Information Document
Facility Modelling Data
ID #2010-001R

Information Documents are not authoritative. Information Documents are for information purposes only and are intended to provide guidance. In the event of any discrepancy between an Information Document and any Authoritative Document(s) in effect, the Authoritative Document(s) governs.

1 Purpose

This Information Document relates to the following Authoritative Documents[1]:

- Section 304.6 of the ISO rules, *Unplanned Transmission Facility Limit Changes* ("Section 304.6"); and
- Section 502.15 of the ISO rules, *Reporting Facility Modelling Data* ("Section 502.15").

The purpose of this Information Document is:

(a) to provide a link to the list of electrical and physical parameters referred to in Section 502.15;

(b) to set out the *Guideline on the Electrical and Physical Parameters for Transmission System Model List*;

(c) to provide contact information for the purposes of providing modelling data, records, written submissions or other information to the AESO in accordance with Section 502.15; and

(d) to provide contact information for the purposes of notifying the AESO of an unplanned limit change to a transmission facility in accordance with Section 304.6.

2 Overview of Authoritative Documents

Section 304.6 concerns communication to the AESO of unplanned transmission facility limit changes, typically derates, that may have implications in the immediate and near term time frames for the manner in which portions of the Alberta interconnected electric system ("AIES") can be reliably operated. Subsection 2(2) of Section 304.6 requires an operator to provide the AESO with its plan to restore the transmission facility to its previous rating. The AESO acknowledges that, in some cases, it may not be appropriate to restore a transmission facility to its previous rating, where the previous rating is excessive for the anticipated future use of the transmission facility.

Section 502.15 concerns the submission of modelling data and records, including ratings, relating to new facilities or planned, urgent or unplanned changes to equipment within existing facilities, which the AESO uses to accurately represent the AIES in system studies.

A legal owner is required to submit information to the AESO in accordance with subsection 3 of Section 502.15, where an unplanned transmission facility limit change described in Section 304.6 precludes the legal owner from complying with the submission timing requirements under subsection 2(3) of Section 502.15. The AESO uses the information provided by the legal owner to accurately model the power system.

Note that while notification of the time period is required to be provided to the AESO pursuant to subsection 2(1) of Section 304.6 and subsection 3(1)(c) of Section 502.15, the information provided under Section 304.6 is made in real time and may be preliminary, whereas the information provided under Section 502.15 is expected to be more refined.

3 The AESO's Modelling of the AIES

The AESO maintains: (i) a transmission-system object model, (ii) a state-estimator model component to the energy management system, and (iii) a geographic transmission system mapping database. Together

[1] "Authoritative Documents" is the general name given by the AESO to categories of documents made by the AESO under the authority of the *Electric Utilities Act* and regulations, and that contain binding legal requirements for either market participants or the AESO, or both. AESO Authoritative Documents include: the ISO rules, the Alberta reliability standards, and the ISO tariff.

these models constitute a comprehensive model of the AIES. A comprehensive model of the AIES is essential to the safe planning and operation of the interconnected electric system.

3.1 The List of Electrical and Physical Parameters

The AESO's *Electrical and Physical Parameters for Transmission System Model List*, is the list of electrical and physical parameters referred to in Section 502.15, and is available on the AESO website.

The modelling data and records provided by the legal owners of transmission system equipment and facilities to the AESO, set out in the *Electrical and Physical Parameters for Transmission System Model List*, support the AESO's maintenance of an accurate and comprehensive data model of the AIES. Data models are used for regulatory analysis, power system studies, asset type and location impact assessments, and real-time power-system coordination.

The AESO's *Guideline on the Electrical and Physical Parameters for Transmission System Model List* (the "Guideline") (attached as Appendix 1), provides further information on the modelling data and records set out in the *Electrical and Physical Parameters for Transmission System Model List*. The Guideline is a technical document that describes the objects in the list and the: (i) attributes of and associations between those objects; (ii) the terminology and nomenclature for referencing modelling objects; (iii) units of measure for expressing those attributes; and (iv) limitations on how objects and attributes are expressed.

4 Modelling Data and Records Submission Process

Section 502.15 sets out the requirements for the submission of modelling data and records. Modelling data may include, but is not limited to, the model of the new or modified equipment and the associated parameters. Records associated with the modelling data includethe provenance and effective dates of the data, and any other supporting documents.

References in Section 502.15 to modifications to existing equipment, machinery or other facility components include the decommissioning of facilities.

4.1 Connection Projects

For new facilities or modifications to existing facilities made pursuant to Section 502.15 that relate to a connection project under the AESO's connection process or the AESO's market participant choice process, a legal owner may provide modelling data and records as described in the *Project Data Update Package - Instruction Manual* ("PDUP IM"). The PDUP IM is available on the AESO website.

Subsection 2(3) of Section 502.15 authorizes the AESO to specify the timeframe within which the modelling data and records are to be submitted by the legal owner to the AESO. The AESO's connection process specifies that modelling data and records are to be submitted in stages with the Stage 5 Project Data Update Package to be submitted one hundred (100) days prior to energization.

Legal owners may submit modelling data and records for a connection project to the AESO in accordance with Section 502.15, in the forms that are available on the AESO website. It is recommended that legal owners consult the PDUP IM in order to properly input the modelling data into these forms.

The AESO is in the process of developing new generating unit ISO rules to replace the requirement in Operating Policy and Procedure 1306, *Reporting Equipment Changes*, which is no longer in effect, for the validation of generating unit modelling data and records to be provided to the AESO. In the interim, the AESO will request generating unit modelling data and records as part of the AESO's connection process, pursuant to subsection 6 of Section 502.15.

4.2 All Other Modifications

For all facility modifications made outside the scope of a connection project, a legal owner may provide the following modelling data and record submissions pursuant to Section 502.15:

- List of equipment(s) subject to modification;
- Date of modification;
- Type of change (e.g. addition, upgrade, replacement, modification or retirement);
- Description (e.g. change of rating, capacity, settings or characteristics);
- Additional supporting documentation which might include:
  - Amended single-line diagrams showing the change;
  - Name plate information and/or test reports; or
  - Engineering calculations of modelled characteristics; and
- Electronic PSS.E Input Data files recording the modelling change.
- A line data update for a line modification where there is a change in connectivity or an impedance change from previous impedance data that is greater than 5%.

In accordance with subsection 2(3) of Section 502.15, legal owners are required to submit this modelling data and records to the AESO no later than thirty (30) days prior to the proposed date of energization of new equipment or the modification of existing equipment, or thirty (30) days prior to the application of new ratings to existing equipment, unless otherwise specified by the AESO.

For facility modifications that are complex in nature, legal owners may choose to provide such modelling data and records to the AESO through the forms that are used for connection projects, in the manner described above.

4.3 Modelling data requests from the AESO

For written requests made by the AESO pursuant to subsections 5 and 6 of Section 502.15, the AESO specifies the required modelling data in the written notice.

5 Contact Information

5.1 Section 502.15

Modelling data and records and written submissions may be submitted to the AESO in accordance with subsections 2 and 4 of Section 502.15 at both of the following email addresses: PSMM@aeso.ca and OPTRAProjects@aeso.ca

Modelling data and records and written submissions may be submitted to the AESO in accordance with subsection 3 of Section 502.15 at the following email address: ops.coordination@aeso.ca

5.2 Section 304.6

Notification of an unplanned limit change to a transmission facility in accordance with Section 304.6 is as follows:

(a) a verbal notification in accordance with subsection 2(1) of Section 304.6 may be made by phone to the AESO system controller; and

(b) a written notification in accordance with subsection 2(2) of Section 304.6 may be submitted to the AESO at the following email address: ops.coordination@aeso.ca

Appendix

Appendix 1 - *Guideline on the Electrical and Physical Parameters for Transmission System Model List*

Revision History

Posting Date	Description of Changes
2018-12-20	Amended section 4.2 updated to include update of line data Amended Appendix section 5.2 to clarify modelling of voltage regulators Amended Appendix section 5.5 to clarify the applicability of various types of machines Amended Appendix sections to reflect adoption of FAC-008-AB-3, *Facility Ratings*.
2017-03-23	Appendix updated to reflect revised List; Bus ranges added to Table 1 of Appendix; Overviews added to Appendix for clarity; Glossary removed from Appendix; and Administrative amendments
2016-09-28	Administrative amendments
2016-07-26	Initial release

Appendix 1 – Guideline on the Electrical and Physical Parameters for Transmission System Model List (the "Guideline")

This Guideline provides technical information on the modelling data and records associated with each type of transmission system object in the *Electrical and Physical Parameters for Transmission System Objects List*. Each heading has the following format:

(a) a short definition of the data categories covering that equipment type (if necessary);

(b) a check list of the required data indicated by check boxes; and

(c) short paragraphs expanding on, or explaining, the check list where necessary.

Changes to the nomenclature for some transmission system modelling objects have been made to align with *IEC 61970-301 Common Information Model* (CIM). The former nomenclature is identified by an asterisk (*) and is included in parentheses after the standard nomenclature. Object nomenclature used in this Guideline are identified in **bold underlined** print.

1. Load and Generation Measurement

1.1 Measurement Point

Overview: A "Measurement Point" is the point where electric power flows into or out from the transmission system into the facilities of the system access contract holder.

Checklist:

☐ Unique **MP_ID**

Explanation:

(i) The Measurement Point identifier or **<u>MP_ID</u>** is defined by the Metering Services Provider. The data submitter obtains the **<u>MP_ID</u>** from the Metering Services Provider and forwards it to the AESO. The AESO may assign an interim, temporary **<u>MP_ID</u>** in consultation with the data submitter. In the case of "Behind-the-Fence" loads (loads which are served by self-generation and which therefore represent power both generated and used at the same site without passing through a revenue meter) a unique **<u>MP_ID</u>** beginning with the letters "*BTF_*" will be assigned by the AESO.

2. Load

Overview: A "Load" is a non-rotating sink or source of MW.

Checklist:

☐ The bus to which load connects

☐ NAICS code

☐ Load response characteristic

☐ Load at energization

Explanation:

(i) Loads are to be aggregated to the first non-transmission bus or generation bus upstream of the physical loads.

(ii) "Unmetered Volumes" (also called "Behind the Fence" loads) are to be submitted in the same way as any other load.

(iii) Every Load is characterized by some industrial type, or group of industries, as identified in the North American Industrial Classification System (NAICS).

(iv) NAICS code is typically one of the codes listed in Table 1.2-1. If using a different NAICS code, submit the supporting reference material from NAFTA.

(v) Specify a separate ***energyConsumer.name*** (**ELEMENT_CODE**) for each different industry to be represented.

(vi) If submitting a NAICS code of "99", specify the load response characteristic as a breakdown of constant power, constant impedance, and constant current, in percent for both real and reactive components, to a total of 100%, with a default value of 100% constant power if no other information is available. Submit unmetered volumes (also called behind-the-fence loads) in the same way as any other load.

TABLE 1.2-1 STANDARD INDUSTRY TYPES

NAICS CODE	Industry
11	Agriculture
32	Manufacturing - general
33	Heavy Manufacturing
40	Commercial and Services
71	Arts, Entertainment and Recreation
113	Forestry and Logging
211	Oil And Gas Extraction
486	Pipelines
814	Private Households
22131	Farming – Irrigation
99	Unspecified

(vii) Specify a separate Element Code for each different industry to be represented.

(viii) Load at energization is the estimate of peak load after reaching steady state on day one (1) of energization.

3. Transmission Facilities

Overview: A "transmission facility" is a substation or transmission line.

Checklist:

☐ **FACILITY_CODE**

☐ Geographic location

☐ **operatorCompany (OWNER*)**

Explanation:

(i) The **FACILITY_CODE** is the unique identifier assigned to each transmission facility assigned by the AESO. The identifier can be up to to twenty characters consisting only of capital letters, the digits 0 through 9, periods and hyphens. The data submitter may request a particular identifier. The preferred **FACILITY_CODE** is a simple, pronounceable, unambiguous word; or a short number optionally combined with one or more letters, for example:

- ROSSDALE
- D05
- 14.83L

(ii) When Transmission Facilities are segmented or merged, the AESO will issue new **FACILITY_CODE**(s) as appropriate. The data submitter may consult with the AESO regarding the new **FACILITY_CODE**(s).

(iii) Geographic location describes the detailed location of the transmission facility. A data submitter may submit geographic location data either as a shape file or as a 1:10,000 scale map showing the line route or substation polygon. The geographic location includes a GPS location for any substation; and GPS locations may be submitted for every structure of a Transmission Line, or for the line termini and for points where the line route significantly changes direction.

(iv) ***operatorCompany*** is the legal corporate name of the entity that holds title to the transmission facility.

3.1 Substations and Switching Devices

Overview: A substation is a facility designed for transformation or switching operations. A switching device is a device designed to close, or open or both, one or more electric circuits.

Checklist:

- ☐ Component substation Single-Line Diagram or Diagrams, indicating for each switching device the:
  - ☐ Type of equipment
  - ☐ Type of control
- ☐ Communications block diagram
- ☐ ***substation.description*** (***SUBSTATION_NAME**)
- ☐ **LAND_LOCATION**
- ☐ ***subGeographicRegion*** (***AREA_CODE**)

Explanation:

(i) A Single Line Diagram shows **ELEMENT_CODE**(s), locations of switching devices with their switch numbers, electrical connectivity of all Elements, and ratings of each component of the current path, metering and control CTs and PTs. Switching devices are identified on a Single Line Diagram using annotation or symbols for:

a. equipment, such as circuit breakers, disconnects, circuit switches; and

b. controls, such as synchrocheck, synchronizer, motor operated, and supervisory controls.

The data submitter may submit multiple Single Line Diagrams to cover all required information.

(ii) **substation.description** is included only where the facility owner assigns names to their substations. The ISO will, upon request, provide assistance in selecting a **substation.description** (*SUBSTATION_NAME). **Substation.description** is a pronounceable text string of 50 characters or less, consisting only ofthe letters, digits 0-9, spaces, and hyphens. Substation names may not include corporate names. Substation names may not include variations on geographical names that are already used for other substations.

(iii) **LAND_LOCATION** is the Dominion Land Survey designation at minimum resolution to the quarter-section, and preferably the legal sub-division.

(iv) **LAND_LOCATION** is to conform to the following format: LL-SS-TT-RRWP where:

A. LL is the legal subdivision or quarter-section

B. SS is the section number

C. TT is the township

D. RR is the range

E. P is the parallel.

The AESO assigns a ***subGeographicRegion*** according to the planning needs of the interconnected electric system.

3.2 Transmission Lines

Overview: A transmission line begins and ends with connection to a substation bus or at its connection to a transmission line of a different owner. A transmission line may have two or more terminals.

Checklist:

☐ Structure List or Line Survey

☐ Transmission Line Segment Summary

☐ Structure Drawings

Explanation:

(i) A Structure List or Line Survey describes the line construction structure by structure

(ii) A transmission line comprises one or more line segments. The Transmission Line Segment Summary consists of a drawing or table showing how the segments connect.

(iii) Structure Drawings are comprised of dimensioned drawings of every tangent structure-type mentioned on the Structure List or Line Survey.

4. topologicalNode (*Busses)

Overview: A ***topologicalNode*** is a node that serves as a common connection for two or more circuits. A ***topologicalNode*** may comprise any number of zero-impedance equipment such as switches, ***connectivityNodes***, and busbars or physical bus segments which are subsumed into the ***topologicalNode***.

Checklist:

☐ Unique ***topologicalNode.name*** (*__BUS_ID__)

☐ ***nominalVoltage*** (*__NOMINAL_VOLTAGE__)

☐ ***equipmentContainer.name*** (*__FACILITY_CODE__)

Explanation:

(1) A new ***topologicalNode.name*** will generally follow the pattern used by existing ***topologicalNode***s in the same area. The ***topologicalNode.name*** is an integer assigned by the AESO consistent with the following:

TABLE 1 – STANDARD BUS RANGES

BUS-RANGE DESCRIPTION	**BUSRANGE BUSRANGE_HIGH**	
	From_	**To _**
General transmission busses	1	999
	1000	1999
	540001	549999
Distribution busses	2000	4999
	15000	19999
	20001	29999
	30000	39999
	40000	49999
	550001	558999
Transformer midpoint busses	5000	8999
	10000	14999
	559001	559999
Temporary busses	9000	9999
Isolated system busses	50000	59999
Collector System (renewable) busses	60000	69999
	560001	569999
Resource Adequacy generation busses	70000	79999
	570001	579999
Unassigned	80000	99999
	580001	599999
Projects at Stage 1	990001	999001

(2) ***nominalVoltage*** on the transmission system is one of 500kV, 240kV, 138kV, or 69kV. ***nominalVoltage*** may differ somewhat from the actual operating voltage of the transmission system at any location. The owner of a distribution facility will assign nominal bus voltage on the distribution-voltage bus

(3) ***equipmentContainer.name*** (*FACILITY_CODE) is the exact ASCII text string previously assigned by the AESO for the facility containing the ***topologicalNode***.

5. Equipment (*ELEMENTS)

*5.1 General requirements for conductingEquipment (*Elements)*

Overview: A ***conductingEquipment*** is a current-carrying device that, by virtue of having inherent impedance, contributes to the admittance matrix of the power-flow model.

Checklist:

- ☐ ***Equipment.name*** (***ELEMENT_CODE**)
- ☐ ***equipmentContainer.name*** (***FACILITY_CODE**)
- ☐ ***operatorCompany*** (***OWNER_NAME**)
- ☐ ***normallyInService*** (***NORMALLY_INSERVICE**)
- ☐ Equipment in-service date or project
- ☐ Equipment decommission date or project (if known)

Explanation:

(i) The ***equipment.name*** is the unique identifier assigned to each piece of conducting equipment. The identifier can be up to twenty characters consisting only of capital letters, the digits 0 through 9, periods and hyphens. The AESO may, upon request, provide assistance in selecting a unique identifier. Preferred identifiers are a simple, pronounceable, unambiguous word; or a short number optionally combined with one or more letters.

(ii) ***equipmentContainer.name*** provides clarity in identifying which facility contains the Element. The ***equipmentContainer.name*** is the exact ASCII string the AESO previously assigned as the ***FACILITY_CODE*** for the facility containing the equipment.

(iii) ***operatorCompany*** is the legal corporate name of the entity that holds title to the Element.

(iv) ***normallyInService*** is identified as TRUE if the equipment is normally energized and able to carry current; and is identified as FALSE if the equipment is normally on standby or de-energized.

(v) If the equipment is put in service by maintenance change-out, the data submitter is to submit the date on which the change-out takes effect. If the equipment is put in service by an AESO project, the AESO will associate the equipment with that project number and energization number. Note that one energization may cover a period no longer than three months.

(vi) If the equipment is decommissioned by maintenance change-out, the data submitter is to submit the date on which the change-out takes effect. If the equipment is decommissioned by an AESO project, the AESO will associate the equipment with that project number and energization number. Note that one energization may cover a period no longer than three months.

5.1.1 Element-to-Measurement Point Mapping

Overview: Each Measurement Point is cross-referenced to elements that either sink or supply the metered power. Every **MP_ID** serves one or more elements (either machines or loads).

Checklist:

- ☐ **MP_ID**
- ☐ ***conductingEquipment.names*** (***ELEMENT_CODE**s)
- ☐ Portion of **MP_ID** delivered to or from each ***conductingEquipment***.

Explanation:

(i) **MP_ID** is the unique identifier assigned by the Metering Services Provider

(ii) ***conductingEquipment.name*** is the exact ASCII string the data submitter previously assigned for the equipment.

(iii) The portions of the **MP_ID** summed over all the ***conductingEquipment*** that serve that **MP_ID** equal to one hundred percent (100%).

5.1.2 Applicable Dynamic Control Systems

Overview: A Dynamic Control System is an automated system that operates within a 0.01s to 10.0s timeframe, to achieve prescribed relationships between selected system variables by comparing functions of these variables to effect control of an identified element. For the purposes of this Guideline, the transfer function inherent to a machine itself is considered a "control system".

Checklist:

- ☐ ***conductingEquipment.name*** (*<u>**ELEMENT_CODE**</u>)
- ☐ Control System Type
- ☐ Manufacturer
- ☐ Model
- ☐ Control System Block Diagram

Explanation:

(i) <u>**conductingEquipment.name**</u> is the exact ASCII string the data submitter previously assigned for the equipment.

(ii) Control system type is one of those listed in Table 1.5-1:

TABLE 1.5-1 STANDARD CONTROL SYSTEM TYPES

CONTROL_SYS	Applies to
Compensator	Large individual machines
Exciter	Large individual machines
Exciter limiter	Large individual machines
Generator/condenser	Machines
Synchronous/induction motors	Machines
Stabilizer	Large individual machines
Turbine governor	Large individual machines
Remedial action scheme	All element types
Load	Loads
Converter controls	Direct current converter
Other power electronics	All elements

(iii) The equipment manufacturer generally provides the data submitter with the control system block diagram.

The AESO may identify the protection data that is to be provided to the AESO on a case-by-case basis through discussions with legal owners. In general, underfrequency load shedding relays, under voltage load shed relays, synchrocheck relays and synchronizers are essential to transmission modeling.

5.1.3 Applicable PSS/E or PSLF Model Data

Overview: Submit dynamic model data that accurately represents the element's dynamic behaviour and appears on the WECC list of accepted standard PSS/E and PSLF library models[2]. A user-written model may be submitted along with the library model.

Checklist:

- ☐ **conductingEquipment.name** (***ELEMENT_CODE**)
- ☐ Model Name
- ☐ Description of Model
- ☐ Model Block Diagram
- ☐ Parameter Names
- ☐ Parameter Values
- ☐ Source-code or compiled object

Explanation:

(i) The **conductingEquipment.name** is the exact ASCII string that was previously assigned for the equipment.

(ii) "Model Name" is the name of a standard library model on the WECC approved models list, to be submitted for every dynamic control system, regardless of whether a user-written model is submitted.

In the case of power electronic control systems that the AESO determines cannot be adequately represented by a standard library model complete with its submitted parameters, an adequate detailed user-written model is to be submitted IN ADDITION to the standard library model. This user-written model is to be adequate for dynamic study of the transmission system in the point zero one second (.01s) to ten second (10s) timeframe and need not simulate proprietary detail of the flexible alternating current transmission system device. Any detailed user-written model submitted to meet this Guideline is to be provided to the AESO for distribution with the AESO dynamic data files.

Models are to be submitted for PSS/E software and / or PSLF software. IEEE models may be submitted in addition to the PSS/E and PSLF models. If models are submitted in only one of PSS/E or PSLF the party responsible for submitting the data is to consult with AESO regarding converting the data to the other format.

(iii) A description is to accompany each model, providing a high-level assessment of the model's accuracy and the scenarios under which it is applicable.

(iv) A Model Block Diagram is to be submitted for all user-written models, except for standard library models.

(v) Parameter names are to be the same as specified for the model in the relevant software documentation.

(vi) All parameter values are to be provided; do not leave any parameter values blank.

(vii) The source-code is a text listing of programmatic commands that represent a control system model. The compiled object is the machine-code produced by a compiling the source-code, which can then be called by the power system simulation program to simulate the control system behavior (often distributed as a .dll file).

[2] The WECC list of accepted standard PSS/E and PSLF library models is available on the WECC website at the following link under the "Approved Documents" tab: https://www.wecc.biz/PCC/Pages/MVWG.aspx.

(viii) Model source-code or compiled object is to be submitted for all user-written models, except for standard library models.

5.2 Transformers

Overview: "Transformer" refers to a voltage transformer, phase-shifting transformer, voltage regulator or grounding transformer. Transformers have significant scope for variation from one transformer to the next. The data is requested in a standard format that can accommodate both common transformers and their variations; and more unusual transformers. Voltage regulators are modelled as the transformer tap changer of the associated power transformer. Test reports are not required for regulators.

Checklist:

☐ Transformer nameplate

☐ Test report

Explanation:

(a) A ***powerTransformer*** contains multiple windings and optionally tap-changers. A single name-plate describes all the ***conductingEquipment*** that the ***powerTransformer*** contains.

(b) Test data in the test report is defined in IEEE Standard C57.12.00. Test data is to be provided for both positive and zero sequence. If the transformer has a tertiary delta winding, test data is provided for the tertiary delta winding closed, and the tertiary delta open circuited. Transformer impedances are not required for regulators.

5.2.1 Transformer Windings

Overview: Refer to the AESO's *Transformer Modelling Guide* for derivation of the Transformer equivalent circuit and windings.

Checklist:

☐ **equipment.name** (***ELEMENT_CODE**)

☐ Winding identifier

☐ Connection (delta/wye)

☐ Neutral Grounding status

☐ Grounding impedance

☐ Ratings

☐ Rated voltage

☐ Identification of the bus to which winding connects

Explanation:

(i) ***equipment.name*** is the exact ASCII string previously assigned to the ***powerTransformer*** that contains this winding.

(ii) Provide the two seasonal normal ratings and four seasonal emergency ratings and terminations for each winding identifier consistent with the methodology documented in accordance with FAC-008-AB-3, *Facility Ratings*.

(iii) Submit the winding connection as either Y or D for each winding. For other connections, please contact the AESO.

(iv) For each winding, neutral grounding status is "TRUE" if the winding is grounded and "FALSE" if the winding is ungrounded. The grounding impedance shall be resistance and reactance values expressed in ohms. Indicate solidly grounded windings by a grounding impedance of zero.

(v) The ratings of the windings may be:

A. identical (for example, in a two-winding transformer, primary and secondary windings are equally rated);

B. related (for example, the two secondaries of a split-secondary are each half the rating of the primary);

C. arbitrary (for example, the windings of a three-winding transformer may all be differently rated.)

Each winding may have one or more ratings, expressed in MVA. Provide all ratings for each winding, including provisional ratings. For each rating, indicate the condition under which the rating is valid. Clearly indicate which ratings are available and which are provisional. If the transformer capacity is limited by separate equipment in addition provide the limiting condition and its rating.

5.2.2 Transformer Tap Changers

Overview: Windings may be associated with tap-changers. For each tap-changer on a winding, provide all of the following information:

Checklist:

☐ Tap points

☐ Tap-changing strategy (manual, automatic)

☐ On-load tap changing (True/False)

☐ Control band

☐ Actual Tap

Explanation:

(i) The voltage rating of each tap (for a voltage controlling tap-changer), or the phase shift for each tap (for a phase-shifting transformer), or indicate that no tap-changer exists for this termination;

(ii) The tap-changing strategy, one of:

TABLE 1.5-1 STANDARD TAP-CHANGING STRATEGIES

TAP_CHANGING_CODE	TAP_CHANGING_DESCR
OFF	Off-load tap changing (having external controls on the transformer tank but requiring de-energization)
OLTC-M	On-load tap changing (manual-local)
OLTC-S	On-load tap changing (supervisory, i.e. manual-remote)
OLTC-A	On-load tap changing (automatic, i.e. under voltage regulation)
FIXED	Fixed taps (having no external control)
PHASE-P	Phase shifting, controlling MW
PHASE-Q	Phase shifting, controlling MVAr

(iii) Indicate which transformer termination is intended to be controlled by the tap-changing action - usually the "X" bushing of a distribution load transformer. If a remote bus is intended to be controlled, enter the bus number. Provide the voltage range for tap-changer control, in per-unit of the system nominal voltage.

(iv) For a voltage controlling tap-changer, specify the control band as the maximum and minimum allowed voltage at the controlled bus. For a phase-shifting tap changer specify the control band as the power flow into the termination.

(v) Model the voltage regulator as a tap-changer on the directly connected winding.

5.2.3 Transformer Impedances

Overview: Refer to the AESO's *Transformer Modelling Guide* for derivation of the Transformer equivalent circuit. The equivalent circuit is to include positive and zero sequence resistance and reactance for every series branch in the equivalent circuit. The equivalent circuit is to include conductance and susceptance to ground for every shunt branch in the equivalent circuit.

Checklist:

☐ Transformer equivalent circuit

☐ Positive and zero-sequence real and reactive impedances

☐ Positive and zero-sequence real and reactive shunt admittances

☐ Short Circuit Impedances and Load Losses

☐ Open Circuit Excitation Currents and No-Load Losses

☐ Phase angle shift

☐ Significant Off-neutral impedance of tap-changing transformers

Explanation:

(i) The equivalent circuit impedances are expressed in per-unit based on rated voltage of the transformer and on the MVA rating that was used to establish impedances.

(ii) Express short circuit impedance in per-cent and load loss in kW.

(iii) Express open-circuit excitation in per-cent and no-load loss in kW.

(iv) If the transformer is a voltage transformer, submit the phase angle shift as a fixed value. If the transformer is a phase-shifting transformer, submit the phase angle limits. If the impedance of a transformer with taps differs by 15% or more from the impedance at the rated tap, then the tested impedance shall be submitted at the maximum and minimum taps in addition to the neutral tap, and at enough of the intervening taps so that the total difference from one submitted impedance to the next is always 25% or less.

(v) The AESO will assign a two-character circuit identifier for each impedance branch in the equivalent circuit.

5.3 Reactor and Capacitor Banks

Overview: A "Reactor and Capacitor Bank" is a simple switched or un-switched bank.

Checklist:

☐ Bank nameplate

☐ Capacitance (Farads)

☐ Inductance (Henrys)

- ☐ Rated MVA (Capacitive)
- ☐ Rated MVA (Inductive)
- ☐ Rated voltage
- ☐ Control strategy
- ☐ Control Bus
- ☐ Maximum control-band voltage
- ☐ Minimum control-band voltage
- ☐ Connection (Delta/Y)
- ☐ Neutral Grounding status
- ☐ Grounding impedance

Explanation:

(i) Express the rated MVA at the bank rated voltage.

(ii) Express the Control strategy as one of the following:

TABLE 1.5-3 STANDARD SHUNT-SWITCHING STRATEGIES

Strategy	Explanation of Strategy
Fixed	The Shunt cannot be switched
Manual	The Shunt can be switched on or off by personnel on site
Supervisory	The Shunt can be switched on or off remotely
Automatic	The Shunt switches on or off under control of an automated control system

(iii) The “Control Bus” is the bus at which the voltage is monitored for the purpose of controlling this shunt device. Refer to the bus by the **BUS_CODE** assigned to the bus by the AESO.

(iv) Express maximum and minimum voltages of the control band in per-unit of the system nominal kV at the Control Bus.

(v) Express grounding resistance and reactance in ohms, with zero indicating a solidly grounded bank.

5.4 Line Segments

5.4.1 Line Segments Construction

Overview: A “Line Segment” is a portion of a transmission line that has consistent physical attributes of conductor and cross-section throughout the length of the segment.

Checklist:

- ☐ **conductingEquipment.name**
- ☐ Line Segment length (km)
- ☐ Conductor type
- ☐ # of conductors per bundle

- ☐ Bundle spacing (m)
- ☐ Average sag (m)
- ☐ Typical tangent structure
- ☐ Typical structure height (m)
- ☐ Positive-sequence real and reactive impedances and susceptances
- ☐ Zero-sequence real and reactive shunt admittance

Explanation:

(i) A tap off a line that enters a substation, irrespective of length, is to be designated as a separate Line Segment. However, if a Line Segment is:

A. less than 500 meters and less than 20% of the line's total length from substation to substation;

B. less than 50 meters; or

C. less than 5% of the line's total length from substation to substation,

it can be considered part of the adjacent Line Segment.

(ii) Conductor type is defined by name as shown in Table 1.5-4. If using a different conductor type, the conductor data sheet is to be submitted.

TABLE 1.5-4 CONDUCTORS

CONDUCTOR_NAME
CHICKADEE
COCHIN
COREOPSIS
COSMOS
CROWSNEST
CURLEW
DOVE
DRAKE
HADDOCK
HAWK
HORNBILL
IBIS
LINNET
MERLIN
OSPREY
PARTRIDGE
PELICAN

CONDUCTOR_NAME
PENGUIN
PIGEON
RAVEN
SPARROW
TRILLIUM
WAXWING

(iii) The tangent structure is designated with a reference to the relevant Structure Drawings.

(iv) The structure height is measured from the ground to the lowest conductor.

(v) Submit Line Segment impedance in ohms.

(vi) Submit Line Segment susceptance and terminal-shunt admittance in Siemens.

(vii) The submission includes the assumed ground resistivity (ohm-m) on which the values are calculated.

5.4.2 Line Segment Ratings

Overview: None

Checklist:

☐ Conditions

☐ Ratings

☐ Limiting Factors

Explanation:

(i) The ampere ratings of the Line Segment for each of Summer Normal, Summer Emergency, Winter Normal and Winter Emergency conditions consistent with the methodology documented in accordance with FAC-008-AB-3, *Facility Ratings*.

(ii) The Line Segment rating as limited by the unconstrained line conductor thermal rating is identified for each condition. If the Line Segment has a more limiting rating, identify the most limiting factor that limits the rating of the Line Segment. The Line Segment is considered to terminate at the breaker or breakers. Submit the rating corresponding to that limiting factor for each condition. Describe limiting factor(s) as one of:

TABLE1.5-5 CAPACITY-LIMITING CONDITIONS

CONDITION_DESCR
Circuit Breaker
Current Transformer
Line conductor Thermal rating
Ground clearance
SLAPAC dampers
Underbuild
Disconnect Switch
Jumpers

Buswork
Protection setting
Connectors

If some other factor limits the capacity of the Line Segment, describe the factor in detail in a letter to the AESO.

5.4.3 Line Mutuals

Overview: None

Checklist:

The following is submitted for each Line Segment Branch in the pair of Line Mutuals:

- ☐ ***conductingEquipment.name***s of the two Line Segment Branches
- ☐ Real and reactive mutual impedances (ohms)
- ☐ Start-of-parallel distance (m)End-of-parallel distance (m)
- ☐ Assumed direction of flow for the mutual calculation

Explanation:

(i) When two Line Segments form any part of a parallel between two Transmission Lines where:

A. the length of the cumulative parallel is greater than 20% of the length of either line, from substation to substation; and

B. the separation of the parallel is less than 500 m,

the mutual impedances are submitted on a Line Segment-by-Line Segment basis..

(ii) Direction of flow is indicated by reference to the ***topologicalNode***s at the line ends by declaring which ***topologicalNode*** current is presumed to be flowing from.

(iii) Start-of-parallel is the distance from the “from” end of the Line Segment Branch to the point where the mutual coupling begins. If the entire length of the Line Segment Branch parallels the other Line Segment Branch this value will be 0.

(iv) End-of-parallel is the distance from the “from” end of the Line Segment Branch, to the point at which the parallel ends. If the entire length of the Line Segment Branch parallels the other Line Segment Branch, this value will be the same as the Line Segment Branch length.

(v) Direction of flow is indicated by reference to the ***topologicalNode***s at the line ends by declaring which ***topologicalNode*** current is presumed to be flowing from.

5.5 Generating Units, Aggregated Generating Facilities, Large Motors and Battery Energy Storage Facility

Overview: A “Machine” is a rotating generator or motor or large power electronic converter set. In the case of a collector-based generating “collector” such as wind, or mini-hydro; “Machine” means the aggregated equivalent machine representing the power plant.

The following table summarizes how this section 5.5 applies to each type of machine:

Relevant Section	Type	Connection	Applicable MARP Size

5.5.1	Generating Unit	Directly connected to transmission system or industrial complex	Greater than 4.5 MW for individual unit
5.5.2	Aggregated Generating Facility		Greater than 4.5 MW for each AGF
5.5.3	Battery Energy Storage Facility	Directly connected to transmission system or industrial complex	Greater than 4.5 MW
5.5.1	Motors	Directly connected to transmission system	Greater than 4.5 MW for individual unit
5.5.1 and 5.5.4		In an industrial complex	Individual unit at > 0.9 MW and aggregate to > 4.5 MW at each point of delivery
		Connected to distribution system at 1kV+	
5.5.1 and 5.5.5	Generating Unit	Connected to distribution system	Greater than 5 MW at each point of delivery
5.5.2 and 5.5.5	Aggregated Generating Facility		

5.5.1 Large individual machines

Overview: “Large individual machines” are generating units or large electric motors of 4.5 MW or more directly connected to the transmission system or connected to an industrial complex..

Checklist: (as applicable to the specific machine or converter type)

- ☐ Nameplate
- ☐ Manufacturer’s datasheet, including at a minimum:
  - ☐ Rated MVA
  - ☐ Rated kV
  - ☐ Maximum Authorized Real Power (MARP in MW)
  - ☐ Minimum stable generation (MW)
  - ☐ Reactive Power capability curve
  - ☐ Inertia constant
  - ☐ Positive-sequence saturated and unsaturated subtransient reactance

- ☐ Positive-sequence saturated and unsaturated subsynchronous reactance
- ☐ Positive-sequence saturated and unsaturated synchronous reactance
- ☐ Transient time constant
- ☐ Subtransient time constant
- ☐ Negative sequence resistance
- ☐ Negative sequence synchronous reactance
- ☐ Zero-sequence resistance
- ☐ Zero-sequence synchronous reactance
- ☐ Station Service load (MW at zero generation)
- ☐ Unit Service load (incremental MW per MW of generation)
- ☐ Saturation
- ☐ “G” for “generator or “M” for “Motor”
- ☐ The bus to which machine connects
- ☐ The “D” curve (for Generators)
- ☐ The “V” curve (for Generators)
- ☐ Power Variation Curve as a function of Temperature
- ☐ Nameplate of Exciter (for synchronous Generators)
- ☐ Model Validation test report

Explanation:

(i) Machine inertia constant is the combination of the Generator and Driver (or for the motor and the connected load).

(ii) Express machine impedances in per-unit on machine MVA rating and machine kV rating.

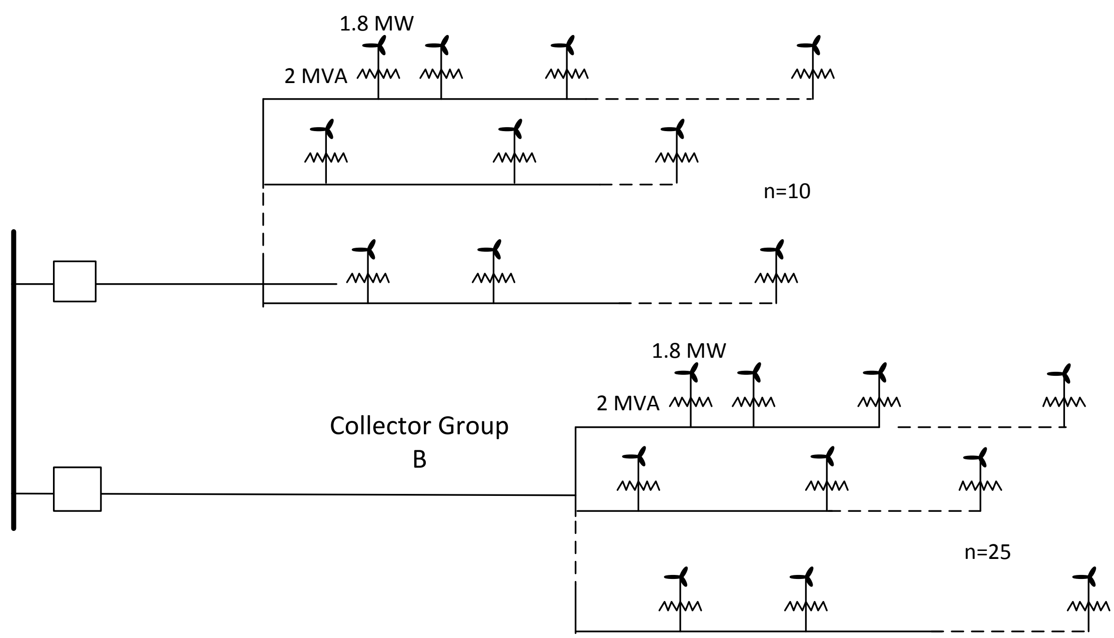
(iii) For synchronous machines, submit both direct-axis and quadrature-axis impedances and time constants.

(iv) Express saturation either as saturation factors or as a saturation curve.

5.5.2 Aggregated Generating Facilities

Overview: Aggregated Generating Facilities are comprised of: a collector switch; a number of individual matched generator units complete with individual step-up transformers; and a collector network made up of line segments of varying length joining the individual generator-transformer units to the main collector switch where the total aggregated capacity is 4.5 MW or more and directly connected to the transmission system or connected to an industrial complex. Data is separately for each collector group in accordance with Figure 1-1.

FIGURE 1-1: TYPICAL COLLECTOR SYSTEM GENERATORS



Checklist: (as applicable to the specific machine or converter type)

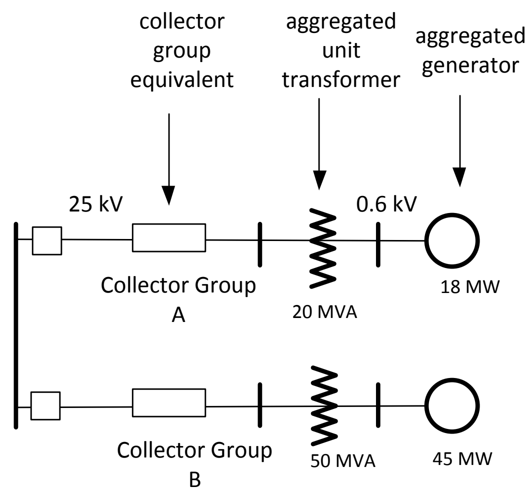
- ☐ Reduced representation diagram of Collector System
- ☐ Positive-sequence total real and reactive impedance of the collector system
- ☐ Zero-sequence total real and reactive impedance of the collector system if grounded
- ☐ Positive-sequence real and reactive shunt admittance of the collector system
- ☐ Zero-sequence real and reactive shunt admittance of the collector system if grounded
- ☐ Step-up transformer Impedances
- ☐ Typical generator nameplate
- ☐ Count of individual generators
- ☐ Maximum Authorized Real Power at collector bus (MARP in MW)
- ☐ Generator's Manufacturer's data sheet, including at a minimum
  - ☐ Generator type
  - ☐ Maximum real power out
  - ☐ Minimum real power operation
  - ☐ Maximum reactive power out
  - ☐ Minimum reactive power out
  - ☐ Equivalent positive-sequence impedance for three-phase fault calculations
  - ☐ Equivalent zero-sequence impedance for single-phase fault calculations

- ☐ Houseload
- ☐ Generator impedance
- ☐ Generator step-up transformer data
- ☐ Shunt device nameplate for shunt devices residing within turbine units
- ☐ Shunt device manufacturer's data for shunt devices residing within turbine units
- ☐ Count of individual shunt devices

Explanation:

(i) The reduced model represents each collector group as the equivalent impedance of the collector network, a single aggregate wind generator and a single aggregate step-up transformer representing the sum of the individual turbines and turbine step-up transformers on that collector group. Figure 1-2 shows the reduced model of the collector systems shown in in Figure 1-1.

FIGURE 1-2: EQUIVALENT COLLECTOR SYSTEM



(ii) Collector equivalent impedances are expressed per-unit on collector nominal voltage and a 100 MVA base.

(iii) The individual data for a single wind turbine generator, and a typical generator nameplate, is to be submitted for each group of identical generators. If all wind turbine generators in a wind power facility are identical, only one nameplate and one set of manufacturer's data need be submitted.

(iv) Generator type will be one of: conventional synchronous, conventional induction, wound rotor induction with variable rotor resistance, doubly-fed induction, or full converter.

(v) Generator impedances are expressed in per-unit on the machine rated MVA base

(vi) Include with the collector-system generator data only those shunt devices that are distributed throughout the collector system within or at the turbine generator locations. Refer to section 1.5.3 to submit data for any centrally located shunt devices.

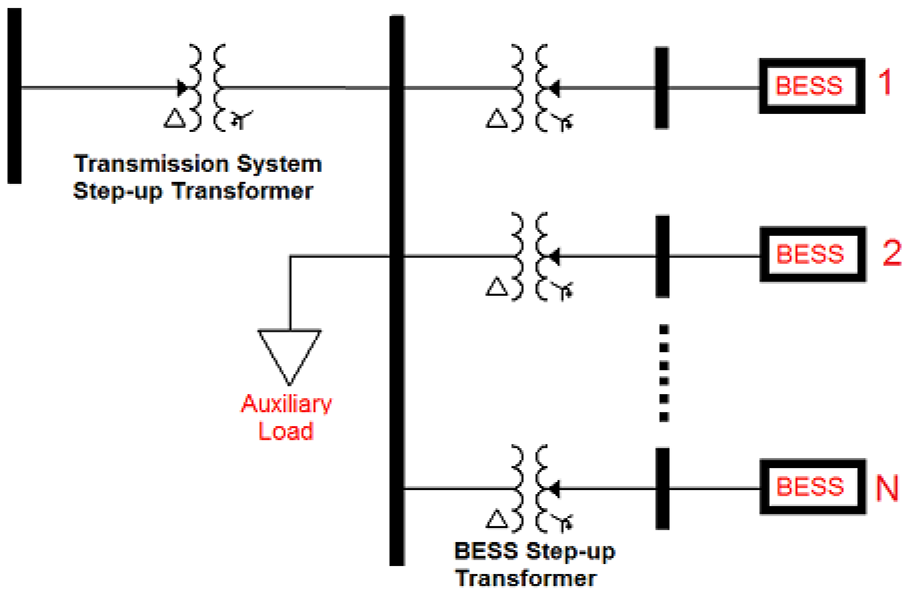
(vii) Refer to section1.5.2 to submit the data for the generator step-up transformer. If all wind turbine generators in a wind power facility are identical, only one set of data need be submitted.

(viii) The requirements to submit controls system data and dynamic modelling dataapply to equivalent collector-system generators.

5.5.3 Battery Energy Storage Facility

Overview: Battery Energy Storage Facilities (BESFs) are facilities governed by Section 502.13 of the ISO rules, *Battery Energy Storage Facility Technical Requirements* and Section 502.14 of the ISO rules, *Battery Energy Storage Facility Operating Requirements* with aggregated capacity greater than 4.5 MW. Data is submitted separately for each collector group in accordance with Figure 1-3.

FIGURE 1-3: TYPICAL BATTERY ENERGY STORAGE FACILITY



Checklist:

- ☐ Reduced representation diagram of Collector System
- ☐ Maximum Authorized Charging Power (MACP in MW)
- ☐ Maximum Authorised Discharing Power (MADP in MW)
- ☐ Generator's Manufacturer's data sheet, including at a minimum
  - ☐ Number of BES Converter Units
  - ☐ Unit Converter Rating (MVA)
  - ☐ Rated Terminal Voltage (kV)
  - ☐ Maximum Temporary Ratings and Time Characteristics
  - ☐ Minimum real power operation
  - ☐ Maximum reactive power out
  - ☐ Minimum reactive power out
  - ☐ Equivalent positive-sequence impedance for three-phase fault calculations

- ☐ Equivalent zero-sequence impedance for single-phase fault calculations
- ☐ Converter Type
- ☐ Equivalent Converter Series Impedance
- ☐ Battery Type
- ☐ Bulk Electric System Step-Up Transformers

☐ Auxiliary Load Characteristics

☐ Maximum Continous Operation under MADP (Hours)

☐ Model Validation Report

Explanation:

(i) See Section 502.13 and AESO's *Consolidated Authoritative Document Glossary* for definitions of maximum authorized charging power (MACP) and maximum authorized discharging power (MADP).

(ii) Maximum reactive power out and minimum reactive power are calculated based on the MACP and MADP.

(iii) The equivalent positive-sequence impedance is the impedance of the converter filter behind the converter step-up transformer. The total impedance of this equivalent impedance and converter step up transformer determines the three-phase fault level at the point of connection.

(iv) Each BES Converter Unit consists of a step-up converter transformer, a converter and a set of battery racks.

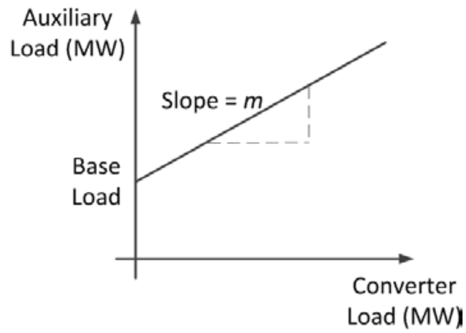
(v) A BESF consists of one or more BES Converter units to reach the required MVA rating and an auxiliary load representing the total cooling load of the BES Converter units. If the BES converter units have different MVA ratings, each unit rating should be provided.

(vi) The auxiliary load consists of the converter cooling load and the substation base load. The cooling load, which is the major part of the auxiliary load in BESFs, is usually a motor load and is a function of the power converted by the converter. When the converter operates at its maximum capacity, the cooling load and consequently the auxiliary load is maximum. The auxiliary load may have a nonlinear characteristics versus converter load but, for the purpose of modelling a simplified liner model as described in the following equation is preferred.

$$P_{Auxiliary} = m \times P_{Converter} + P_{Base\ Load}$$

Figure 1-4 shows the characteristics of this simplified load:

FIGURE 1-3 - AUXILIARY LOAD CHARACTERISTICS VERSUS CONVERTER LOAD (MW)



(vii) The auxiliary load may have a low power factor because it is a motor load. The load power factor or the reactive power at the auxiliary load value should be provided.

5.5.4 Industrial Complex Aggregated Machines and Distribution Connected Motors

Overview: Aggregated machines are a totaled MVA equivalent for induction motors, synchronous motors and motors controlled by a power electronic drive located on the load side of a point of delivery or generating units connected to an industrial complex where:

(i) the individual machines are connected at 1000 V or higher;

(ii) the individual machines have a capacity of 0.9 MW or more; and

(iii) the total connected capacity is 4.5 MW or more.

If any of the foregoing three conditions is not true, the data does not need to be submitted.

Checklist

The checklist includes all applicable items of Large individual machines or Aggregated Generating Facilities and:

- ☐ ½-cycle Fault contribution on the high voltage side of the Point of delivery
- ☐ 3-cycle Fault contribution on the high voltage side of the Point of delivery
- ☐ Aggregate MVA (low-voltage induction motors)
- ☐ Aggregate MVA (medium-voltage induction motors)
- ☐ Aggregate MVA (medium-voltage synchronous motors)
- ☐ Aggregate MVA (synchronous generators)
- ☐ Aggregate MVA (induction generators)

Explanation:

(i) ½-cycle Fault contribution is the asymmetric fault current in amperes coming from the site system for a fault on the transmission system side of each of the supply transformers.

(ii) 3-cycle Fault contribution is the symmetrical fault current in amperes coming from the site system for a fault on the transmission system side of each of the supply transformers.

(iii) Where multiple transformers supply a site, the faults are to be applied simultaneously to all supplying transformers.

(iv) Aggregate MVA is the sum of the rated MVA of all induction motors or generators in the specified class.

(v) Low-voltage motors are those motors directly connected at 1000 V or below, excluding all motors connected through variable-frequency drives.

(vi) Medium-voltage motors are those motors directly connected at greater than 1000 V, excluding all motors connected through variable-frequency drives.

(vii) Aggregate MVA values are to include any machines that are also submitted as large individual machines.

5.5.5 Distributed Generators

Overview: Aggregated distribution generators are a totaled MVA equivalent for distribution-connected generators located on the distribution side of a point of delivery, where the total distribution-connected capacity is 5 MW or more

Checklist:

The checklist includes all applicable items of of Large individual machines or Aggregated Generating Facilities and:

☐ Aggregate MVA for the Metering Point

Explanation:

(i) Aggregate MVA is the sum of the rated MVA of all generators downstream from the Metering Point.

5.6 HVDC Converter Terminals

Overview: detail to be established through discussion with the ISO.

5.7 Series Compensation

Overview: Series Compensation is a series component, typically a reactor or capacitor, which modifies the series reactance of a line.

Checklist:

☐ Nameplate

☐ MVAR rating

☐ Rated voltage

☐ Rated current

☐ Control strategy

Explanation:

(i) Discuss the control strategy with the AESO to identify which details are to be submitted.

5.8 Static VAr Compensators

Overview: A “Static VAr Compensator” is a shunt-connected capacitive or inductive conducting equipment whose output is automatically and rapidly adjusted to maintain or control some parameter of the electrical power system, typically voltage.

Checklist:

☐ Nameplate

- ☐ Maximum/Minimum MVA (Capacitive)
- ☐ Maximum/Minimum MVA (Inductive)
- ☐ Rated voltage
- ☐ Control strategy
- ☐ Control Bus
- ☐ Maximum control-band voltage
- ☐ Minimum control-band voltage
- ☐ Connection (Delta/Y)
- ☐ Neutral Grounding status
- ☐ Grounding impedance

Explanation:

(i) MVAr rating is to be expressed at the bank rated voltage.

(ii) The Control Strategy is one of the following:

TABLE 1.5-6 SVC-SWITCHING STRATEGIES

☐ Strategy	☐ **Explanation** of Strategy
Manual	The SVC output can be adjusted by personnel on site
Automatic	The SVC output is adjusted under control of an automated control system
Supervisory	The SVC output can be adjusted remotely via SCADA

(iii) The “Control Bus” is the bus at which the voltage is monitored for the purpose of controlling this shunt device. Refer to the bus by the (**BUS_CODE)** assigned to the bus by the AESO.

(iv) The maximum and minimum voltages of the control band are expressed in per-unit of the system nominal kV at the control bus.

(v) Grounding resistance and reactance expressed in ohms, with zero indicating a solidly grounded bank.

6. Other FACTS Devices

Overview: “FACTS Devices” or “Flexible AC Transmission System Devices” refer to power electronic based systems and their associated static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability.

Checklist:

- ☐ Nameplate
- ☐ Component Single-Line Diagram
- ☐ Manufacturer’s Test report
- ☐ Manufacturer’s Data Sheet
- ☐ Details established by discussion with the AESO

☐ Description of operation

Explanation:

(i) A Component Single-Line Diagram is used to show all the main circuit components of the FACTS installation, including Transformers, Line Segments, capacitors, and reactors.

(ii) Provide a text description of the operation of the FACTS installation, to a level of detail to be discussed with AESO.

(iii) Submit the data for any Transformers, Line Segments, capacitors, reactors, or dynamic control systems associated with the FACTS device as detailed in the relevant section of this Guideline.