ISO Rule Section 502.11 (Substation) Workgroup Meeting – Proposed Agenda

Meeting Date: December 17, 2015 from 10:00 am to 3:00 pm
Meeting Place: AltaLink Head Office, 2611 3rd Ave SE, Calgary

Agenda Item	Time	Presenter
1. Welcome and finalization of Nov 19 meeting minutes	10:00 – 10:10	[AESO]
2. Action items from Nov 19 meeting: • BIL levels for indoor 25 kV switchgear – **All** • Proposed BIL levels for 13.8, 25, 34.5 and 69 kV equipment – [AESO] • Snow, icing and wind limits used in substation design standards – **All**	10:10 – 11:00	[AESO] / All
3. Discussions on what will be included in the substation rule 502.11 • Bus layout • Power transformers • Shunt reactors and shunt capacitors • Instrument Transformers (CTs and PTs) • Other	11:00 – 12:00	All
4. Lunch break	12:00 – 1:00	All
5. Continue discussions on substation rule 502.11	1:00 – 2:50	All
6. Summary and next meeting	2:50 – 3:00	[AESO]

1. Proposed BIL Levels for 13.8, 25, 34.5 and 69 kV Equipment

At the Nov 19 WG meeting, an agreement was made to specify the lightning impulse levels (BIL) for MV and LV equipment in a transmission substation, to ensure proper insulation coordination between HV, MV and LV equipment in the substation.

The following presents proposed BIL values for the MV and LV voltage class, for both GIS and AIS equipment.

Nominal Voltage Classification (kV rms)	13.8	25	34.5	69
Circuit breakers	110	150	200	350
Transformers, shunt reactors (with surge arresters)	95	125	170	350
All other equipment (CTs, PTs, busbars, etc.)	110	150	200	350

2. Bus Layout

The bus layout of a substation determines many critical aspects of a substation, including land requirement, reliability of supply, type and amount of equipment and the cost. Bus outages result in the loss of all transformers or transmission circuits connected to the bus.

A good bus lay out should

- support and promote safety and reliability of supply
- provide maximum maintenance and operating flexibility and
- be cost effective for current needs and future expansions

Before talking in detail about the allowable bus configurations, we need to craft out the design guideline or criteria for bus design. The following can be something to start with (note that "**element**" refers to a generator, transformer, circuit breaker, bus section, or transmission line. An element may be comprised of one or more components).

For all substations:

- Bus layout will be such that it minimizes line crossings
- A tie breaker must be installed if there are three or more line terminations
- A faulted **element** must not result in the loss of two or more of other **elements**
- No additional **elements** be taken out of service to accommodate the maintenance of an **element**
- Only power transformers can be connected directly to a bus
- Lines connecting to the same remote substation cannot be terminated to the same diameter. Power transformers within a substation cannot be terminated to the same diameter.
- No terminal components will be the limiting factor for the rating of the **transmission facilities** connected
- When constructing an incomplete breaker-and-half or breaker-and-third diameter, disconnect switches be installed so as to minimize outage time during the installation of the remaining breakers
- A ring configuration is acceptable with up to six (6) breakers. A ring bus with more than six breakers is acceptable only if there are two or more transformer terminations within the substation
- A disconnect switch at the line side is required on each transmission line, power transformer and generator connection to the substation
- Should we specify the minimum bus ampacity values such as shown in the following table:

Component	**138/144 kV**	**240/260 kV**	**500 kV**
Main Bus[1]	1200	2000	4500
Cross Bus[2]	600	2000	4000
Feeder[3] or Line terminal[4]	600	2000	3000

[1] Main bus includes all sections of a ring bus scheme, or each bus section of a simple bus, a breaker-and-half or a breaker-and-third scheme.
[2] Cross bus includes diameter sections of breaker-and-half or breaker-and-third schemes.
[3] Feeder includes all equipment from the connection at the low voltage bus to the riser pole.
[4] Line terminal includes all equipment and conductor from the transmission line to the line breakers.

For Type 1 substations – additional to above requirements:

- Each **element** must be separated by at least one circuit breaker
- A failed line or transformer breaker or a bus section fault does not result in the loss of another bus section
- A faulted **element** must not result in the loss of any other **element** or **elements**
- A ring configuration is acceptable with up to six breakers

- If all three voltage levels (500/240/138 kV) exist, breakers shall be installed between adjacent buses of different voltages
- Extendibility or expandability – where a Type 1 substation is initially designed with a simple bus or ring bus, but is ultimately a breaker-and-half (or breaker-and-third) or ring bus. We need to require that the initial layout be such that it can be converted into other layout with minimal incremental cost and minimal disruption
- In ring bus design, the substation shall be physically and electrically designed so that lines are not terminated in positions that will ultimately evolve into buses. Transformers, however, are permissible to terminate in these positions
- The AESO must provide in its functional spec document the ultimate substation configuration including the number of terminations, voltage compensation devices, and bus ampacity. However, in the absence of ultimate layout, the initial design must be such that at least one extra diameter is built in the initial design

Questions

<u>General</u>

- Under what condition do we allow double-breaker, breaker-and-half, breaker-and-third and ring-bus configurations?
- Should breaker-and-half be disallowed for 138 kV connections?
- Should we require that circuits ending at the same remote substation cannot be in the same diameter?
- Should we require a breaker on the HV side of a power transformer in a simple bus layout?
- Do we have any special requirements for GIS substations (such as grounding switch)?

<u>Ampacity requirement:</u>

- Under what condition do we require rigid bus vs. flexible bus?
- Ampacity determination – should we determine the ampacity of bus and breakers based on “one breaker plus one bus section out”?
- Breaker ampacity – how do we determine the overloading capability of a breaker?
- Breaker short-circuit interruption rating – should we build a margin into the breaker’s short circuit interruption rating?

<u>Expandability</u>

- Bus expandability – How do we enforce expandability in substations to ensure easy and cost effective expansion from a simple bus to a more complex configuration?

3. <u>Power transformers</u>

Power transformers are often the most expensive equipment in a typical substation. The average life span of a power transformer is 25-35 years in normal operation. From a substation rule perspective, the rules around power transformers must be such that they promote reliable operation of the system, and prolong the life of the transformers to support a cost effective system.

The following points will be discussed:

- All transformers should be designed for an in service operating life that is comparable to other electrical apparatus in the same substation
- Single phase vs. three phase – Should we require single phase transformers for circumstances such as
    - The GSU units at very large base load power plants (>800 MW or other values)
    - 500/240 kV autotransformers with >800 MVA (or other value)

- Over Voltage Protection
    - All power transformer terminals shall be equipped with surge arresters with adequate protective margins
    - All surge arresters should be installed as close as possible to the transformer bushings

- Transformer rating and cooling
    - Should we specify how transformers rating is determined for normal condition?
    - Should we specify overloading capability for large power transformers (like >1000 MVA)? The AESO has been specifying 30-minutes and 3.5-hours overloading capability for large transformers with >1,000 MVA
    - Should we require 55^{o}C rise (instead of 55/65^{o}C or 65^{o}C) for certain sized transformers?
    - Should we require FCBN for all 240/138 and 500/240 kV autotransformers?

- Tap changer
    - Should we require OLTC on any power transformers (except GSUs and 500 kV transformers)?
    - Should we preclude the use of DETC for certain transformers?
    - Should we require LTC be always placed at the primary winding (or the wye winding)?
    - Range – should we require minimum number of steps and the range, or power factor range?

- Transformer impedance and losses
    - Should we require a transformer loss study be conducted for all 500 kV or other voltage level transformers?
    - Should we specify a range of impedance?
    - Should we require that no-load loss, load loss and auxiliary loss must be all considered when conducting loss studies?
    - Should we mention IEEE Standard C57.120 as the transformer loss evaluation method?

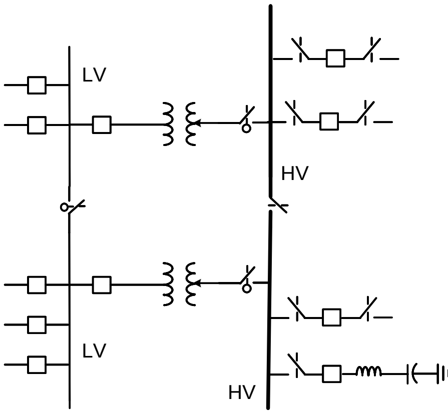
- Short circuit withstand
    - Should we specify that “transformers shall withstand, without damage, the mechanical and thermal stresses by external faults”
    - Should we specify 2 seconds short circuit duration?

- Parallel operation
    - Under what conditions do we allow parallel operation of transformers in a substation?

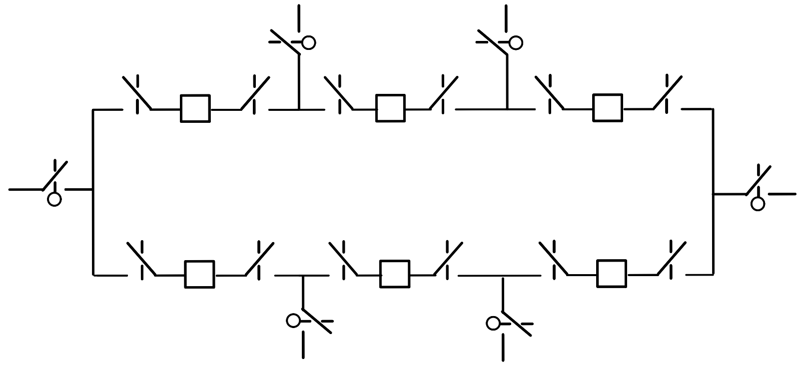
- Geomagnetical disturbance and geomagnetically induced current
    - Do we need any special requirements for geomagnetical disturbance?

- Any other points by WG members

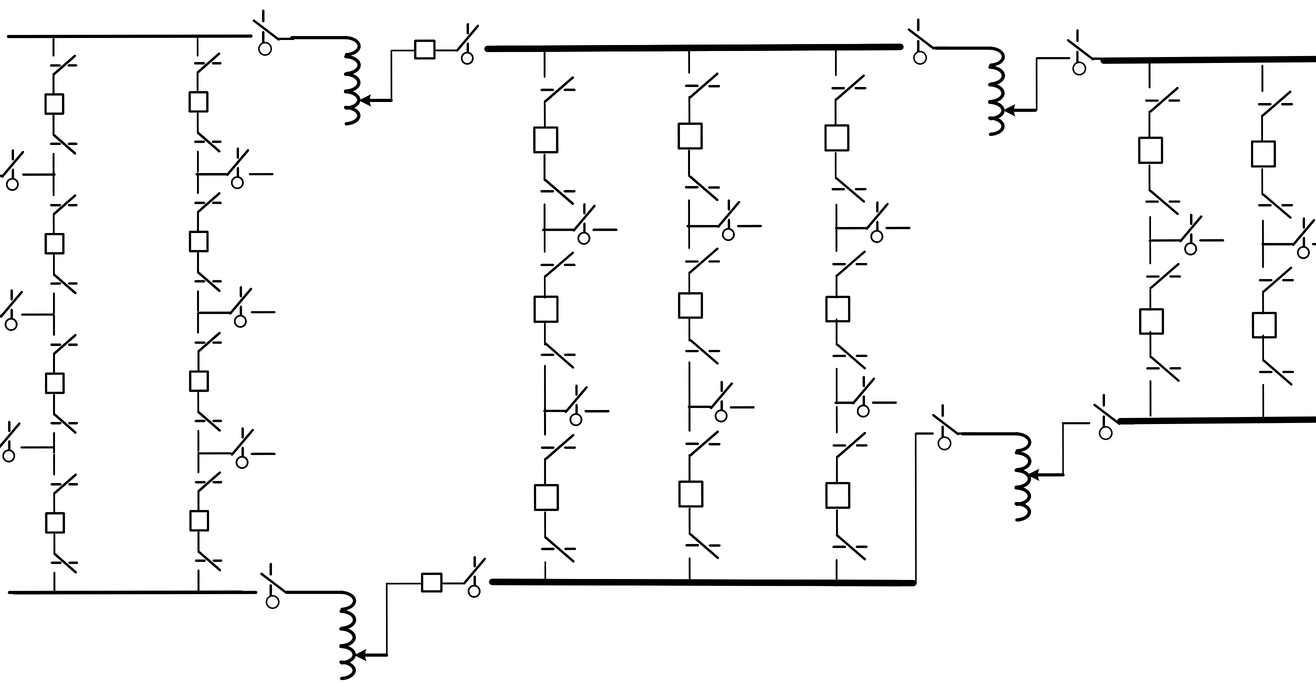
Simple bus



Ring Bus



Double-breakers
Breaker-and-half
Breaker-and-third



4. Shunt Reactors and Shunt Capacitors

The following are proposed to be discussed. WG members may have additional points.

Shunt capacitor bank

- Under what condition do we require a shunt capacitor to be connected to a diameter between buses?
- Shunt capacitor banks must be solidly grounded with the neutral grounded at a single point
- For multiple parallel capacitor banks which are switched back-to-back, each bank shall have a circuit breaker
- H-coupled capacitor banks must have unbalance protection, both alarm and trip function
- Should we require that a TRV study be done for each project having capacitor bank(s) to determine the use of series reactors or other schemes (such as pre-insertion resistors) to limit the switching transient overvoltage and resonance?
- Any other points from WG members

Shunt reactor bank

- For line connected shunt reactors – Should we prescribe minimum compensation level?
- Should we limit the construction types of reactors to either gapped core type or magnetically shielded air core having fixed impedance?
- Should we require reactor to have constant impedance up to, say, 1.5 times the rated voltage?
- Under what condition do we require a shunt reactor to be connected to a bus or a tertiary winding?
- For line connected shunt reactors – Auto reclosing of a transmission line with line shunt reactors is prohibited unless it can be assured that the fault is in the line section
- For line connected shunt reactors – Shunt reactors must be either solidly grounded or grounded through a neutral reactor
- For line connected shunt reactors – Under what condition do we require a four legged reactor (if not four legged reactor, a separate neutral reactor)?
- For tertiary winding connected reactors – There must be a circuit breaker connected
- Any other points from WG members

5. Instrument Transformers

Do we have any other technical requirements than the ones already specified in the current 502.3 rule as follows?

ISO Rule 502.3 – Interconnected Electric System Protection Requirements

Instrument Transformers

9(1) The **legal owner** of a **generating unit**, the **legal owner** of an **aggregated generating facility** and the **legal owner** of a **transmission facility** must ensure the facility uses protection class voltage and current transformers.

(2) Each **protection system** must have separate current cores and utilize separate secondary voltage transformer windings.

Voltage Transformers

10(1) Voltage transformers for a facility must be wire wound, capacitive or optical voltage transformers, and any other form of transformer is prohibited.

(2) For two hundred and forty (240) kV or higher voltage facilities, **protection system** devices that require voltage transformer inputs to provide protection functions must be connected to voltage transformers that are directly connected to the protected element.

(3) For one hundred and forty four (144) kV or lower voltage facilities that utilize simple bus design, the use of common bus voltage transformers is acceptable.

Fuse Failure Alarm for Voltage Transformers

11 A voltage transformer used for protective purposes, including synchronism checking, must have a loss of potential alarm.

Current Transformers

12(1) A current transformer used in a **protection system** must be either magnetic or optical, and must not be the limiting element in the transmission facility's rating.

(2) The maximum available current transformer ratio must be sized for the ultimate fault level of the facility as set out in the functional specification.

(3) A current transformer used in a **protection system** must meet the two point five (2.5L) low internal secondary impedance accuracy requirement as set out in *CAN/CSA-C60044-1:07, Instrument transformer – Part 1: Current transformers, Table 1B*, or an equivalent accuracy requirement at its maximum possible ratio, regardless of the ratio actually being utilized.

Breaker Failure Protection

35(7) For applications where free standing current transformers are used with live-tank breakers it is acceptable to have a breaker fail operation for faults located between the breaker and the current transformer.