kV capacitor bank needs to be switched off, first switch off one 240 kV capacitor bank and then switch on 50 MVAR or more of 138 kV capacitor banks in the Calgary area.
6. When the SVC is out of service, and a 240 kV capacitor bank is required to be switched on, then the following will be performed within 20 minutes:
 - a. switch off 138 kV capacitor banks and adjust transformer taps as necessary to achieve voltage levels of 237 – 239 kV on the Janet T74S 240 kV bus and 135 – 137 kV on the Janet T74S 138 kV bus and
 - b. switch on a 240 kV capacitor bank.

With the Langdon SVC out of service, switching one 240 kV bank at Sarcee (T42S) or Janet T74S will raise the 240 kV voltage in the Calgary area by no more than 10 kV and the 138 kV voltage by no more than 5 kV.

With Langdon SVC in service, switching one 240 kV bank at Sarcee (T42S) or Janet (T74S) will raise the 240 kV voltage in the Calgary area by no more than 3 kV and 138 kV voltage by no more than 2 kV.

Voltage Management at Key Busses of the SOK-240 Cut Plane

If minimum voltage levels are violated at any of the SOK-240 busses (T310P, T320P, T89S, T63S, T17S, T42S, T74S and T102S) after all normal voltage control actions have been taken, then assess if the following guidelines will help remove the violation. If so, then implement the guidelines consecutively as needed.

Note: It may be necessary to implement the guidelines out of sequence to meet the operating criteria. Should this occur, return to and complete the skipped guidelines when the limit violation has been removed.

- Curtail exports on the Alberta- BC interconnection and on the Alberta – Saskatchewan interconnection on a pro-rata basis based on actual schedule.
- Curtail demand opportunity service (DOS) loads that are located downstream of the SOK-240 kV cut plane (refer to Figure 1 in OPP 521).
- Dispatch Calgary area generators for TMR in accordance with Section C of Appendix A in [OPP 510](#).
- Issue directives to Calgary Area generators for TMR in accordance with Section 5.4 of [OPP 510](#).
- Reduce SOK-240 flow in accordance with [OPP 521](#).
- If minimum voltage levels are still violated then consider other actions to remove the violation including the curtailment of firm load.

When operating conditions permit return to normal operation in the reverse order of these guidelines

South-central area

Battle River and Sheerness generating stations are major influences on the area voltage. Voltage control is achieved by adjusting the unit terminal voltage or the unit OLTCs. Battle River 3 and 4 are generally used for 144 kV voltage adjustments, while Battle River 5 and the Sheerness units adjust the 240 kV voltage. Normally, area voltages are adjusted toward the top of the desired operating range during heavy load periods and adjusted toward the lower part of their range during lower load periods.

The Sunken Lake (T221S) capacitor breaker is not equipped to control transients; therefore, if possible, it should be left closed. Instead, the Hardisty (T377S) capacitor may be switched as required since it has a zero crossing breaker for transient control.

To prevent 749L line from reclosing on a trapped charge, Killarney Lake (T267S) capacitors have an under voltage trip setting of 97 kV for two seconds. If the capacitors are tripped due to under voltage they will be locked out for 10 minutes.

The SC must coordinate Hardisty, Killarney Lake, Lloydminster (A716S) and Hill (A751S) capacitor switching between AltaLink and ATCO Electric because of the effect the switching will have on the adjacent TFO voltages.

Strachan (T263S), Harmattan (T256S) and Violet Grove (T283S) have one 27 MVAR capacitor each and they are equipped with zero-crossing breakers for transient control. Brazeau hydro and Joffre co-generation can influence voltage by adjusting their generator VAR output.

Big Horn hydro has limited VAR adjustment capabilities.

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Wabamun area

As a minimum, the Wabamun area generators voltage control should be adjusted to achieve area voltages towards the upper end of the desired operating voltage range before the morning load peak and generator voltage control moved down after the evening load peak. The Northwest, Edmonton and Calgary rely on this voltage adjustment for proper voltage levels.

Voltage adjustments must be coordinated between generators to avoid VAR adjustments on one generator being compensated for by an automatic adjustment on an adjacent generator. It is important that VARs are proportionately balanced between plants. Also, due to the far reaching impact on area voltages TFOs should be consulted before adjusting these voltages.

Edmonton area

The Lamoureux (I71S) and East Edmonton (I38S) capacitor banks are equipped with zero-crossing breakers for transient control. The Fort Saskatchewan capacitor is switched by a circuit switcher with a pre-insertion reactor for transient control.

Northeast area

Operating in the 264 to 269 kV range at Ruth Lake (A848S) offers the best post contingency voltage. The upper end of the range is preferred.

Over voltage protection is applied to 9L990, 9L57/56 and 9L22/9L55/9L07 terminals.

Ruth Lake has three reactors available for voltage control, including one 20 MVAR and two 5 MVAR reactors. Line connectable reactors also exist at Ruth Lake (909R 35 MVAR) and at Dover (916R 40 MVAR). These reactors are used primarily for the purpose of line energization but can also be used for system voltage control as required. Reactors and tap changers are the preferred method of voltage adjustment in the area. There are also four GFOs in the area that can adjust VARs on the system. To prevent VARs supplied by one generator being absorbed by another, the SC must coordinate VAR adjustments with all GFOs and the TFO in the area. Refer to [OPP 505](#) for details on voltage control in the Fort McMurray area.

There is a 20 MVAR reactor at each of the new Kinosis (A856S), McMillan (A885S) and Heart Lake (A898S) substations. These reactors are used both for 240 kV line energization or to control voltages along the 240 kV lines, depending on the levels of energy transfer out of the Fort McMurray area.

The Wabasca (A720S) reactors are not normally used due to 25 kV considerations. They can be used when energizing 9L56 from Mitsue (A732S) to suppress line end voltage or when radially feeding the Wabasca load from the 240 kV.

Winefred (I818S) has two capacitor banks controlled by circuit switchers 818S14 and 818S17. Breaker 818S14 has no ability to control transients on closing, therefore if both capacitors are required, close it first. Circuit switcher 818S17 is equipped with pre-insertion reactors for transient control.

Bonnyville (A700S) has three 15 MVAR capacitors that can be used as system conditions require.

There are also three GFOs in the Cold Lake area that can be called upon to adjust VARs on the system.

Northwest area

The 240 kV voltage in the northwest area is a key indicator of area reliability. Voltage in the area can be adjusted by switching the capacitors and reactors listed in [Table 2](#). The Wabamun area generator voltages can be adjusted to coincide with daily load changes. Generators located

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throughout the northwest can have their VARs adjusted. Minimum TMR levels can be exceeded if all other options have been exhausted.

Valleyview and Poplar Hill generators have clutches installed to disconnect the turbine from the generator so it can be run in synchronous condenser mode.

TransCanada Bear Creek and ATCO Power Valleyview are LBC SO generators (see [OPP 513](#)) and therefore must be capable of 0.85 lagging to 0.95 leading power factor.

In the Grande Prairie area, Poplar Hill (A790S) and Crystal Lake (A722S) capacitors have zero-crossing breakers, while Clairmont Lake (A811S) does not. When there is a choice to switch either Crystal Lake capacitor or Clairmont Lake capacitor the Crystal Lake capacitor is preferred.

The Little Smoky 240 kV bus voltage will be maintained in accordance with [OPP 501](#), which includes the shedding of firm load if the minimum operating limit, as indicated in [Table 2](#), cannot be sustained.

Cranberry Lake static VAR compensator (SVC)

The reactive capability of the SVC to provide reactive power into the Cranberry Lake (A827S) 144 kV bus is +30 MVAR to -30 MVAR.

In order to maintain reliable operation in the Lubicon area and to minimize internal losses, the SVC will be operated in voltage regulation mode with a voltage set point in the range of 148 kV to 150 kV.

The SVC will be kept within the range of -15 MVAR (inductive) to +5 MVAR (capacitive) in order to provide sufficient dynamic reactive reserves to prepare for the next critical contingency. Switching the Lubicon 2x30 MVAR capacitor banks can be used to assist in providing the required regulation.

Refer to [OPP 501](#) for details on voltage control in the northwest area.

4. Responsibilities

4.1 ISO

The ISO will:

- Settle with service providers, if any generator is directed to come on line for voltage control in accordance with the System Support Service Agreements.
- Jointly develop operating policies and procedures with TFOs and GFOs involved in voltage control.

System Controller

The SC will:

- Maintain bus voltages within the desired operating range ([Table 1](#)) by issuing requests for reactor or capacitor switching and generator VARs.
- Issue directives for generator voltage setting adjustments directly to the generation operators operating any generators connected to the transmission system.
- Coordinate voltage control actions with TFOs giving due consideration for minimizing system losses and transmission must-run generation costs.
- Direct or approve voltage control actions such as line switching.

4.2 Transmission Facility Owners

The TFOs, through their control centres, will:

- Advise the SC if voltage limits are being exceeded or if voltage adjustments are required.

4.3 Generation Facility Owners (GFOs)

The GFO will:

- Monitor and keep in service the AVR and power system stabilizers (PSS), or wind generation related voltage regulation devices on generating units on a continuous basis.
- Operate their generators in voltage regulation mode so that they are not influenced by power factor or VAr controllers.
- Availability of AVRs and PSSs will be reflected in the ancillary service declaration in the ISO's energy trading system at all times.
- Advise the ISO on a monthly basis of the availability and in-service levels of any PSS and periods when the AVRs were not on automatic voltage control.
- Comply with SC directives for generator VAr and/or voltage adjustments.
- Not adjust their generator voltage without first advising the SC.
- Advise the SC, if a voltage adjustment affects the MW output of the generator.

5. System Controller Procedures

None specified.

6. Figures and Tables

Table 1

Voltage levels

Substation Name and Number	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)	Minimum Voltage Based on Studies ⁵
AltaLink					
East Calgary T5S	240	240	240 – 254	255	x
	138	138	138 – 142	142	x
Deerland T13S	240	245	245 – 256	260	x
	138	140	140 – 144	145	
Fort MacLeod T15S	138	138	138 – 144	145	
Benalto T17S	240	242 ¹	246 – 256	260	x
	138	138	138 – 144	145	x
Wabamun T19S	240	250	250 – 258	260	
	138	140	140 – 144	145	
West Brooks T28S	240	245	245 – 260	264	
	138	138	138 – 144	145	

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Substation Name and Number	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)	Minimum Voltage Based on Studies ⁵
North Calder T37S	240	240	244 – 255	260	
	138	137	138 – 144	145	
East Edmonton T38S	240	240	240 – 253	255	
	138	139	139 – 144	145	
Bickerdike T39S	240	255	258 – 263	264	
	138	135	140 – 144	145	
Medicine Hat T41S	138	135	138 – 144	145	
Sarcee T42S	240	245 ¹	247 – 253	253	x
	138	138	138 – 142	142	x
Edson T58S	138	138	138 – 144	145	
Peigan (TransAlta) T59S	240	235	235 – 258	260	
	138	135	138 – 144	145	
Lodgepole T61S	138	138	138 – 144	145	
Brazeau T62S	240	240	240 – 256	257	
	138	140	140 – 144	145	
Red Deer T63S	240	240 ¹	245 – 256	257	x
	138	138	138 – 143	145	x
East Crossfield T64S	240	240	240 – 254	255	x
	138	138	138 – 144	145	x
Amoco Willesden Green T68S	240	243	245 – 256	264	
North Barrhead T69S	240	250	250 – 263	264	
	138	140	140 – 144	145	
Lamoureux T71S	240	240	240 – 254	255	x
	138	140	140 – 144	145	
Leismer T72S	240	260	266 – 271	280	
Janet T74S	240	246 ^{1,2}	248 – 254	255	
	138	138 ²	138 – 142	142	
Sagitawah T77S	240	250 253	250-253 – 263	264	x
	138	140 141	140 – 144	145	x
Taber T83S	138	135	138 – 144	145	
Bigstone T86S	240	³	243 – 253	260	
	138	135	141 – 145	145	
Gaetz T87S	240	240	240 – 256	260	x
	138	138	138 – 144	145	x
Ellerslie T89S	500	505	520-540	550	x
	240	243 ¹	246 – 254	255	x
Langdon T102S	500	510	510 – 535	540	x

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Substation Name and Number	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)	Minimum Voltage Based on Studies ⁵
	240	250 ¹	251 – 255	258	x
Alberta Newsprint T122S	240	250	253 – 260	263	
Ware Junction T132S	240	250	254 – 262	264	
Lac La Biche T157S	138	138	138 – 144	145	
Amoco Empress T163S	240	247	247 – 260	264	
	138	140	140 – 144	145	
Cutting Lake T227S	138	138	138 – 144	145	
Bighorn 250P	138	135	135 – 148	150	
Killarney Lake T267S	138	138	138 – 144	145	
Whitecourt T268S	138	138	138 – 144	145	
Jenner T275S	240	250	250 – 260	264	
Acheson T305S	138	138	138 – 144	145	
Sundance 310P	240	252 ¹	255 – 262	264	x
	138	138	138 – 144	145	
Keephills 320P	500	512	520-540	550	
	240	248 ¹	250 – 258	260	x
	138	138	138 – 144	145	
North Lethbridge T370S	240	235	240 – 260	264	
	138	135	138 – 144	145	
Hardisty T377S	138	140	140 – 144	145	
Balzac T391S	138	136	138 – 144	145	
Empress T394S	138	138	138 – 144	145	
Pincher Creek T396S	138	138	138 – 144	145	
Bullshead T523S	138	135	138 – 144	145	
Joffre T535S	138	138	138 – 142	142	x
Metiskow T648S	240	250	250 – 260	260	
	138	140	140 – 144	145	
ATCO Electric					
Bonnyville A700S	144	141	147 – 151	155	
Leming Lake A715S	144	140	144 - 151	155	
Lloydminster A716S	144	137	144 - 148	151	
Crystal Lake A722S	144	144 <u>149</u>	147 – 151	155	<u>x</u>
Mitsue A732S	240	248 <u>256</u>	255-256 – 268	275	<u>x</u>
	144	140 <u>147</u>	147 - 151	155	<u>x</u>
H.R. Milner A740S	144	140 <u>145</u>	147 - 150	151	<u>x</u>
Sarah Lake A743S	144	137	144 - 150	155	
Flyingshot Lake A749S	144	144 <u>149</u>	147 – 151	155	<u>x</u>

Routine System Operations

OPP 702 Voltage Control

Substation Name and Number	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)	Minimum Voltage Based on Studies ⁵
<u>Rycroft A730S</u>	<u>144</u>	<u>149</u>	<u>:</u>	<u>155</u>	<u>x</u>
Hill A751S	144	137	144 - 148	151	
Cordel A755S	240	240	250 – 257	260	
Battle River A757S	144	141	144 – 151	155	
Nevis A766S	240	240	245 - 257	265	
	144	137	144 - 150	155	
Oyen A767S	144	137	140 - 144	155	
Lubicon A780S	144	146	148 - 150	<u>155</u>	x
High Level A786S	144	144	148 – 151	155	
Hotchkiss A788S	144	144 <u>149</u>	148 <u>154</u>	155	<u>x</u>
Keg River A789S	144	144	148 – 151	155	
Poplar Hill A790S	144	140 <u>150</u>	145 <u>154</u>	155	<u>x</u>
Rainbow Lake A791S	144	137	148 – 150	155	
West Peace River A793S	144	148 <u>151</u>	148 <u>154</u>	155	x
Anderson A801S	240	255	255 – 262	275	
	144	141	146 - 151	155	
Louise Creek A809S	240	254 <u>256</u>	257 – 268	275	x
	144	144 <u>145</u>	146 - 152	155	x
Clairmont Lake A811S	144	144 <u>150</u>	147 <u>152</u>	155	<u>x</u>
Little Smoky A813S	240	255 ⁴ <u>257</u> ⁴	257 – 268	275	x
	144	146 <u>150</u>	148 <u>152</u>	155	x
<u>Goodfare A815S</u>	<u>144</u>	<u>149</u>	<u>:</u>	<u>155</u>	<u>x</u>
Whitefish Lake A825S	240	240	245 - 260	275	
Marguerite Lake A826S	240	248	255 – 268	275	
	144	141	148 – 151	155	
Cranberry Lake A827S	144	146	148 - 150	<u>155</u>	x
Wesley Creek A834S	240	257 <u>261</u>	257 <u>261</u> – 268	275	x
	144	148 <u>150</u>	148 <u>154</u>	155	x
McNeill A840S	230	219	235 – 244	248	
	138	132	138 – 142	144	
Big Mountain A845S	144	144 <u>150</u>	147 <u>152</u>	155	<u>x</u>
Ruth Lake A848S	240	240	264 – 269	275	
	144	144	147 – 152	155	
<u>Friedenstal A800S</u>	<u>144</u>	<u>151</u>	<u>:</u>	<u>155</u>	<u>x</u>
McMillian A885S	240	240	264 – 269	275	
	144	141	148 – 151	155	
Heart Lake A898S	240	240	260 – 269	275	

Routine System Operations

OPP 702 Voltage Control

Substation Name and Number	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)	Minimum Voltage Based on Studies ⁵
	144	138	140 – 144	145	
ENMAX					
C9S	138	136	138 – 142	142	x
C13S	138	136	138 – 142	142	X
C21S	138	136	138 – 142	142	X
C31S	138	136	138 – 142	142	X
C41S	138	136	138 – 142	142	X
Beddington C162S	240	240	242 –255	255	X
	138	138	140 – 144	144	X
EPCOR					
Jasper Terminal Station E805S	240	240	245-254	255	X
Cloverbar E987S	240	240	245-254	255	X
Bellamy Terminal E1814S	240	3	3	255	X
Genesee 330P	500	518	525-540	550	X

Note:

1. If this limit is violated after normal voltage control action, then follow the guidelines for the SOK-240 busses in [Section 3.3](#).
2. Voltage levels will go below the minimum operating limit in accordance with guidelines for switching a 240 kV capacitor bank when the SVC is out of service. Voltage levels at other substations in the area may also go below their minimum operating limit during this time.
3. Intentionally left blank, operate the 240 kV system as required to maintain the 138 kV voltage within operating limits.
4. Maintain the Little Smoky 240 kV bus voltage in accordance with [OPP 501](#), which includes the shedding of firm load if the minimum operating limit cannot be sustained.
5. Blank indicates that minimum voltages are based on past experience.

Table 2

Reactors and capacitors

Substation Name and Number	Device Number	MVAR at Base Voltage	Switching Transient Control	Special Conditions/ Preferred State
AltaLink				
Benalto T17S	17S16 Cap	110.8	Zero-crossing breaker	supervisory/as required
Nisku T149S	Cap	30	Zero-crossing breaker	supervisory/as required
East Calgary T5S	5S7 cap	80	Zero-crossing breaker	
	5S71 cap	80		

Routine System Operations

OPP 702 Voltage Control

Substation Name and Number	Device Number	MVA _r at Base Voltage	Switching Transient Control	Special Conditions/ Preferred State
West Brooks T28S	28S44 reactor	50		
East Edmonton T38S	38S3052 cap	49	Zero-crossing breaker	
	38S3152 cap	49	Zero-crossing breaker	
Sarcee T42S – 138 kV	42S32 cap	49		
Bruderheim T127S	Cap	45	Zero-crossing breaker	supervisory/as required
Sarcee T42S – 240 kV ³	42S74	100.8	Zero-crossing breaker	42S74 and 42S76 may be closed in any order.
	42S76	100.8	Zero-crossing breaker	
Fort Saskatchewan T54S	54S45 cap	49	Pre-insertion reactor	
Boyle T56S	56S27 cap	14.9		
Edson T58S	58S35 cap	27.1		
Lamoureux T71S	71S952 cap	49	Zero-crossing breaker	
	71S1052 cap	49	Zero-crossing breaker	on
Janet T74S – 138 kV	74S54 cap	73.4	Pre-insertion reactor	Close 74S56 before 74S54
	74S56 cap	73.4		
Janet T74S – 240 kV ¹	74S102 cap	134.4	Zero-crossing breaker	74S102 and 74S103 may be closed in any order.
	74S103 cap	134.4	Zero-crossing breaker	
Taber T83S	83S61 cap	24.5		Close 83S61 before 83S67
	83S67 cap	24.4	Zero-crossing breaker	
Canmore T118S	118S18 cap	24.5	Pre-insertion reactor	
Magcan T142S	142S3 cap	24.5		Undervoltage trip
Strathmore T151S	151S44	24.4	Closing Resistor	
Lac La Biche T157S	157S23 cap	10.8		
Amoco Empress T163S	163S64	24.3	Pre-insertion reactor	
	163S63	24.3	Pre-insertion reactor	
North Red Deer T217S	217S652 cap	49	Closing Resistor	
Sunken Lake T221S	221S32 cap	18.1		on
Blackie T253S	253S182 cap	24.5	Pre-insertion reactor	

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Substation Name and Number	Device Number	MVAr at Base Voltage	Switching Transient Control	Special Conditions/ Preferred State
Harmattan T256S	256S53 cap	23	Zero-crossing breaker	
Strachan T263S	263S35 cap	23	Zero-crossing breaker	
Killarney Lake T267S	267S22 cap 267S23 cap	2 x 10.9	Pre-insertion reactor	Undervoltage trip
	267S24 cap	9.1	Pre-insertion reactor	Undervoltage trip
Violet Grove T283S	283S31 cap	25	Zero-crossing breaker	
Acheson T305S	305S32 cap	24.4		On
Burdett T368S	368S35 cap	24.5		Close 368S35 before 368S44
	368S44 cap	24.4	Zero-crossing breaker	
Hardisty T377S	473S102 Cap	<u>20.452.8</u>	Zero-crossing breaker	
Pincher Creek T396S	396S56 Cap	24.5		
Waupisoo T405S	405S17 Cap	10.8	Zero-crossing breaker	
Hays T421S	421S30 Cap	27		
Hussar T431S	431S152 Cap	9.2	Zero-crossing breaker	
Gregg River T476S	476S6 cap	10		Out-of-service
<u>Tucuman T478S</u>	<u>478S552 cap</u>	<u>27</u>		
Bullshead T523S	523S33 Cap	18.3		
Cold Creek T602S	602S17 Cap	4.8		
Winefred T818S	818S14 cap	4.5		Close 818S14 before 818S17
	818S17 cap	4.5	Pre-insertion reactor	
Pigeon Lake T964S	964S21 Cap	4.5		Out-of-service
ATCO Electric				
Bonnyville A700S	703/4C	2 x 15	Zero-crossing breaker	supervisory/as required
	706C	14.3	Zero-crossing breaker	supervisory/as required
St. Paul A707S	506C	4.8		manual/on
	505C	2.4		Auto
Lloydminster A716S	701C	19.7	Zero-crossing breaker	Supervisory/on
Wabasca A720S	501/2/4R	3 x 5		supervisory/emergency

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Substation Name and Number	Device Number	MVA _r at Base Voltage	Switching Transient Control	Special Conditions/ Preferred State
Crystal Lake A722S	703C	29.6	Zero-crossing breaker	supervisory/as required
	501/2C	2 x 4.8		supervisory/as required
Mitsue A732S	501/3R	2 x 20		supervisory/as required
H.R. Milner A740S	507C	5.4		supervisory/as required
Fox Creek A741S	504C	4.8		manual/on
Hill A751S	701C	19.7	Zero-crossing breaker	supervisory/on
Ksituan 754S	702C	15	Zero-crossing breaker	
Hanna A763S	501C	2.7 + 2.25*		Supervisory/on
Rowley A768S	604C	5.4		Auto
Three Hills A770S	506C	4.95		manual/on
Youngstown A772S	504C	2.4		manual/on
Monitor A774S	704C	20	Zero-crossing breaker	supervisory/on
	<u>705C</u>	<u>30</u>		
Sullivan Lake A775S	604C	10.8	Zero-crossing breaker	supervisory/on
High Level A786S	301R	5		manual/emergency
	505C, 506C, 507C, 508C	4 x 2.4		supervisory/as required
Lubicon A780S	706C, 707C	2X 30		supervisory/as required
Hotchkiss A788S	701R	10		supervisory/as required
Keg River A789S	701R	10		supervisory/as required
	701C	14.3	Zero-crossing breaker	supervisory/as required
Poplar Hill A790S	701C	24.7	Zero-crossing breaker	supervisory/as required
	509C	12.6		supervisory/as required
W. Peace River A793S	701/2C	2 x 15		supervisory/as required
Friedenstal A800S	501C1/2	2 x 2.4*		manual/on
	703C	15	Zero-crossing breaker	
Michichi Creek A802S	705C	10	Zero-crossing breaker	supervisory/on

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Substation Name and Number	Device Number	MVAr at Base Voltage	Switching Transient Control	Special Conditions/ Preferred State
Louise Creek A809S	701C	52.8		supervisory/on
	503R	20		Supervisory/off
	504R	10		supervisory/as required
Clairmont Lake A811S	701C	25		supervisory/on
Little Smoky A813S	501/3R	2 x 20		supervisory/as required
	714C, 715C and 716C	3X30		supervisory/as required
Marguerite Lake A826S	502/3/4R	3 x 20		supervisory/as required
Sulphur Point A828S	507C1 / C2	2 x 4.8		supervisory/preferred on
Wesley Creek A834S	502R <u>909R</u>	20 <u>25</u>		supervisory/as required
Big Mountain 845S	705C	30	Zero-crossing breaker	
Ruth Lake A848S	401/2/3/4R	20 + (2x 5)		supervisory/off
	909R	35		supervisory/as required
Kinosis A856S	505R	20		supervisory/as required
McMillian A885S	501R	20		supervisory/as required
Dover A888S	916R	40		supervisory/as required
Heart Lake A898S	501R	20		supervisory/as required
ENMAX (City of Calgary)				
C14S	Cap 14.1	24.4	Pre-insertion reactor	Two 12.2 MVAr banks in parallel
	Cap 14.2	24.4	Pre-insertion reactor	Two 12.2 MVAr banks in parallel
C21S	Cap 21.1	52.5	Breaker with closing resistor	A 21 MVAr bank and a 31.5 MVAr bank in parallel
C31S	Cap 31.1	48	Breaker with closing resistor	Two 24 MVAr banks in parallel
C38S	Cap 38.1	48	Pre-insertion reactor	Two 24 MVAr banks in parallel
C41S	Cap 41.1	54	Pre-insertion reactor	Two 27 MVAr banks in parallel
Epcor				
Clover Bar E987S	Cap	36	Filter bank	

Routine System Operations

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Substation Name and Number	Device Number	MVA _r at Base Voltage	Switching Transient Control	Special Conditions/ Preferred State
Jasper E805S	Cap	110	Filter bank	
Rossdale	R72C1	50	Zero-crossing breaker	On
	R72C2	50	Zero-crossing breaker	On
City of Medicine Hat				
Medicine Hat T41S		7.2		Call Medicine Hat to operate capacitors
		7.2		
		9		
TransAlta Wind				
Summerview 354S		6X 6.6		See OPP 515

Note:

1. See [Table 3](#) for voltage protection settings.

Table 3

Capacitor bank voltage protection settings

Substation	Device Number	Voltage Trip Setting
Benalto T17S	17S16 Cap	262 kV @ 10 sec.
	17S16 Cap	269 kV @ 5 sec.
E. Calgary T5S	5S71	158.7 kV @ 11 sec.
	5S7	158.7 kV @ 19 sec.
	5S71 & 5S7	165.6 kV - instantaneous
Sarcee T42S – 240 kV	42S74	256.1 @ 8.0 sec.
		276 kV @ 40 cycles
	42S76	256.1 kV @ 12.0 sec.
		264 kV @ 4.0 sec.
Sarcee T42S – 138kV	42S31	158.7 kV @ 15 sec.
		165.6 kV - instantaneous
Janet T74S – 240 kV	74S102	256.1 kV @ 6.0 sec.
		276 kV @ 20 cycles
	74S103	256.1 kV @ 10.0 sec.
		264 kV @ 2.0 sec.
Janet T74S – 138 kV	74S56	158.7 kV @ 8.5 sec.
	74S54	158.7 kV @ 16 sec.
	74S54 & 74S56	165.6 kV - instantaneous

7. Revision History

Issued	Description
xxxx-xx-xx	Supersedes 2009-05-28
2009-05-28	Supersedes 2009-02-19
2009-02-19	Supersedes 2008-11-13
2008-11-13	Supersedes 2008-05-30
2008-05-30	Supersedes 2007-09-27
2007-09-27	Supersedes 2007-06-14
2007-06-14	Supersedes 2006-12-22
2006-12-22	Supersedes interim OPP effective 2006-10-04
2006-10-04	Approved for interim implementation effective 2006-10-04, Supersedes 2006-09-29
2006-09-29	Supersedes 2006-07-11
2006-07-11	Supersedes interim OPP effective 2006-04-27
2006-04-27	Approved for interim implementation effective 2006-04-27, supersedes 2005-05-25
2005-05-25	Supersedes 2004-10-14
2004-10-14	Supersedes 2004-03-03
2004-03-03	Supersedes 2003-07-28
2003-07-28	Revised to ISO Operating Policies and Procedures