March 31, 2016

Summary on

August 2015 – February 2016

WG Activities

[redacted] AESO

502.11 Workgroup (WG)

	Primary	Alternate
AltaLink	[redacted]	[redacted]
ATCO	[redacted]	[redacted]
EPCOR	[redacted]	[redacted]
ENMAX	[redacted]	[redacted]
FortiaAlberta	[redacted]	

502.11 – History & Future

What happened

- June 2015 – AESO internal approval
- July 2015 – WG formed
- Aug 27 – 1st WG meeting @ AESO
- Sep 17 – 2nd WG meeting @ ATCO
- Oct 29 – 3rd WG meeting @ ENMAX
- Nov 16 – CANA as consultant
- Nov 19 – 4th WG meeting @ EPCOR
- Dec 17 – 5th WG meeting @ AltaLink
- Jan 21 – 6th WG meeting @ AESO
- Feb 18 – 7th WG meeting @ AESO

What will happen

- March 31, 2016
  - 8th (last) WG meeting @ AESO
- April
  - Recommendation paper
  - Finalize recommendation paper
  - Start drafting 502.11 rule
- July – August
  - Circulating draft 502.11 to WG
- November
  - Finalize draft 502.11 rule
- December
  - File 502.11 rule with AUC

Mid November, 2015

CANA to provide consulting assistance

Two objectives:

- What are the minimum technical requirements of the comparable US/Canadian utilities?
- What are the extra technical considerations on substation rule when connecting new generation technologies?

AESO Rules Consultation Process

Step 1.0	Identify need for new ISO Rule
Step 2.0	Invitation to stakeholders to participate in WG with draft T of R
Step 3.0	Finalize T of R. Hold workshops & technical sessions
Step 4.0	Recommendation Paper to stakeholders. Reply to stakeholders comments. Determine if further consultation is needed
Step 5.0	Letter of Notice / Posting draft Rule to industry / Reply to stakeholders comments / Determine if re-consultation is necessary
Step 6.0	Final draft Rule / Legal review / Notice of Filing / Filing with AUC

What Is a Recommendation Paper?

- Executive Summary
- Introduction & Background
- Recommendations
  - Guiding Principles
  - Technical Requirements – Proposals & Options
  - Stakeholder Positions
- Implementation Considerations
- Next Steps
- Appendices (if any)

- Recommendations
  - Reliability and availability
  - Safety and security requirements
  - Service conditions
  - Grounding & insulation
  - Station power supply & control building
  - Bus layout
  - Power Transformers
  - Reactive compensation Devices
  - Other equipment

What Does Draft Rule 502.11 Look Like?

Proposed ISO Rule

Part 500 Facilities

Division 502 - Technical Requirements

Section 502.11

Transmission Substation Technical Requirements

Final Proposed Filing Draft

Applicability

1 Section 502.11 applies to:

(a) the **legal owner** of a **transmission facility** with at least one rated voltage equal to or greater than one hundred (100) kV; and

(b) the **ISO**.

Requirements

New and Existing Substations

2(1) On and after the effective date of this Section 502.11, the **legal owner** of any new substation which is to be directly connected to the **interconnected electric system** must comply with the provisions of this section 502.11, prior to the new substation being energized.

(2) The provisions of this section 502.11 do not apply to any new substation with a functional specification the **ISO** approves of prior to the effective date of this section 502.11, but that substation must remain in compliance with that functional specification including all of the standards and requirements referenced in that functional specification.

(3) Notwithstanding any other provision of this section 502.11, the **ISO**, through an amendment to the original functional specification or the issuance of a new functional specification, may require the **legal owner** of an existing and commissioned substation to comply with any specific one or all of the provisions of this section 502.11, if the **ISO** determines that such compliance is critical for the safe and reliable operations of the **interconnected electric system**.

Functional Specification

3(1) The **ISO** must, in accordance and generally consistent with this section 502.11 and any other applicable **ISO rules**, approve of a functional specification containing further details and discrete work requirements and specifications for the design, construction and operation of any substation project and any associated **transmission system** connection facilities.

ISO Rules
Part 500 Facilities
Division 502, Technical Requirements
Section 502.11 Transmission Substation Technical Requirements

(2) The functional specification for the connection project referred to in subsection 3(1) must be generally consistent with the provisions of this section 502.11, but may contain material variances the **ISO** approves of based upon its discrete analysis of any one or more of the technical, economic, safety, operational and **reliability** requirements of the **interconnected electric system** related to the specific connection project.

Successor to Prior Requirements

4 Subject to subsection 2, this section 502.11 succeeds and replaces the *Technical Requirements for Connecting to the Alberta Interconnected Electric System (IES) Transmission System Part 3 Technical Requirements for Connecting Transmission Facilities* which came in effect as of December 29, 1999, and that standard together with any other prior standards or drafts of standards on the subject matter no longer will be in force and effect as of the effective date of this section 502.11.

Other Code Requirements

5(1) The design, construction and operational specifications for any new transmission substation must meet or exceed the most recently published edition and applicable provisions and requirements as set out in all federal and Alberta provincial enactments, standards, guidelines, codes, mandatory requirements and regulations governing such a bulk transmission line, including:

(a) the *Alberta Electrical Utility Code*;
(b) the *Alberta Health and Safety Code*;
(c) the Canadian Standards Association (CSA) codes referenced in the *Alberta Electrical Utility Code*; and
(d) the International Electrotechnical Commission (IEC) *Standard 61472 Live working – Minimum approach distances for a.c. systems in the voltage range 72.5 kV to 800 kV – A method of calculation*.

(2) The **legal owner** in addition must ensure that the transmission substation is designed, constructed and operated in a manner that is compliant with all provisions of any order, ruling, permit or license that the **Commission** issues, or that any other body having jurisdiction issues under any enactment.

Type 1 Substation

6(1) For this section 502.11, a substation is deemed a Type 1 Substation if one of the following applies:

(a) having a total of more than six (6) source line and/or power transformer terminations; or
(b) having a voltage level at 500 kV or higher; or
(c) being designated by the **ISO** in its own discretion.

Substation Major Equipment

August 27, 2015 – 1st WG Meeting
Major Topics to be Covered in 502.11

- Reliability and availability
- Safety and security requirements
- Service conditions
- Grounding & insulation coordination
- Bus layout
- Station power supply & control building
- Power transformers
- Circuit breakers (load interrupting devices)
- Shunt reactors and shunt capacitors
- Other equipment

August 27, 2015 – 1st WG Meeting
Broad Issues & Agreements

- No participants from manufacturing industry in the WG
- 502.11 rule should cover ISD-owned substations meeting the criteria
- ≤ 69/72 kV be excluded (with exceptions)
- Creation of “Major Substation” (later “Type 1 Substation”)
- Life expectancy of a substation not be specified
- Only the minimum reliability & availability be defined

September 17, 2015 – 2nd WG Meeting
Guiding Principles

- In line with ARS standards and other rules
- Allow for new technology to the maximum extent possible
- Reliability/availability be measurable as much as possible
- To the maximum extent possible – limit the number of exceptions
- Higher requirements for “Type 1” (or Major) Substations
- Definition of “element” (NERC / WECC / AIES)

September 17, 2015 – 2nd WG Meeting
Applicability

Section 502.11 applies to

a) the **legal owner** of a **transmission facility** with at least one rated voltage equal to or greater than one hundred (100) kV; and

b) the **ISO**.

- ISD-owned HV substations are included
- Generators who own HV substations are also included
- HVDC substations are inherently included?

October 29, 2015 – 3rd WG Meeting
"Type 1" Substation

Definition

- Any 500 kV substations; or
- Any 240 kV substation having ≥6 source line and/or power transformer terminations; or
- Any substation designated by the AESO in its own discretion

* under above definition, about 23 substations in existing AIES system would have been called "Type 1" substations

October 29, 2015 – 3rd WG Meeting
Grounding Requirements

- AIES is an effectively grounded system for ≥100 kV voltages
- A grounding study shall be conducted for each and every transmission substation project (do we need to define what is included in a grounding study?)
- AESO shall provide 10-year (or longer period) short circuit level forceast

* Currently, for every substation project, all TFOs conduct a grounding study

October 29, 2015 – 3rd WG Meeting
Insulation Coordination

- Agreed to
  - split BIL into LIL and SIL in 502.11
  - create a 260 kV nominal voltage class*
  - use MCOV=150 kV for 138 kV class
- Recommended to include BIL levels for 13.8/25/34.5/69 kV equipment (inside substations) for insulation coordination purposes
- No need to specify a higher LIL/SIL for GIS equipment
- MTBF=1000 years for transformers, and MTBF=400 years for bus & other equipment, for lightning failure
- Altitude factor be considered where altitude exceeds 1000 m

* For all 240 kV buses from Whitefish north and Sagitawah north

October 29, 2015 – 3rd WG Meeting
Voltage Class & MCOV

Nominal (kV)	Extreme Continuous Minimum (kV)	Normal Continuous Minimum (kV)	Normal Continuous Maximum (kV)	MCOV (kV)
138	124	135	145	150
144	130	137	151	155
240	216	234	252	264
260*	234	247	266	275
500	475	500	525	550

* For all 240 kV buses from Whitefish north and Sagitawah north

BIL levels for MV/LV Equipment in Substations

Nominal Voltage (kV rms)	13.8	25	34.5	69/72
Circuit breakers	110	150	200	350
Indoor switchgear, xformer & shunt reactor windings(with surge arresters)	95	125	170	350
Transformers, shunt reactors bushings (with surge arresters)	110	150	200	350
All other equipment (CTs, PTs, busbars, etc.)	110	150	200	350

October 29, 2015 – 3rd WG Meeting
Insulation Coordination

Air Insulated Substations

Nominal Voltage Classification (kV rms)	138/144		240/260		500	
	LIL	SIL	LIL	SIL	LIL	SIL
Post Insulators & Disconnect Switches	550	NA	900	750	1550	1175
Circuit Breakers	650	NA	1050	850	1800	1425
CTs & PTs	650	NA	1050	850	1800	1425
Xformer Windings (with surge arresters at both ends)	550	NA	850	750	1550	1175

Gas Insulated Switchgear

Disconnect switches, Buswork, Switchgear, CTs & PTs	750	N/A	1050	850	1550	1175

BIL levels for MV/LV Equipment in Substations

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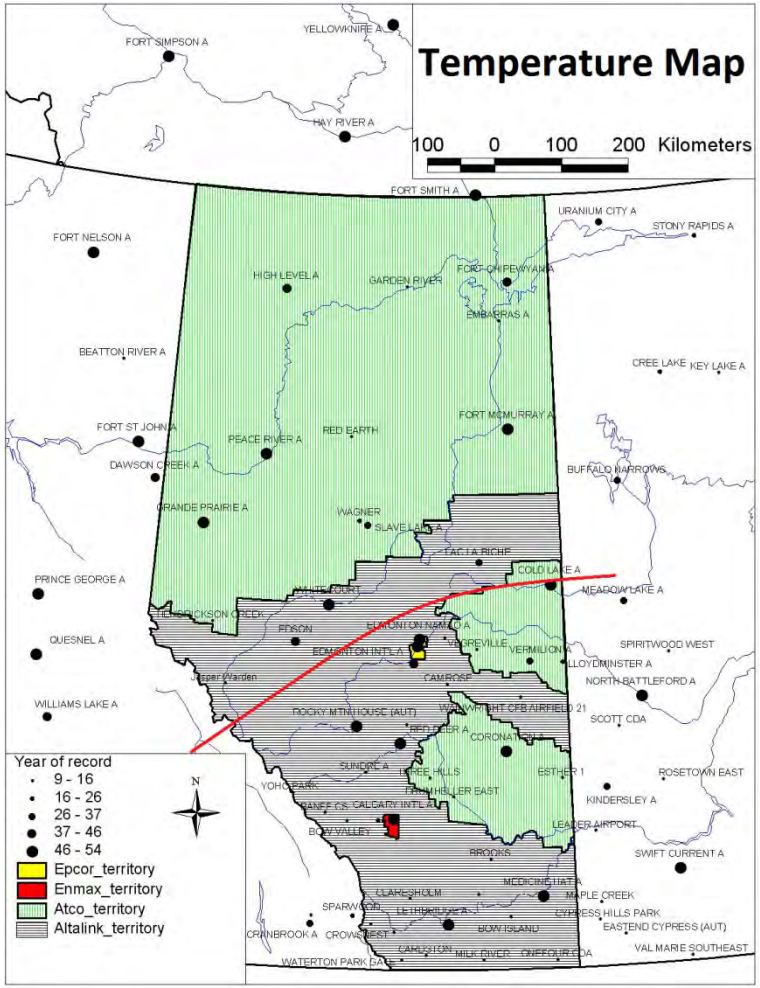
All other equipment (CTs, PTs, busbars, etc.)	110	150	200	350

October 29, 2015 – 3rd WG Meeting
Service Conditions

- Recommend to create two temperature zones with -50°C and -40°C, demarcated at Edmonton and Cold Lake
- Maximum ambient temperature of +40°C for both zones
- Temperature change rate of 15°C per hour
- Use same wind map as for 502.2 rule



November 19 – 4th WG Meeting
AC/DC Station Power Supply & Control Building

- For all substations
  - 8 hours of discharge time from loss of AC station supply
  - 24 hours or less charging time from “empty” to full capacity
- **For “Type 1” Substations**
  - Dual independent AC sources
  - If SST is directly connected to HV bus, protection be such that outage be limited to the SST (breaker is required)
  - Two independent battery banks with independent chargers, each with 4 hours of discharge time at full load (8 hours of individual load). Common mode failure should be avoided
  - Control building be installed with temperature controlled area

November 19 – 4th WG Meeting
Circuit Breakers

- All CBs must be able to perform an O-C-O sequence after 8 hours of power loss
- All CBs must be tested in accordance with IEEE C37.09 or the corresponding IEC standard
- Point-on-wave required for cap banks and shunt reactors (the AESO may specify POW for other applications)
- Single pole circuit breakers required for 240/500 kV, unless the AESO specifies otherwise
- Minimum operating time for opening:

Nominal (kV)	34.5/69	138/144	240/260	500
CB/CS operating time (cycles)	5.0	3.0	2.5	2.0

December 17 – 5th WG Meeting
Bus Layout

- Snow, Icing and Wind Limits
  - The ID presents minimum design parameters of TFOs in a table (Also use AESO wind map for 50 year return period. Must use local environmental conditions)

- Bus Layout

  A good bus layout should

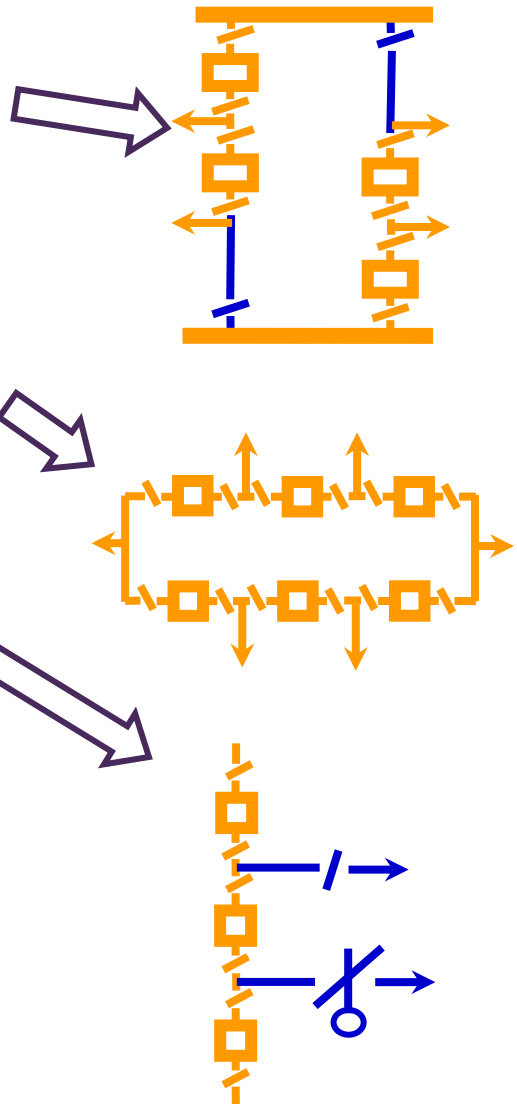
  - support & promote safety and reliability of AIES
  - provide maximum maintenance and operating flexibility
  - be cost effective for both current and future needs

December 17 – 5th WG Meeting
Bus Layout for All Substations

- A faulted element must not result in loosing another transformer element
- No additional elements be taken out of service on an extended basis to accommodate maintenance of an element
- Ampacity of all terminal components connecting a transmission line or power transformer be NO less than the rating of the line or the transformer
- Breaker failure should not trip all the circuits which terminate at the same remote substation, or the same generating station
- Bus tie breaker or disconnect switch to be based on the reliability requirement

December 17 – 5th WG Meeting
Bus Layout for All Substations (cont'd)

- In an incomplete 1.5/1.3 breaker diameter, DSs close to bus should be installed to minimize outage time during the installation of the remaining breakers in the future
- A ring configuration is acceptable with up to six (6) nodes. A ring bus with >6 nodes will be approved on a case-by-case basis
- A disconnect device at the line side be installed for each transmission line, power transformer and/or generator connection
- If all 3 transmission voltage levels (500/240/138 kV) are present, failure of an autotransformer shall not result in tripping more than 4 circuit breakers



Minimum Bus Continuous Current Ratings (A)

Component	138/144 kV	240/260 kV	500 kV
Main Bus	1,200	3,000	4,000
Cross Bus	600	2,000	3,000
Feeder or Line terminal	600	2,000	3,000

December 17 – 5th WG Meeting
Bus Layout (cont'd)

- AESO to provide the ultimate number of terminations and voltage compensation devices in the FS
- In the ID Document
  - examples be included to show typical bus layouts
  - pros and cons of each bus configuration
- For "Type 1" Substations
  - A faulted element not result in the loss of any other elements
  - If initially designed with a simple bus or ring bus, the design must be such that it can be converted into the ultimate layout without having to relocate any existing equipment
  - In ring bus, positioning of equipment be such that lines are not terminated in positions which will ultimately be buses

January 17 – 6th WG Meeting
Power Transformers

- Transformer life should be comparable to other apparatus

  Yes ☐ **No ☑**

- Single-phase units be used for large GSU or large base load transformers

  Yes ☐ **No ☑**

- Transformer terminals be equipped with SAs except enclosed cable termination boxes in which case SA be placed at switchgear end of feeders

  Yes ☑ No ☐

- SAs be installed as close as possible to the transformer bushings taking arrester clearance requirement into account

  Yes ☑ No ☐

January 17 – 6th WG Meeting
Power Transformers (cont'd)

- Transformer rating be based on CSA C88 M90 or later versions

  Yes ☑ No ☐

- Overloading capability of very large power transformers will be AESO's responsibility

  Yes ☑ No ☐

- Minimum average temperature rise is 65^{o}C. However, TFOs can use 55^{o}C rise in special applications

  Yes ☑ No ☐

- FCBN (Full Capacity Below Norminal) for all and any power transformers

  Yes ☑ No ☐

January 17 – 6th WG Meeting
Power Transformers (cont'd)

- All power transformers have LTC (except GSUs and 500 kV autotransformers) (to be further discussed)

  Yes ☑ No ☐

- LTC be always placed at the primary winding (or the wye winding)

  Yes ☐ **No ☑**

- Minimum voltage range is ±10% with x% for each step

  Yes ☑ No ☐

- Transformer loss evaluation be conducted for all transformers based on IEEE C57.120 (to be further discussed)

  Yes ☑ No ☐

January 17 – 6th WG Meeting
Power Transformers (cont'd)

- The AESO to provide loading levels data & economic factors for transformer loss evaluation

  Yes ☑ No ☐

- Transformer impedance is a TFO responsibility (however, AESO may specify uncommon impedance for certain transformers in the FS) (to be further discussed)

  Yes ☑ No ☐

- For system transformers, consideration be given to the design and control such that parallel operation is capable (for load transformers, parallel operation is up to TFO & load customers)

  Yes ☑ No ☐

February 18 – 7th WG Meeting
Power Transformers (cont'd)

- Mobile transformer connections be provided

  Yes ☐ **No ☑**

- Transformer overloading capability – there should be consideration in the bid and design review, and test report

  Yes ☑ No ☐ (to be further discussed at March 31 meeting)

- Transformer monitoring devices or systems must be provided

  Yes ☐ **No ☑**

- Transformer testing is a TFO responsibility and undertaking

  Yes ☑ No ☐

- Special requirements for GMD

  Yes ☐ **No ☑**