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NEW TRANSMISSION LOAD CONNECTIONS

Functional

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1.0 INTRODUCTION

The *Transmission System Code* (TSC) issued by the Ontario Energy Board (OEB) provides load customers with three options for constructing and owning new load connection facilities:

1. The connection applicant can elect to have Hydro One Networks Inc. ("**HONI**") construct and own the new load connection facilities.
2. The connection applicant can elect to construct the new load connection facilities and transfer ownership to HONI. (This option only applies to new load connection facilities that have been identified by HONI as contestable.)
3. The connection applicant can elect to construct and own the new load connection facilities. (This option only applies to new dedicated load connection facilities that have been identified by HONI as contestable.)

All three of the above options require that the design and construction methodologies for the load connection facilities meet the requirements set out in the TSC. For option 1, these requirements will be met through the use of HONI's internal design and construction practices.

For option 2, the TSC requirements will be met through the use of HONI's project technical requirements which HONI will provide to the load customer. For option 3, the TSC requirements will be met by complying with HONI's load connection interface requirements, and accepted industry practices and standards.

The TSC sets out the minimal generic requirements for connecting new loads to the transmission system in a manner that does not reduce the reliability or performance of the transmission system or cause a negative impact on another customer connected to the transmission system. The purpose of this document is to describe HONI's functional requirements to provide guidance for customers contemplating a new load connection to HONI's transmission system.

The functional requirements presented are applicable to load connection facilities that are intended to be connected (tapped) to HONI's transmission system at 115 kV or above. These requirements do not apply to terminal type Load Connection Facilities, that is, non-tapped stations.

Should a generation facility be connected to the high voltage side of a load connection facility at some future date, then at that time additional requirements may then be imposed on the load connection facility. These requirements are covered, in part, by HONI document "Transmission Generation Connection Technical Interconnection Requirements." Any potential connection of generation to a planned or existing load connection facility must be reported to HONI and examined through the appropriate channels for approval.

HONI will currently not accept ownership of a load connection facility (under Option 2) that is designed and built based on the IEC 61850 standard ("Communication Networks and Systems in Substations"). Load Connection Facilities designed and built under Option 3 where the facility is neither owned nor operated by HONI can be designed and built using IEC 61850 subject to HONI approval and the requirements of the TSC, accepted industry practice, and this document.

Organization of this Document

The format of this functional requirements document for New Transmission Load Connections closely follows the format of the TSC wherever possible. HONI has attempted to avoid repetition of the specific requirements set out in the TSC. However, in some cases, TSC requirements have been repeated to underscore those particular needs. In general, the Functional Requirements for New Transmission Load Connections contains requirements that should provide the customer with further clarification as well as supplementing the requirements set out in the

TSC. Where applicable, each section also includes further clarification of specific functional requirements for customers who select Option 2. Additional sections (in comparison with the TSC) are included in this document.

Section 14 of this document has been provided for customers who select Option 2 and includes functional requirements not addressed in the TSC. In accordance with Contestability Procedure which is part of HONI's OEB-approved Transmission Connection Procedures, Load Customers who proceed with Option 2 will be provided with a separate set of technical requirements to allow the connection customer to proceed with detailed engineering of facilities that will be transferred to HONI to own, maintain, and operate. HONI will provide these technical requirements to the customer upon execution of the appropriate confidentiality agreement.

Conflict with the Transmission System Code or the OEB-Approved Transmission Connection Procedures

These Functional Requirements for New Transmission Load Connection Facilities are subject to the TSC and HONI's OEB-Approved Transmission Connection Procedures. If any provision of these Functional Requirements is not consistent with the:

1) *Transmission System Code,* then the said provision shall be deemed to be amended so as to comply with the *Transmission System Code;*
2) OEB-Approved Transmission Connection Procedures, then the said provision shall be deemed to be amended so as to comply with the OEB-approved Transmission Connection Procedures; and
3) Connection Agreement made between the parties associated with the new load connection facilities, on the same subject matter then the TCA governs.

The following is a list of supporting document required for Option 2.

OEB Documents
The requirements for a new load connection to the transmission system are set out in the TSC (available at:

http://www.ontarioenergyboard.ca/OEB/Industry/Rules+and+Requirements/Rules+Codes+Guidelines+and+Forms including particular technical requirements set out in Version A – FORM OF CONNECTION AGREEMENT FOR LOAD CUSTOMERS attached to the TSC as Appendix A (the "**Connection Agreement**" or "**TCA"**).

Agreements with HONI
All Load Customers planning to connect to HONI's Transmission System are required to complete a Connection Application and execute a Connection and Cost Recovery Agreement ("**CCRA**"). Both documents are available to customers on the HONI web site (www.HydroOne.com). Prior to actual connection, load customers will be required to enter into a Connection Agreement with HONI.

HONI Transmission Connection Procedures
HONI's Transmission Connection Procedures have received the approval of the OEB [EB-2012-0031]. In accordance with Section 6.1.4 of the TSC, the Transmission Connection Procedures include procedures on: Total Normal Supply Capacity, Available Capacity, Security Deposit, Customer Impact Assessment (CIA), Economic Evaluation, Contestability, Reconnection and Dispute Resolution.

Refer to http://www.hydroone.com/IndustrialLDCs/ConnectionProcess/Pages/default.aspx for access to the HONI web page describing the Load Connection process.

HONI Transmission Connection Process
HONI has also produced guidelines on the six stage process for application and connection to the Transmission Grid (available on the website and link included below).

http://www.hydroone.com/IndustrialLDCs/ConnectionProcess/Pages/default.aspx

To assist customers in understanding the overall customer connection requirements, Figure 1 below lists the relationship between the various codes and documents.

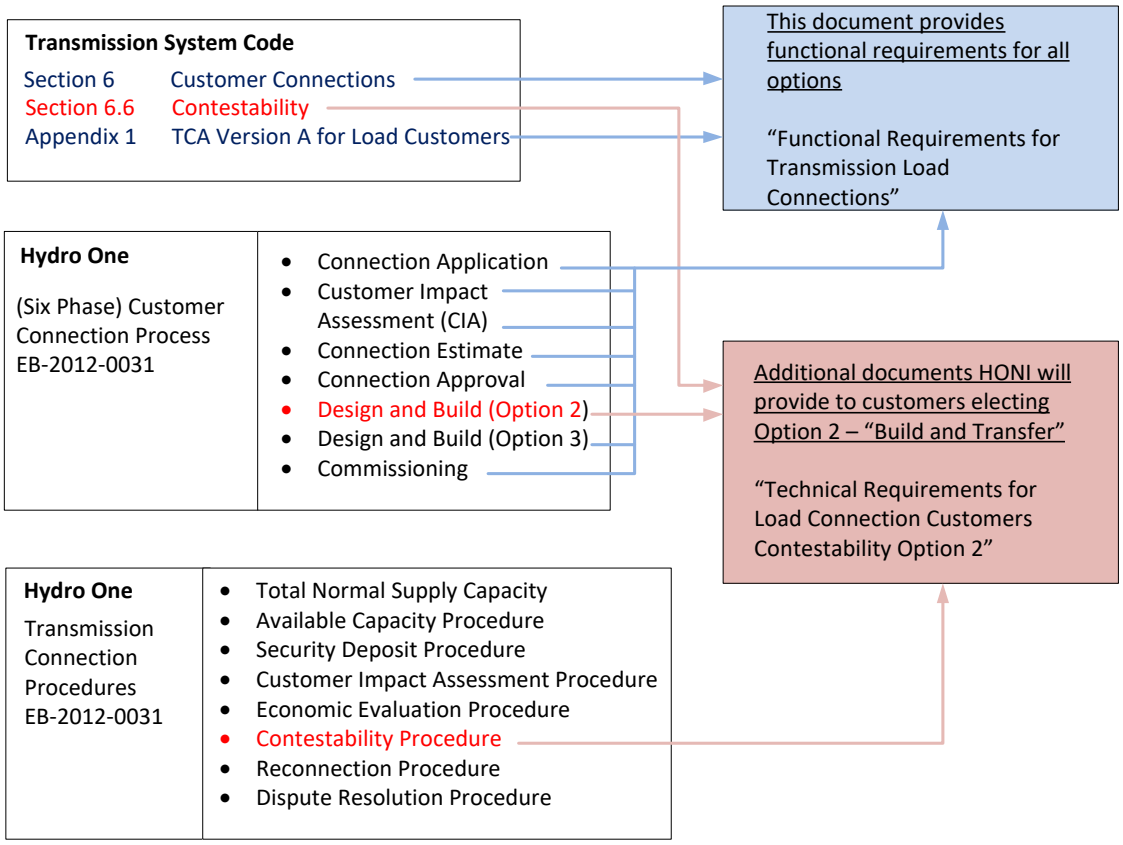

Figure 1 - Connection Process – Relationship Between Various Codes and Documents

Note: Customers should initiate the IESO's Application and Approval Process simultaneously with initiating HONI's Customer Connection Process as the two processes run in parallel.

2.0 ABBREVIATIONS AND DEFINITIONS

All definitions used in the Transmission System Code (including the TCA attached thereto) will apply to these Functional Requirements for New Transmission Load Connection Facilities. In addition, all references to the technical equipment, processes and schemes will be as per accepted industry standards.

For the purpose of this document, an emergency situation has been defined as one in which human life, property or system stability is at risk.

CCRA	Connection and Cost Recovery Agreement
CIA	Customer Impact Assessment
COVER	HONI's Confirmation of Verification Evidence Agreement
Customer	Refers to the entity that constructs and owns a Load Connection Facility
DESN	Load Connection Facility built as per Dual Element Spot Network design. The DESN design is that by which the secondary windings of two transformers are paralleled through a normally closed bus-tie breaker. Each transformer is supplied by a separate transmission line.
Load Connection Facility	The load facility that connects to the HONI system
Load Connection	Same as Load Connection Facility
Load Customer	Equivalent to "Customer"
ESA	Electrical Safety Authority
HALT	Highly Accelerated Life Test
HVI	High Voltage Interrupting device
IED	Intelligent Electronic Device
LiDAR	Light Detection and Ranging
MMF	MagnetoMotive Force
OEB	Ontario Energy Board
QA	Quality Assurance
SIA	System Impact Agreement
Station	Equivalent to Load Connection Facility
TSC	Transmission System Code
TCA	Transmission Connection Agreement
Transmitter	In the context of this document, refers to HONI unless specified otherwise

3.0 APPLICATION AND INTERPRETATION

The Transmission System Code (issued by the Ontario Energy Board on August 26, 2013) applies to this document.

Note, from this point onwards, section and subsection numbering corresponds with that of the TSC to the best extent possible.

4.0 REQUIREMENTS

4.1. GENERAL REQUIREMENTS

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

HONI will provide Load Customers with any necessary information that is in HONI's possession, or reasonably available, in order to comply with their obligations under the TSC.

All transmission Load Connection Facilities, whether owned by HONI or not, shall conform to all applicable government, safety, regulatory, and industry related requirements, practices and standards unless noted otherwise. All transmission Load Connection Facilities owned by Load Customers with generation connected to those stations shall ensure that those facilities conform to the applicable sections of the TSC and all government, safety, regulatory, and industry related requirements, practices and standards unless noted otherwise. In addition, generation directly connected to HONI's transmission system must also adhere to HONI's Protection Planning Standard for Transmission Generation Connections (PP-60000-003-R0).

All connections to the transmission system shall be made by HONI with due regard for the safety of HONI employees and the public. New Load Connection Facilities shall not in any way reduce the reliability or performance of HONI's existing transmission facilities or cause a negative impact on any other customer connected to the transmission system (including, but not limited to existing customer's power quality).

Customers who propose to make any changes after the commissioning of a Customer-owned Load Connection Facility that may impact the performance or operations of the interconnection protections[1], whether a setting change, design change, equipment change or any other changes, must communicate that proposed change to HONI and that change must be reviewed by HONI prior to the change taking effect. Where necessary as determined by HONI, such change will be incorporated into the customer's TCA. The need for a COVER, to ensure the changes in customer facilities do not adversely impact the transmission system, will be determined HONI.

4.2. TRANSMISSION SERVICES CHARGES

Not applicable for the purpose of these Functional Requirements.

4.3. FACILITIES STANDARDS

In addition to the provisions in the TSC and the requirements set out in the TCA, the following requirements apply. Additional project specific requirements may also be applicable.

The Load Customer must ensure that the Load Connection Facility:

1. Meets all applicable requirements of the Ontario Electrical Safety Authority (ESA).
2. Conforms to all applicable industry and reliability standards including, but not limited to, Canadian Standards Association (CSA), the Institute of Electrical and Electronic Engineers (IEEE), American National Standards institute (ANSI), the International Electrotechnical Commission (IEC).
3. Is designed and constructed in accordance with good utility practice (as that term is defined in the TSC).
4. Is designed, constructed, operated, maintained in accordance with the Market Rules and the applicable reliability standards including, but not limited to, NPCC and NERC reliability standards.
5. Conforms to HONI's OEB-approved Transmission Connection Procedures EB-2012-0031.

The Load Customer must ensure that the modeling data of customer procured transformers, lines etc., required for the planning, design and operation of connections, and for the Customer Impact Assessment (CIA) study and System Impact Assessment (SIA) study are complete and accurate and provided to HONI and as applicable to IESO. Testing may be required to establish modeling data at the customer's expense.

The Load Customer must allow HONI to verify the commissioning and testing under the provisions and terms of the TSC at the discretion of HONI.

[1] Interconnection protections, or interface protections, are those protections that cover, protect, or influence the connection of the load connection to the HONI system.

Additional project specific requirements may also be applicable.

4.4. OPERATIONAL STANDARDS AND REPORTING PROTOCOL

Not applicable for the purpose of these Functional Requirements. Refer to the TCA for customer obligations.

4.5. PERFORMANCE STANDARDS

Not applicable for the purpose of these Functional Requirements.

4.6. COMPLIANCE OF FACILITIES WITH STANDARDS

Not applicable for the purpose of these Functional Requirements.

4.7. CONFIDENTIALITY

HONI includes confidentiality provisions in all study agreements and CCRAs that it executes that are consistent with the confidentiality provisions of the TCA. For Customers pursuing Option 2, HONI will require that a separate confidentiality agreement be executed before it releases HONI's technical specifications for load connection facilities to be transferred to HONI.

5.0 REQUIREMENTS FOR OPERATIONS AND MAINTENANCE

Not applicable for the purpose of these Functional Requirements. Refer to the TCA for Customer obligations.

6.0 CUSTOMER CONNECTIONS

Refer to Section 1 of these Functional Requirements for New Transmission Load Connections for information regarding HONI's OEB-approved Transmission Connection Procedures and HONI's customer Connection Process.

7.0 COMPLIANCE, INSPECTION, TESTING AND MONITORING

The compliance, inspection, testing and monitoring section of the TSC is not applicable for the purpose of these Functional Requirements. Refer to Section 10 of these Functional Requirements for information on the maintenance, testing and commissioning of protection, control, and telecom equipment.

The requirements for compliance, inspection, testing and monitoring of Customer equipment is set out in the TCA.

8.0 GENERAL TECHNICAL REQUIREMENTS

8.1. GUIDELINES OF RELIABILITY ORGANIZATIONS

The provisions under the TSC apply for this section.

8.2. PROTECTION AND CONTROL

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

All Load Connection Facilities, whether owned by the Customer or HONI, shall be designed with redundant protection systems, unless otherwise stated. All protection design practices should be followed with due consideration to:

1. Sensitivity
2. Speed
3. Selectivity
4. Operating security
5. Dependability
6. Maintainability

Each protection system shall be capable of detecting and clearing faults within their own Zone of protection. Overlapping protection Zones must be employed to ensure that all power system elements are protected. Each protection system shall be designed using diverse manufacturers in order to prevent common mode (single contingency) failures.

Dual breaker trip coils shall be used on all breakers and interrupters from 115 kV and above.

In the case of Load Connection Facilities that will be owned by HONI, HONI will specify the design and equipment to be used. Failure of one component shall still allow complete tripping of the protected element by the remaining (redundant) system. Also, removing one primary protection system from service (for maintenance, for example) shall leave a second fully operational redundant or backup protection system in-service.

8.2.1 Instrument Transformers

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

A detailed record must be provided to HONI of all nameplate data for all current and voltage transformers. This includes, but is not limited to:

- Manufacturer
- Date of manufacture
- Ratios
- BIL
- Physical dimensions and weight
- Accuracy class or classes
- Thermal ratings
- Temperature ratings, and
- Voltage/current ratings.

All potential transformers (wire wound PTs, capacitive CVTs, or optical voltage transformers) used for transmission Load Connection protection purposes for HONI-owned stations must be approved by HONI. All potential transformers shall have adequate volt-ampere capacity for designed loads. Potential supplies from PTs or CCVTs shall be individually fused. PTs and CCVTs should have factory installed and activated ferroresonance circuitry.

Each potential device should have a minimum of two secondaries. Each Load Connection Facility must have either one or three HV PTs. Where the application warrants one PT, then consideration must be given to standard 30 degree phase shift and transformer impedance must be considered when using LV PTs for line protection.

Minimum CT ratios for primary protection equipment shall be rated at 10L400 (C400) on the LV side of the transformer and 10L800 (C800) on the HV side of the transformer. Current transformers shall be designed with a continuous current rating of 125% of the maximum expected circuit loading. CT's shall not saturate for worst case faults with full DC offset. Unused CTs shall be shorted at the CT or at the earliest possible point thereafter, and grounded.

A minimum of three CT cores are required on each bushing and phase of each transformer. A minimum of two CT cores are required for each phase of bus tie breakers and each phase of transformer secondary breakers. Either wire wound current transformers, or optical current transformers or Rogowski coils can be used subject to approval by HONI.

For Load Connection Facilities that will be owned by HONI, all specified nameplate ratios shall have fully distributed windings about the iron core.

Potential transformer and current transformer secondary circuits must be grounded in one location only (at the first point of termination within the relay building). Ground connections shall be easily opened, or removable, for maintenance and testing, if required. HONI approved EMC cable glands shall be used to connect cable sheaths to CCVT boxes for Load Connection Facilities built for, or transferred to, HONI.

8.2.2 **Protection Zones**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Protection Zones (transformer and line, transformer and bus, bus and feeder, etc.) must overlap in order to ensure that no part of the transmission load connection is left vulnerable to fault conditions without being adequately protected. Where overlapping Zones are not possible, these cases shall be approved by HONI prior to construction of transmission Load Connections. Either redundant protections or primary and backup protections are required, as appropriate.

8.2.3 **Breaker Failure**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

All Load Connection Facilities shall have breaker failure protection on any HVI, transformer secondary breaker, and transformer secondary bus tie breaker.

Under no circumstances for any Load Connection Facility connected to the HONI transmission system shall automatic ground switches be used for triggering line protection operation following the failure of a HVI.

1. The breaker failure protection need not be duplicated and preferably should be supplied from the "A" battery supply. If breaker failure protection is duplicated, then the "A" breaker failure should use the "A" battery and the "B" breaker failure protection should use the "B" battery.
2. The breaker failure protection should recognize mechanical failure of the HVI or the inability of the HVI to extinguish an arc under fault conditions.
3. The breaker failure protection signal must:
    a. Seal-in for 45 seconds to ensure reclosing does not occur from HONI breakers.
    b. Be supervised by the status of the motorized disconnect switch.

8.2.4 Reclosing and Synchronizing

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Protection and control equipment must not reclose a live source onto a dead HONI connection. That is, no possible back-feed condition into the HONI system should exist or be possible under any circumstances without the prior express written consent and approval of HONI.

HONI must control reclosing and energization of the line. Reclosing coordination must be mutually agreed upon by HONI and the Customer before any reclosing scheme is put into service. Synchronizing equipment may be required at the discretion of HONI. Reclosing with Load Connection Facilities that also have dispersed generation shall be done in accordance with HONI's Protection Planning Standard for Transmission Generation Connections (PP-60000-003-R0).

HONI utilizes a single-shot, three-phase, automatic reclosing attempt for transmission line tripping with no prior initiation to the Load facility provided.

8.2.5 Utility Grade Equipment

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Utility grade equipment must be employed for the protection of transmission Load Connection equipment.

The relays, telecommunication equipment, and any PC/Windows type computer must meet the following (minimal) requirements where applicable:

1. Be substation hardened to meet or exceed ANSI/IEEE standards for protective relaying and telecommunication equipment such as C37.90-2005, C37.90.1-2012, C37.90.2-2004, C37.90.3-2001 and 1613-2003, 1613 amendment 1 2006, 1613.1-2013.

2. PC/Windows type computers must be DC powered from the station battery, use solid-state drive(s), and operate without any internal fans or other moving parts. There must be no connection whatsoever from the PC or any protection device to the internet (World Wide Web).

3. Output control contacts (or electronic contacts) shall be rated as per the following minimum requirements.

    a. Make
        i. 30 A
        ii. Carry 6 A continuous
        iii. 1 s rating of 50 A
    b. Break
        i. 48 V, 0.5 A L/R = 40 ms
        ii. 125 V, 0.3 A, L/R = 40 ms
        iii. 250 V, 0.2 A, L/R = 40 ms
    c. MOV Protection (if present) 250 V ac and 330 V dc

    Contacts that are used for tripping breaker trip coils directly shall be rated according to maximum trip coil characteristics.

4. Relevant documentation (owner's manual, technical manuals, operational manuals, etc.) must be provided from the manufacturer and be readily available for operating, maintenance, testing, and troubleshooting purposes. The documentation must correspond with the model of the equipment being described in the

documents as well as the firmware being used in the equipment. In some cases technical notes or amendments from the manufacturer that supplement existing documentation may be available. Any supplemental information must also be provided. Technical details, including equipment specifications, must be submitted to HONI for HONI-owned stations.

5. Protection equipment must provide as a minimum: trip; alarm; and event recording capability as defined by HONI. The records and oscillography must be time stamped using a GPS synchronized clock.

6. Protection equipment to be owned by HONI must have manually re-settable trip target indication.

7. Protection equipment to be owned by HONI must provide isolation of input quantities and output trip signals via ABB Flexi Test (FT-1) or comparable isolating switches.

8. Protection equipment to be owned by HONI must be capable of synchronizing their internal clock to a GPS signal (refer to 8.2.7 of this document).

9. All protection equipment must be powered by station battery DC supply, typically 125 VDC with shielded supply cables.

10. Protection equipment to be owned by HONI must have DC supply failure alarm annunciation (DC monitoring).

For Load Connection Facilities to be owned by HONI, the use of microprocessor-based protection equipment (Intelligent Electronic Devices or "IED") for primary protection equipment is required due to the self-testing, event recording, time stamping, and local network capabilities. All relays used on transmission load connection equipment to be owned by HONI must be approved by HONI. HONI takes great care in selecting IEDs that are highly reliable and thoroughly tested to ensure compliance with HONI requirements and specific operating needs.

Protection equipment to be owned by HONI shall:

- Be designed for a minimum expected life of 20 years.
- Have an expected minimum MTBF of 250 device-years per failure. The MTBF for the device shall be provided by the manufacturer and the method used to determine the MTBF shall be clearly stated by the manufacturer. Any device having a MTBF of less than 250 years shall not be used on the HONI transmission system.
- Have a minimum availability of 99.99%.
- Come with an absolute minimum 5 year warranty from the manufacturer (minimum 10 years is preferred).

For Load Connection Facilities to be owned by HONI the following requirements for protection and control related equipment must also be met:

1. DC supplies and supply voltage (typically 125 VDC) must be as specified by HONI.
2. DC control and AC voltage and current wires and cable types must be approved by HONI.
3. All terminal block types, fuses and fuse holders must be approved by HONI.
4. All relay types and models used in the Load Connection Facility must be approved by HONI.
5. All protection schemes for HONI-owned substations will be provided by HONI and any discrepancies in implementation approved by HONI prior to design of the Load Connection Facility.
6. All telecommunication schemes must be approved by HONI.

7. All telecommunication equipment, including media (fiber, microwave, power line carrier, radio, etc.) must be approved by HONI and be reliable and consistent with protection equipment requirements.
8. HONI approved procedures for terminating cables with appropriate grounding (and EMC glands, where required) will be used for all cables.
9. All instrument transformers (current and voltage) must be approved by HONI. This includes, but is not limited to, all ratings, number and type of windings, burdens, location, etc. Auxiliary CTs shall be avoided if at all possible, but shall be approved by HONI if used.
10. Where ferroresonance is considered to be a possibility, all ferroresonance suppression implementations shall be reviewed and approved by HONI.

Any supporting equipment such as interface cables from protection or control equipment and software used for accessing protection and control equipment (such as setting software) must be surrendered to HONI upon the transfer of the station to HONI as well as any associated passwords and training material. In addition, all manufacturer warranties (for either hardware or software) shall also be transferred to HONI upon assignment of ownership.

8.2.6 **Battery Banks**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

All Load Connection Facilities with single battery systems must be capable of supplying maximum station DC load for a minimum of 8 hours in the event that station service to the charger is lost.

For dual battery systems, each battery shall be capable of supplying its own load for a minimum of 6 hours and each battery shall be capable of supplying total station DC load for a minimum of 4 hours. Battery charging systems shall be capable of restoring a depleted battery to full charge within 12 hours. Battery sizing should be rated according to IEEE 485-2010 and must be approved by HONI. Battery sizing must consider the maximum demands for equipment dependent on battery source voltage.

Duplicate supplies (trunks/breakers) with an automatic transfer schemes are no longer acceptable for use in HONI-owned Load Connection Facilities.

The DC Station Service shall have a high degree of dependability and must ensure that no single contingency or common mode failure results in the loss of critical relay protection or automatic tripping of power circuit breakers. This shall be achieved through implementation of redundant protection systems namely “A” and “B” protections and duplicate battery banks and battery charger sets (“A” and “B”) with a manual DC transfer scheme to switch the supply between the “A” and “B” sources.

In Load Connection Facilities with a single battery, critical functions are duplicated and supplied from independent circuits. “A” and “B” supplies imply the presence of two circuits, not necessarily two batteries.

HONI requires that battery sizing calculations be clearly detailed and provided to HONI to ensure that battery capability is sufficient in the event of an emergency. HONI also requires that battery duty cycle calculations be provided to HONI for HONI-owned Load Connection Facilities. This information is to be provided to HONI during the design stage prior to construction. After the battery has been installed and prior to operation of the station, proof of discharge testing must be provided to HONI to verify that the battery has sufficient capability to support load and trip operations as per IEEE 450-2010.

For HONI-owned Load Connection Facilities, the following shall also apply:

a) Each battery room shall be designed to accommodate a vented lead acid (VLA) battery sized to the maximum estimated dc load corresponding to the ultimate (future) development of the Load Connection Facility or switchyard(s) served by the battery.
b) The station battery shall be segregated from other equipment in a separate room with approved fire-resisting construction and full height walls.
c) When possible, the battery room shall be sited adjacent to an outside wall in order to: facilitate direct exhaust of air to the outside; to have a better natural air circulation; and to reduce the amount of ventilation ducts.
d) Batteries shall be located on the north side of the building to avoid large temperature changes caused by the sun. If the battery cannot be located on the north side of the building, no windows shall be installed in the battery room.
e) Batteries shall not be located below grade due to possible flooding hazards.
f) Ceilings shall not have unventilated recesses in which hydrogen may accumulate, e.g. between ceiling beams, and recessed-type lighting fixtures are not to be used. Ceilings shall therefore be flush and the use of false ceilings is not permitted.
g) Services not associated with the battery should not pass through the battery room.
h) No water pipes shall be allowed in the battery rooms and no roof drainage pipes shall be routed through battery rooms.
i) The battery room shall not be used as access to another space or room.
j) For new installations the battery room floors shall not be of raised type. The battery room floor shall be designed to have the loading capabilities of present equipment and future needs.
k) The battery room floor shall be covered with a slip-resistant and acid-resistant material and for VLA battery, the walls and ceiling finish shall be acid-resistant.
l) The general battery area should be clean, dry, well ventilated, and provide adequate ambient temperature, space and illumination for operation, inspection, maintenance, testing, and battery cells replacement. The battery aisles should be large enough to accommodate maintenance clearances; operation of cell's lifting devices; and portable material handling equipment if required.

All battery specifications for HONI-owned Load Connection Facilities shall be approved by HONI during the design stage prior to construction.

8.2.7 Satellite Clock

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Protection, control, and SCADA equipment located at transmission Load Connection Facilities must be connected to a functioning GPS synchronized clock so that event records and operational information is accurately time stamped using Eastern Standard Time (EST). This is required for consistency in analysis after fault, or abnormal, operating conditions. This also may be required for operational issues relating to troubleshooting, end-to-end protection testing, and maintenance. Any exceptions must be reviewed by HONI. In addition, all Load Connection Facilities with under frequency load shedding also require a satellite synchronized clock.

Satellite clocks shall be capable of synchronization to an external IRIG-B time source to within an accuracy of ±0.5 ms or better. The internal clock shall maintain its drift to within ±1.0 minute per month deviation from actual time with the external synchronization source unavailable or disconnected.

8.2.8 Special Protections

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

From time-to-time it may be necessary to implement Special Protection Schemes or Remedial Action Schemes for the purpose of safety, system stability or system security. These schemes may be mandated by the IESO or by system requirements as determined by HONI. It is expected that Load Customers would cooperate with HONI and the IESO in either installing appropriate equipment for remedial action schemes or by allowing HONI to install remedial action schemes at their (the customer) site, where appropriate.

In addition, emerging technologies may need to be considered at customer owned substations. It is expected that Load Customers will cooperate with HONI in the event that system requirements and technological advances make it necessary, or advantageous, to implement new, or additional, technologies at a customer owned substation.

8.2.9 **Contact Personnel**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

During design, construction and commissioning of any transmission Load Connection Facility, one qualified person must be appointed to act as a point of contact for protection and control related issues. This person shall have adequate training and experience to deal with protection and control issues related to HONI.

For Customer-owned Load Connection Facilities, the Customer shall provide HONI with the name and phone number for contact personnel who are sufficiently capable of dealing with protection, control and SCADA related issues. This person, or persons, shall be able to be contacted on a 24 hour, 7 days a week basis. Names and telephone numbers shall be recorded in Schedule A of the TCA. In addition, the Customer should contact HONI under any condition in which the protection system might be compromised, or if the protection system has operated. The Customer shall also contact HONI to make it aware of any changes in the name(s) or phone number(s) of the contact personnel should any changes occur.

8.2.10 **Safety**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Any protection and control equipment installed in a transmission Load Connection Facility connected to HONI must adhere to current safety guidelines as outlined by the Canadian Electrical Code, ESA requirements, industry, and HONI practices. In addition, the impact of relay coordination and high speed primary tripping to minimize arc flash hazards must also be considered.

Due to the increased concern with arc flash hazards, interconnected protection equipment must seek to reduce the severity of arc flash by means of settings, bus protection, or fast bus tripping schemes, to name a few. Sufficient calculation details must be provided to HONI to indicate the use of specific protection equipment, and/or settings, has minimized the severity of arc flash hazard.

IEEE 1584-2002 presents various methods for calculating arc flash energies and arc flash protection. Various industry documents present methods for minimizing arc flash hazards by the judicious use of protection settings and coordination.

All HONI-owned power system equipment shall be designed and constructed such that appropriate work protection can be taken out on such equipment in order to isolate it from the power system, with the goal that activities on protection, control, and telecommunications equipment can be carried out in a safe manner.

Specific requirements for Personal Protective Equipment (PPE) over and above that which is currently required by HONI for safe work practices in a substation environment, shall be clearly stated for all equipment constructed for, or transferred back to, HONI.

Hazardous working conditions at Customer-owned sites must be rectified for HONI personnel to have safe access to HONI-owned equipment. Access may be required for inspection, testing, calibration repair or other HONI related activities.

8.2.11 **Information Provided By HONI**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Listed below is some of the basic power system information that HONI may provide to Customers in order to design a transmission Load Connection Facility. All information that is required shall be discussed with HONI prior to the Customer entering into any contractual agreements with third parties.

1. Available utility short-circuit current and associated X/R ratio.
2. Expected minimum, maximum, and nominal voltage levels.
3. Outage history of the supply.
4. Estimated frequency, duration, and magnitude of momentary voltage dips.
5. Operating requirements and restraints.
6. Requirements necessary to coordinate protections with the utility system.
7. Harmonic content, voltage fluctuation, and current unbalance limits imposed by the utility.
8. Load shedding requirements.
9. Temporary overvoltages due to faults or load rejection.
10. Voltage unbalance.

Additional information may be provided.

8.2.12 **Information Provided by the Customer**

Listed below is some typical information that may be required by HONI for protection and control related discussions:

1. Expected in-service date.
2. Complete one-line and three-line diagrams of the connection system.
3. Supply voltage.
4. Transformer ratings, connections, voltage taps, and impedances.
5. Transformer voltage regulation settings.
6. Power factor correction capacitor ratings and connections.
7. Available short-circuit current.
8. Switchgear specifications and ratings.
9. Protective relay types, model numbers, serial numbers, firmware versions and setting ranges. Note: if the protection devices are of a modular design, then the serial number, date code and model number of all *modules* must also be provided. This is due to the fact that manufacturer recalls may be based on specific components/boards/modules within specific dates of manufacture.
10. Communication equipment types, model numbers, serial numbers and firmware versions.
11. Protection and control schematic drawings and settings, as appropriate.
12. Protection philosophy and tripping matrix.
13. Motor loads, types, sizes, starting current, contactor data, and frequency of starts.
14. Unusual load characteristics.
15. Generator and large synchronous motor information, including ratings, impedance data, time constants, and exciter data.
16. Expansion plans, which include projected loads, future substation development, and estimated dates.

17. Method used to ground neutrals and ratings of the neutral grounding device.
18. All main and auxiliary current transformer ratios, taps, taps used, and accuracy class.
19. All main and auxiliary potential transformer ratios, taps, taps used, and accuracy class.
20. Interrupting time of all HVI, transformer secondary and bus tie breakers.
21. Calculated and measured station ground resistance.
22. Voltage and KVAR rating of capacitors.
23. Voltage and KVAR rating of reactors.
24. Battery voltage, rating, capability to support load in event of a blackout, and charging characteristics.
25. Telecom equipment types and specifications.
26. Contact personnel names and phone numbers.
27. Load criticality (emergency, hospital, essential services, manufacturing, residential, etc.)

Additional information may be required. Any information may need to be updated at the discretion of HONI. Any changes to the above information must be forwarded to HONI in a timely manner.

8.2.13 **Documentation**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Written documentation is required that outlines compliance with NERC, NPCC, and IESO regulating agency requirements, if required.

Documentation shall be provided to HONI both in printed copy form and permanent electronic form using up-to-date media such as DVDs or memory sticks (floppy disks or CDs for instance, will not be accepted). Electronic documentation must be in a common format such as Word 2010 or later. Documentation, if compressed, must use commonly used compression technology such as “zip” but must not be password protected, unless otherwise specified by HONI.

Drawings shall be supplied via printed and electronic copies. Printed and electronic copies shall comply with HONI’s drawing design specifications and electronic copies shall be in AutoCAD 2011 (or later) format. A master transmittal list showing all documents and revisions numbers and dates shall be submitted with the package to HONI. Any changes made to prints, documentation, schematics, etc., shall be documented and included in the final version submitted to HONI.

For Customer built and owned Load Connection Facilities, documentation pertaining to the interface protection, control and telecom equipment must be submitted to HONI. The interface equipment is defined as any equipment that covers, protects, or influences the connection of the load connection to the HONI system. The documentation shall be a subset of the list provided below for customer built and transferred stations. HONI may at its discretion require additional documentation.

For Customer built and transferred Load Connection Facilities, two copies of all documentation associated with protection and control related equipment must be provided to HONI upon transfer of ownership. This applies to manufacturer documentation, commissioning procedures and records, maintenance procedures, purchasing specifications, design documentation, schematic diagrams (including EWD, CWD), calibration reports, and manufacturer change notices or service bulletins. All drawings and reports must be prepared and stamped by a licensed Professional Engineer in the province of Ontario.

Documentation supplied to HONI shall include the following (non-exclusive):

1. All protection AC & DC EWDs & CWDs.
2. All breakers control AC & DC EWDs & CWDs.
3. All SCADA AC & DC EWDs & CWDs.

4. Teleprotection schemes AC & DC EWDs and CWDs.
5. Special protections AC & DC EWDs and CWDs.
6. All relay logic diagrams.
7. All relay settings & supporting calculation documents as required.
8. Panel Layout (Electrical Arrangement EA).
9. Floor plans.
10. Switchyard schematic one line diagram.
11. Switchyard phasing diagram.
12. AC & DC station service diagrams.
13. Single line and three line diagrams.
14. All P&C equipment labeling information.
15. Cable list.
16. Protection description.
17. Equipment documentation.
18. Test procedures for commissioning and maintenance of protection and control equipment as well as power system equipment.
19. Any IEC 61850 configuration files (ICD, SCL, SCD, SED, IID, etc.) if applicable.

8.2.14 **Nomenclature**

Protection nomenclature used for all drawings, documentation, and correspondence, shall be as defined in the latest version of IEEE C37.2 and supplemented by any HONI specific requirements. Drawing symbols shall be as per IEEE 315.

For HONI-owned Load Connection Facilities, all panels, cables, protection devices (primary or auxiliary relays), switches, current links, fuses, auxiliary CTs or PTs, target indicators, control switches, dc circuit breakers, communication channels, and mimic panels must be labeled according to their functionality based on the electrical Wiring Diagram (EWD) identification or Connection Wiring Diagram (CWD) identification. Accurate labeling is very important and will be verified during commissioning. Cables must be labeled at both ends.

8.2.15 **Sparing**

Due to the occasionally long lead times associated with purchasing, and the need to minimize any down-time, no critical equipment shall be used in any HONI site without a proper sparing analysis. This will be conducted with the purpose of determining if spares are available; what typical lead times will be to obtain spares; how many spares should be kept in inventory; and what is the anticipated life of this equipment with respect to manufacturer support; etc.

Critical equipment includes, but is not limited to instrument transformers, primary relay equipment (IED's) and communication equipment.

Under no circumstance shall obsolete, un-supported, "previously used", recycled, or refurbished equipment be used in the construction of any HONI-owned substation.

All sparing studies shall be reviewed and approved by HONI prior to construction in order to avoid the use of unacceptable devices.

An inventory of recommended spare parts for all protection and control-related equipment shall be provided to HONI for Customer built and transferred Load Connection Facilities owned by HONI.

8.2.16 **Application Software**

For protection and control equipment transferred to HONI, the software used to interface with devices shall allow the user to perform the following:

a. Create a new offline IED configuration file using factory default parameters.
b. Modify and save changes to offline IED configuration files to implement various application-dependent schemes.
c. Upload an offline setting file residing on a PC to an IED.
d. Modify and save changes to an existing configuration with an IED via an active communications session.
e. Monitor real time status of all available binary status points, including physical and communications inputs and outputs, protection elements, logic variables and function blocks.
f. Monitor all available real-time operator telemetry.
g. View non-operational such as SER, DFR and equipment monitoring history within the IED on-line.
h. Download non-operational data from the IED to a PC.
i. Clear and/or reset non-operational and historical data.
j. Clear or reset IED diagnostic flags and logs.
k. Perform comparison between settings and parameters either within the IED and an offline setting file, or between two offline setting files.
l. Have the capability to capture or create COMTRADE files (2013 format).

The software shall permit viewing of all current and voltage traces from IED fault records off-line. The software shall allow the correlation of digital fault records (DFR) to an SER record for the given IED.

The IED configuration parameters shall be available as a comma delimited text file, where various IED parameters are clearly identifiable. If the native IED setting file is in a proprietary binary format, the user software shall provide a utility to export the settings as a comma separated file.

All necessary software components, including, but not limited to, device configuration programs, diagnostics and utilities shall be provided to HONI. One set of user interface software and related manual(s) shall be provided with each IED.

The user software shall support printing of all IED parameters or only those enabled in a concise, neatly organized format.

The user software shall support printing all user-defined logic using standard, easy to read graphical symbols. The logic graphic shall also include all source and destination functions as configured for a particular application, including discrete I/O points, protection elements, and communications channels.

The software shall not permit circumvention of any security feature within the device it is connected to and shall require the appropriate security authorization and credentials when performing various activities while interfacing with the device.

The software shall be compatible with Microsoft Windows 7, Service Pack 1. The software shall not require any network connection, including the Internet (World Wide Web). The software shall not under any circumstances transmit or attempt to transmit any information whatsoever to any external party should the computer the software is installed upon be connected to the Internet.

The software shall support an automated disconnection from the device that requires the user to re-log into the device after a period of inactivity of no more than 30 minutes. An event shall be registered in the event records indicating that the link between the device and software was terminated due to inactivity. This automated disconnection shall cleanly close the link (and associated communications port connections) in such a way that does not compromise the integrity of any files being uploaded or downloaded or adversely impact the performance of the device.

Any software update mechanism (automatic or otherwise) shall be permanently disabled. Should HONI decide to update its approved version of software with a newer release from the Vendor, the update process will be done through HONI's internal deployment methods. This will ensure that:

1. HONI maintains control of the upgrade process.
2. HONI can ensure uniformity for all installations and all staff.
3. HONI can oversee the integrity of the software product (ensure there are no viruses, adware, Trojans, spyware, open ports, etc.)
4. HONI can ensure compatibility of new software releases with other existing, installed software.

8.2.17 **Firmware**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

Protection equipment firmware used in HONI-owned microprocessor-based devices will be maintained in a reasonable fashion. It is highly recommended that the process defined in IEEE C37.231 be implemented for maintaining firmware integrity in Customer-owned Load Connection Facilities.

Protection equipment used in HONI-owned Load Connection Facilities must have up-to-date HONI standard firmware installed. Any deviation from this practice will be dealt with by HONI on a case-by-case basis 30 days prior to commissioning the Load Connection Facility.

Protection equipment used to interface with HONI-owned equipment should also be maintained with up-to-date firmware releases. Any critical firmware release must be implemented and notice of such implementation passed on to HONI.

The device shall support in-situ upgrading of the internal device firmware, including enabling software options and features obtained subsequent to the initial purchase, using vendor-supplied software tools. Any upgrade process requiring the removal and replacement of hardware, including internal ICs such as EPROMS, is unacceptable.

The device firmware upgrade and settings/parameterisation upload process shall be designed such that the device will:

a. Verify the authenticity and validity of any firmware or settings/parameterisation file to ensure that the file is from a legitimate source and has not been corrupted during the transfer process
b. Return to a safe state and not apply firmware or settings/parameterisation changes should the associated file be from an invalid source or corrupted, or should communications be interrupted during any upload/download process. The device shall maintain the current firmware or settings that were in place prior to the attempted file upload and shall not reset, lock up, lock out, or misbehave in any manner whatsoever should the communications connection be interrupted unexpectedly.
c. Generate an internal event that the upload process was unsuccessful, indicating the root cause for the failure (invalid source, file corrupted, unexpected communications interruption, etc.)

8.2.18 **Cyber Security**

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

For Load Connection Facilities deemed to be critical to the operation of the Ontario power grid, any modem connections, wireless connections, fiber connections, or any other connection by which data or information can be transmitted to or from the Load Connection Facility must conform to current cyber security requirements as published by NERC.

HONI requires that Customers who own a transmission Load Connection Facility deemed to be critical, will cooperate in all matters of security related to the operation of the transmission system. As part of the NERC standards, compliance is monitored and it is expected that Customers who own transmission Load Connection Facilities cooperate in HONI initiatives to verify compliance with NERC CIP requirements.

Under no condition are manufacturer default passwords to be used for any protection device. Passwords must be changed on a routine basis of at least once per year and follow NERC CIP guidelines for "strong" passwords.

User names and passwords for all electronic devices owned by HONI must be surrendered to HONI upon completion of commissioning. A detailed list of the equipment, location, and serial number for each device is to be associated with the appropriate password(s) in order to ensure that every password is accounted for. For devices that have multiple levels of security, each and every password must be provided to HONI. This applies to all electronic relays, modems, SCADA, and any other device that may use password protection.

Contact personnel from the Customer may be subject to a background security clearance check at the discretion of HONI.

Passwords and confidential information shall not be transmitted to HONI over unencrypted media such as email, or unsecure web links or any means by which the integrity of sensitive data may be compromised.

Critical cyber data stored in Customer-owned devices related to HONI operations (say, IP addresses, for example), must be expunged from all devices according to NERC requirements when these devices are removed from service (temporality for maintenance at the manufacturer's facility, for example) or permanently.

8.3. INSULATION COORDINATION

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

The insulation coordination (i.e. the correlation of the insulation of electrical equipment and circuits with the characteristics of protective devices) for the Load Connection Facility must withstand a variety of overvoltages of different magnitudes, shapes and durations. The wave-shape of the overvoltages is important in determining the withstand level of the insulation system. The voltages to which the insulation system is exposed include, and are not limited to the normal 60 Hz voltage, temporary overvoltages, slow front (switching) surges and fast front (lightning) surges.

Insulation coordination is the selection of appropriate insulation strength. Insulation coordination must be done properly to ensure electrical system reliability and personnel safety. An Insulation Co-ordination Study incorporating the Load Connection Facility's Basic Surge Levels, surge arrester protective characteristics, surge generation and transfer, conductor spacing, co-ordination between station and transmission line, and shielding from lightning, shall be documented and submitted to HONI.

For connection to the Transmission System, HONI will provide nominal operating voltages and maximum system operating voltages.

Devices connected to the transmission system shall be specified with LIL/BIL levels consistent with normal and maximum operating voltages. The intent is that such devices will enable a Load Connection Facility to withstand switching surges and lightning surges consistent with all other facilities forming the transmission system.

For Customer built and transferred Load Connection Facilities:

- The preferred system for protecting against lighting involves the installation of an optimized arrangement of lightning protection masts to provide the necessary degree of shielding to the Load Connection Facility.
- The term "mast" is used for a structure or spike without provision for stringing any conductor (skywire).

- Requirements to maintain or replace skywires are incompatible with the requirement to maintain continuity of service to the load customers.
- The effectiveness of the shielding system is dependent on the number and location of the lightning protection masts within the Load Connection Facility site, and on the height difference between the masts and the equipment to be protected.
- The shielding system shall be designed to provide a Mean Time between Shielding Failure of a minimum 500 years, per Load Connection Facility.
- The standard approach to surge protection is to provide suitably rated metal oxide, station class surge arresters at major components and systems, such as power transformers, shunt capacitors and underground cable interfaces. Rod or pipe gap surge protective devices are not acceptable.
- Strike distances for elements of the Load Connection Facility which are not tested separately and guaranteed by the manufacturers, have been developed to take into account the typical environmental conditions encountered at a Load Connection Facility within Ontario. Factors such as rain, wind, ice, pollution, and the probable presence of small animals and birds (particularly at the medium voltage range) are taken into account when establishing the phase-to-phase and phase-to-ground strike distances. Table 1 below indicates the Minimum Striking Distance in Air (Metal-to-Metal) for a Load Connection Facility.

Table 1 - Minimum Striking Distance in Air (Metal-to-Metal) for Load Connection Facility

Rated Voltage/ Nominal Voltage	Rated Lightning Impulse Voltage	Minimum Striking Distance in Air (Metal-to-Metal)			
Phase-to-Phase	Phase-to-Ground	Phase-to-Phase		Phase-to-Ground	
		Indoor	Outdoor	Indoor	Outdoor
kV rms	kV peak	mm	mm	mm	mm
15/13.8	95	250	300	180	250
36/27.6	200	480	480	380	380
48/44	250	610	619	480	480
145/115	650	1600	1600	1300	1300
250/230	900	2100	2100	1800	1800

Project specific requirements for insulation coordination of major equipment will be provided by HONI. Additional project specific requirements may also be applicable.

Refer also to Section 14.1.13 (Safety by Design) for Load Connection Facilities to be built by Customer and transferred to HONI.

8.4 GROUNDING

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

The Load Connection Facility's grounding system shall meet ESA requirements on a "standalone" basis, and shall not rely on HONI's grounding system in any way.

Station grounding systems are to be connected to any of HONI's grounding system(s), only after:

- HONI reviews the Customer's ground potential rise ("GPR") study (produced at Customer's expense by a Professional Engineer registered in Canada, or Professional Engineer with credentials recognized by the

PEO – Professional Engineers of Ontario), and such grounding system is adequate on a "stand alone" basis.

- HONI is provided by the Customer with written certification from ESA's Professional Engineer registered in Canada or PEO recognized credentials that the Customer's Load Connection Facility, including their grounding system, meets ESA requirements on a "stand alone" basis.

For the Load Connection Facility, the grounding systems shall be designed and installed to ensure safety of personnel and equipment in and around the Facility. Grounding systems shall provide a means of ensuring a common potential between metal structures and equipment accessible to personnel so that hazardous step, touch, mesh and transferred voltages do not occur. In addition, effective grounding systems shall limit the damage to equipment during faults or surges and ensure proper operation of protective devices such as relays and surge arresters.

The Canadian Electrical Code (Sections 10 and 36) and IEEE Guide for Safety in AC Station Grounding (IEEE Standard 80) stipulate the requirements for the design of these systems to maintain safe levels of step and touch potentials.

The basic design of an effective grounding system is required to:

- Provide grounding of all conductive enclosures that may be touched by personnel thereby eliminating shock hazards.
- Limit voltage in the electrical system to definite fixed values of step and touch potentials to ensure personnel safety.
- Limit voltage to within insulation ratings of equipment.
- Provide a more stable system with a minimum of transient over-voltages and electrical noise.
- Provide a path to ground for fault currents to allow quick isolation of equipment with operation of ground fault protection.
- Reduce static electricity that may be generated within the facilities.
- Provide protection from large electrical disturbances (such as lightning) by creating a low resistive path to earth.
- Provide a stable grounding system for telecommunication system.

The grounding installation shall be capable of carrying the ultimate maximum ground fault current for the specific station fault magnitude and duration, as specified in the Table of Ratings, without causing any hazardous potentials, potential gradients, interference to other systems, or damage.

For customer built and transferred Load Connection Facilities:
The Load Connection Facilities shall include and not be limited to permanent grounding systems, as well as temporary bonding and grounding system to ensure staff to safely work on de-energized equipment.

Permanent Grounding Systems: Grounding systems are comprised of predominantly ground rods and copper conductors connected together into a mesh that is buried and bonded to all station structures, buildings, transformers, breakers, and fencing. Grounding systems in a Load Connection Facility shall be designed to 40 kA fault level.

All above grade metallic facilities shall be securely bonded to the grid with grounding conductors. Additional ground rods shall be securely bonded to the grid at major facilities and particularly at surge arrester locations. One type of service that is normally isolated from the ground grid is telephone service using

metallic pair cable. Such cables are typically isolated from ground in order that exterior telephone equipment is not damaged by the high voltage spikes that are observed in ground grids during faults.

All transmission line structures within the Load Connection Facility must be adequately bonded and grounded to the ground grid to control step and touch potentials and to provide adequate lightning performance.

Temporary Grounding Systems: Temporary grounding and bonding systems are installed for personnel safety when working on de-energized apparatus. These are required to eliminate hazardous induced potential differences caused by adjacent energized conductors, residual charges on capacitive circuits or accidental re-energization of circuits or apparatus. A HONI approved ground mat shall be used under all manually operated switches.

Additional project specific requirements may also be applicable.

8.5 TELEMETRY AND MONITORING

In addition to the requirements of the TSC, the following requirements apply for Option 2.

8.5.1 Real-time data to be provided by the customer

Under the TSC, Owners of Load Connection Facilities connected to HONI's transmission facilities, have an obligation to provide real time data pertaining to their equipment operation**.**

These requirements for real time operating information apply to all Customer-owned Load Connection Facilities connected to HONI's HV facilities. The quantities and device statuses, defined below, shall be monitored and transmitted continually to HONI. Details and specifications are to be captured in Schedule I of the Customer's TCA, as required by HONI and the TSC. Real time data may also be transmitted to the IESO by HONI as per IESO requirements.

The following information is required as a minimum:

A) Analogue Quantities
   (a) Where HV voltages are monitored
      i. HV active power (MW) and reactive power (MVAR) flows and directions for each transformer
      ii. Three phase-to-phase or three phase-to-neutral voltages of each HV transformer winding or bus
   (b) Where HV voltages are not monitored
      iii. Low voltage active power (MW) and reactive power (MVAR) flows and directions for each transformer winding or for each LV bus
      iv. Three phase-to-phase voltages of each low voltage bus
   (c) Under load tap changer (ULTC) positions
   (d) Off load tap changer (OLTC) positions do not have to be telemetered. However, the customer must provide HONI with the in service OLTC positions and notify HONI of any changes thereafter.

B) Device statuses
   (a) All HV circuit breakers/switchers and bus tie breakers

(b) All HV line-disconnect switches
(c) All HV bus/tie sectionalizing switches
(d) All LV transformer and bus tie breakers and switches
(e) All LV capacitor breakers or isolating switches

For Load Connection Facilities operated by HONI, the following information is also required:

(a) Three phase feeders currents
(b) Status of all feeder breakers
(c) Status of all feeder-breaker reclosing (armed or not armed)
(d) Status of all feeder-tie switches
(e) Other site specific data

C) Alarms
An alarm signal shall be generated and transmitted to HONI whenever a Customer-owned protection, which is designed to trip HONI's breakers, operates. A separate alarm must be provided for each circuit supplying the Customer. The alarms shall identify the name of the Load Connection Facility and the designation of the HV interrupted circuit.

8.5.2 **Monitoring Reporting**

Adverse situations involving the operation of the transmission system, such as false trips or misoperations must be reported to the appropriate regulatory authorities. It is expected that any protection operation involving the transmission Load Connection Facility will be fully documented along with appropriate records from monitoring devices and provided to HONI immediately following any such operation.

Customers must comply with requests for sequence of events records (SER) or digital fault records as requested by HONI or any controlling authority such as the IESO or NPCC within 30 days of request.

Waveforms and event data supplied to HONI must be in COMTRADE format (2013). Customer owned Load Connection Facilities shall analyze all protection system misoperations in order to take corrective actions to avoid future misoperations.

HONI-owned Load Connection Facilities shall be equipped with digital fault recording functionality. Digital fault recorders, or IEDs with digital fault recording capability, shall be connected to an IRIG-B signal from a GPS synchronized clock.

8.5.3 **Method of Delivery**

Communication Protocol and Demarcation

Customers can provide real time operating information to HONI directly from the station(s) or from the Customer's SCADA master, as described below.

The Customer shall provide all the required hardware and software and make arrangements, as needed, with a commercial provider of communication services to deliver the operating data to the demarcation point. Each party will be responsible for all costs, initial and ongoing, and maintenance of their equipment and communication circuits up to the demarcation point.

(a) From the RTU at the Customer's Load Connection Facility to HONI's control center using serial DNP 3.0 protocol as follows:

i. To HONI's communication hub site and through the gateway to HONI's control center, with the demarcation point being inside HONI's hub site.
ii. Where (i) is not feasible, to a HONI HV station and through the RTU or gateway to HONI's control center, with the demarcation point being inside HONI's station.
iii. Where (i) and (ii) are not feasible, through a Frame Relay Network of a common carrier to HONI's control center, with the demarcation point being the CO nearest to the customer's Load Connection Facility.
iv. Where (i), (ii) and (iii) are not feasible, HONI will suggest communication circuit options available for a particular site.

Where modems will be used in any of the above communication methods, HONI will determine the modem type and requirements considering communication media, site location, reliability, and amount of data transfer.

(b) From a SCADA master through a Frame Relay Network to HONI's SCADA master using ICCP. The communication demarcation point will be the Central Office (CO) of a common carrier.

Reliability Requirements
The delivery of the real time data at the communication demarcation point shall have unplanned failure rates and repair times as described in Table 2 below:

Table 2 - Reliability Requirements

Failure	Mean Time to Failure	Mean Time to Repair
Failure to deliver data from a single station	4 years	24 hours
Simultaneous failure to deliver data from 2 to 5 stations	5 years	4 hours
Simultaneous failure to deliver data from more than 5 stations	20 years	4 hours

Prior to connection to HONI facilities, the Customer shall submit a reliability evaluation report which demonstrates that the above reliability requirements can be satisfied.

Planned Outages
The Customer must coordinate any planned interruption to the delivery of real time data with HONI.

Performance Requirements
At the output of the Customer's RTU, the operating data delivered to HONI shall:

(a) Have an overall end-to-end measurement error no greater than 2%.
(b) Have a delay no greater than 2 s from the change in the field of the monitored quantity or status for a simultaneous change of up to 15 monitored points, following a single contingency at or outside the customer's Load Connection Facility.
(c) Have a skew no greater than 0.5 s.

Prior to connection to HONI facilities, the Customer shall submit a report which demonstrates compliance with the above requirements.

8.6 SITE ACCESS (ADDITIONAL REQUIREMENT FOR OPTION 2)

Site access shall be in accordance with the terms of the CCRA executed by the customer and HONI.

9.0 TECHNICAL REQUIREMENTS FOR TAPPED LOAD CONNECTION FACILITIES SUPPLYING LOAD

For all load connection facilities, the customer must meet all requirements of the OEB TSC as applicable and other OEB and regulatory requirements.

The following is intended to provide further clarification of requirements as defined in the TSC.

9.1 SUPPLY CONSIDERATIONS

The provisions under the TSC apply. Additional project specific requirements may also be applicable.

9.2 PROTECTION REQUIREMENTS

Transmission Load Connection Facility equipment shall consist of protection elements as indicated in generalized tables in this section (Tables 3–7). These protections are referred to as "interface protections" and are required for the safe and reliable operation of the power system. Specific (detailed) requirements for connection protection shall be discussed with HONI Head Office planning staff during the design stage prior to any work being commenced. All settings on transmission Load Connection Facility equipment shall be reviewed by HONI at least 4 months prior to being placed in-service.

Neither HONI nor the Customer shall rely on the other's protection scheme to protect their own equipment. HONI will not be held liable for mis-coordination or improper protection of Customer-owned equipment.

HONI utilizes three-pole tripping exclusively and no exceptions will be made to this philosophy. HONI-owned Load Connection Facilities must comply with the TSC and the design, construction, maintenance procedures, etc., must be reviewed by HONI Head Office planning staff. Customer owned equipment, such as line differential protections, communications equipment, transfer trip relaying, etc. must be compatible with HONI-owned equipment where applicable, such as in line differential schemes and certain communication schemes used for teleprotection.

In the case of Load Connection Facilities not built by HONI but where ownership is transferred to HONI, HONI will provide the technical details for major equipment (transformers, breakers, disconnects, arrestors, line connectors, etc.) where required.

9.2.1 Line Backup Protections

Line backup protection is required when:

- Transformers are connected to separate supplies (transmission lines) and are connected in parallel on the transformer secondary (see Figure 2) or
- If a large magnetomotive force (MMF) infeed, such as dispersed generation, exists on the low level bus (Figure 3). For such cases, the line protection shall "see" all line faults and trip at the connection site to remove all connection site fault infeeds.

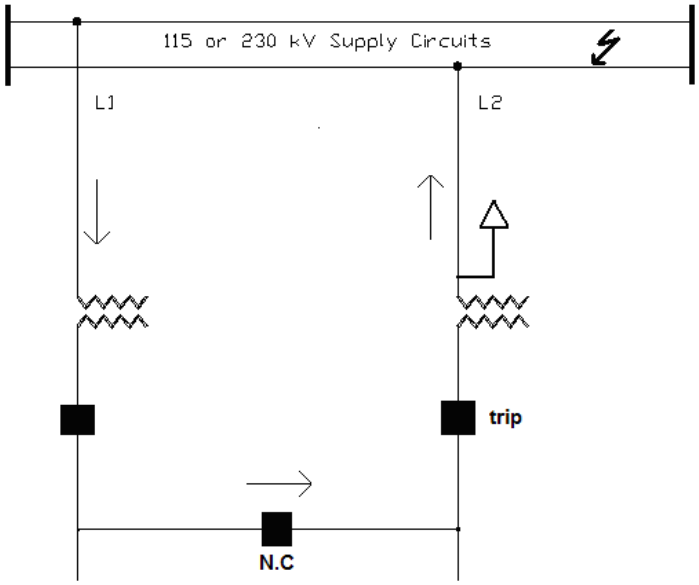

Figure 2 - Line Backup Protection Required – Transformers in Parallel

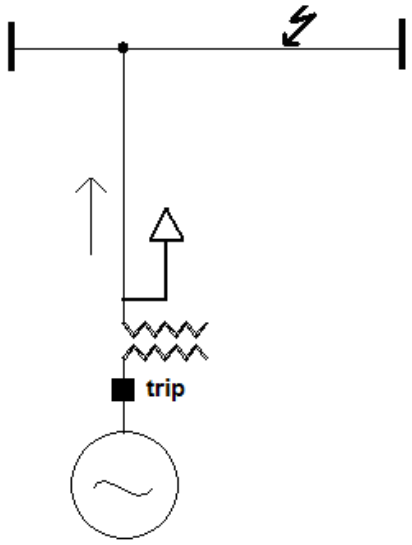

Figure 3 - Line Backup Protection Required – Large MMF exists on Low Voltage Bus

Line backup protections shall be installed at Dual Element Spot Network (DESN) Load Connection Facilities to isolate the sources of energy from being back-fed from the DESN Load Connection Facility following a line fault, by opening the transformer LV winding breaker and cancelling reclose. The line backup protection shall be delayed to provide coordination with the line terminal protection.

Line Backup Phase Protection

Line backup phase protection may be implemented either via MHO distance or directional overcurrent elements directioned toward the line away from the Load Connection Facility. Directional phase overcurrent may be deployed as long as there is no risk of operating on reverse current flow from dispersed generation (DG). These elements are immune from operation for Load Connection Facility load and will operate for line faults as a backup to transfer trip from the terminal stations should communications fail. In order to be directioned (that is, to "see" in the correct direction), these elements require voltage polarization. The voltage polarizing can either be implemented via a three phase voltage instrument transformer on the HV side of the Load Connection Facility or on the LV bus (with voltage transfer between the two transformers). Where the LV bus voltage instrument transformers are used the -30 degree phase shift through the power transformer must be accounted for where current is measured on the HV side of the transformer. A rule of thumb for the line distance (phase) setting (phase) is 1.25 times line apparent impedance times the number of DESN Load Connection Facilities stations on the line. The protection timer must coordinate with the remote breaker failure protection and is typically set to 400 ms. For Load Connection Facilities owned by or to be transferred to HONI, only high side, three-phase voltage sources will be accepted.

Line backup protection at Load Connection Facilities (typically included with the transformer protection) shall be blocked for loss of potential due to the possibility of misoperations. Traditionally the loss of potential condition has resulted in numerous misoperations of the line back up so this condition shall be clearly annunciated as it results in a blocked protection.

Line Backup Ground Protection

The ground protection shall depend mainly on whether the HV transformer winding is grounded or ungrounded and can be a source for ground current. A grounded primary shall only require a protection to measure the current in the HV winding neutral to ground connection as the grounded transformer winding will act as a ground source for faults on the line with zero sequence current return. Where voltage is measured from the LV side, the transformer impedance and phase angle shift, typically 30°, must be taken into account. This only applies to distance relays supplied from LV VT's. For HONI-owned stations, it is required that three phase HV voltage sources be used exclusively. LV PTs will be considered by exception only.

The three-phase voltage transformers shall be configured to measure the zero sequence voltage (3V0) on the line side and line-to-ground faults shall be detected using a zero sequence overvoltage element. The timing for the ground protection shall be set to override temporary system voltage imbalances that could cause the protection to mistrip during normal system conditions; typically 2 seconds.

If other DESN stations, tapped to the same line, have their HV transformer neutral grounded, the zero sequence current from these ground sources could interfere with the measured voltage. As such, a fault study shall be performed in this case when setting the overvoltage/undervoltage protections to ensure that the protection would operate in all cases. The timing for the ground protection shall be set to override temporary system voltage imbalances that could cause the protection to mistrip during normal system conditions; typically 2 seconds.

9.2.2 LV Transformer Breaker Failure & Reclose

The LV transformer breakers are equipped with a simple breaker failure scheme. When a protection initiates a breaker failure of the LV breaker and the breaker has not opened (detected by an "a" pallet) within 0.3 s, all system elements electrically connected to this breaker will be tripped. LV breaker failure also will send transfer trip to HONI breakers if no HVI device is present. In the event of an actual LV breaker failure condition where there is no HVI to isolate the failed device, the Load Connection Facility shall not clear the ensuing transfer trip signal to HONI until the actual faulted condition is completely isolated from the system.

To prevent misoperation during maintenance, a contact of a Test/Normal switch is connected in series with the "a" pallet. This arrangement ensures that the breaker failure can be blocked during maintenance conditions.

Automatic reclosure of the LV breaker is also required to restore power to the LV bus following the clearance of a HV fault and the subsequent restoration of the line. With voltage monitoring on both sides of the breaker, reclosure occurs under two conditions:

1) HV voltage presence, LV undervoltage plus a time delay.

2) Synchrocheck or HV and LV voltage presence plus time delay.

9.2.3 Bus Tie Breaker Failure

This is similar to LV transformer breaker failure but no reclosure is provided and TT is not initiated.

9.2.4 Transformer Protections

For transformers rated at 50 MVA or greater, two transformer differential protections, gas protection (accumulation and sudden pressure) and ground connected overcurrent protection shall be provided. These shall be designated as "A87" and "B87" and "63" and "64", respectively (refer to Figure 4). The high impedance grounding of the transformer neutral will limit the fault current for an internal fault so that the differential relay may not receive sufficient current to operate. In this case, a restricted ground fault protection using the high impedance differential principle is required (refer to Figure 5).

For transformers rated below 50 MVA, one transformer differential designated "A87," and a HV connected overcurrent (51) transformer phase backup protection with 64 ground connected overcurrent (used for ground fault protection) shall be provided (refer to Figure 6).

Transformer protection relays can be exposed to harmonics during energization or de-energization of the bank (magnetic inrush). These harmonics can appear as differential currents and falsely trip the protection. HONI HV transformer protection relays must have harmonic filtering such that harmonics will not compromise the dependability and reliability of the protection scheme.

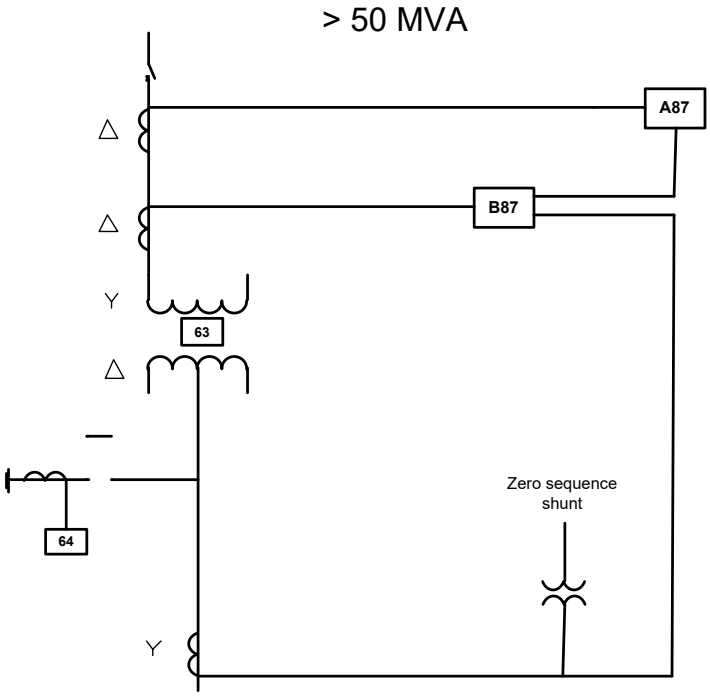

Figure 4 - 64 Ground Connected Overcurrent

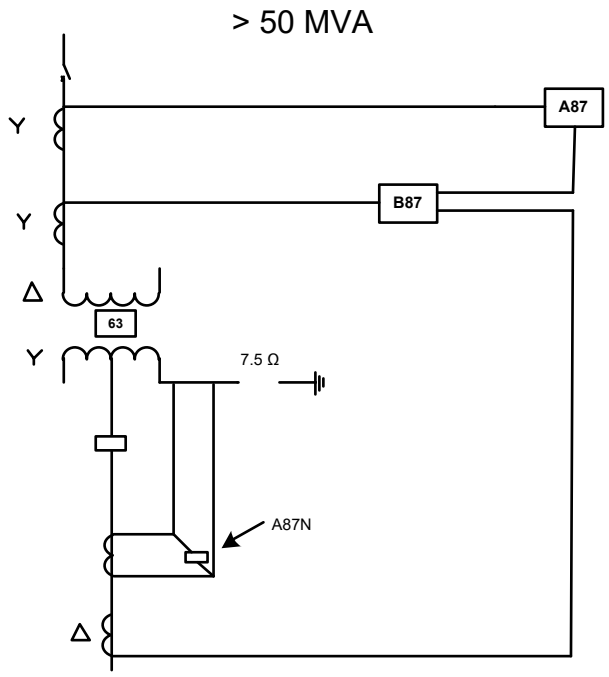

Figure 5 - A87N Transformer Protection

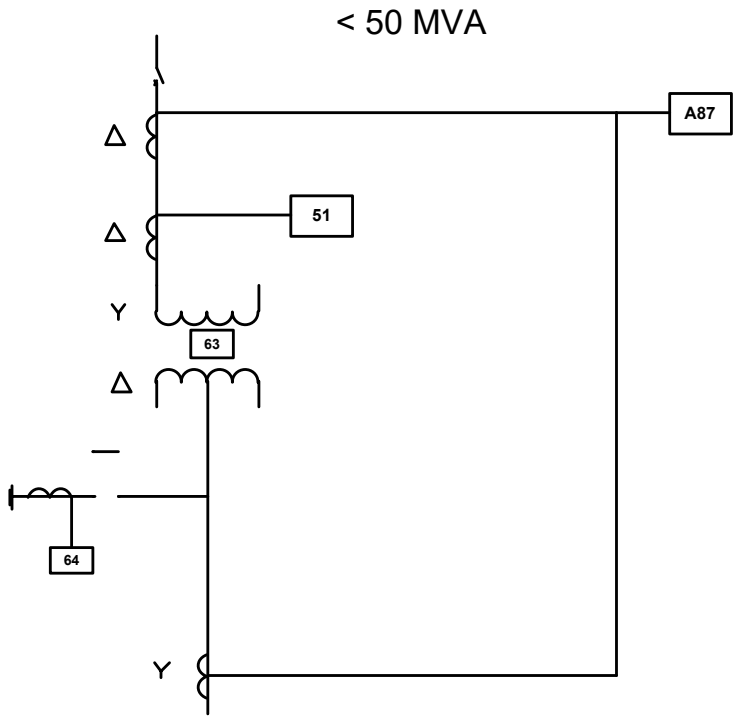

Figure 6 - Transformer 51 Protection

9.2.5 Master Ground Protection (3-wire LV systems)

For HONI-owned Load Connection Facilities, master ground protection shall be provided. During the transfer of loads between two feeders or buses, the three phases may not be switched simultaneously, causing short duration zero sequence current flow in the CT residual circuits and operate the feeder and bus ground relays.

To prevent misoperation, a master ground relay is provided to supervise the ground relays. The master ground relay is connected in parallel with both transformer neutral CTs. When zero sequence current is generated during switching, current will flow up the neutral of one transformer and down the neutral of the other such that the master ground relay detects no current and does not operate. For a ground fault, zero sequence current flows in both transformer neutrals in the same direction causing the master ground relay to operate.

Two master ground relays must be provided to facilitate maintenance on the protection.

9.2.6 Typical Transformation Configurations

In general there are three scenarios for connecting to the HONI system; one will be the case where there is no High Voltage Interrupting (HVI) device, the second where there is an HVI and the third is a variant of second where the LV bus tie breaker is normally open. These three scenarios are discussed below and primarily affect the line protections only. Discussions regarding the transformer protection, bus protection and breaker failure protection follow this section on the various line protections.

Scenario A – No HVI

In this first scenario, the Load Connection to the HONI system is by means of a disconnect switch only. There is no HVI included in the substation design. Refer to Figure 7 below for an example of a DESN station with no HVI. Figure 7 also shows the power system elements as well as some of the various protection elements.

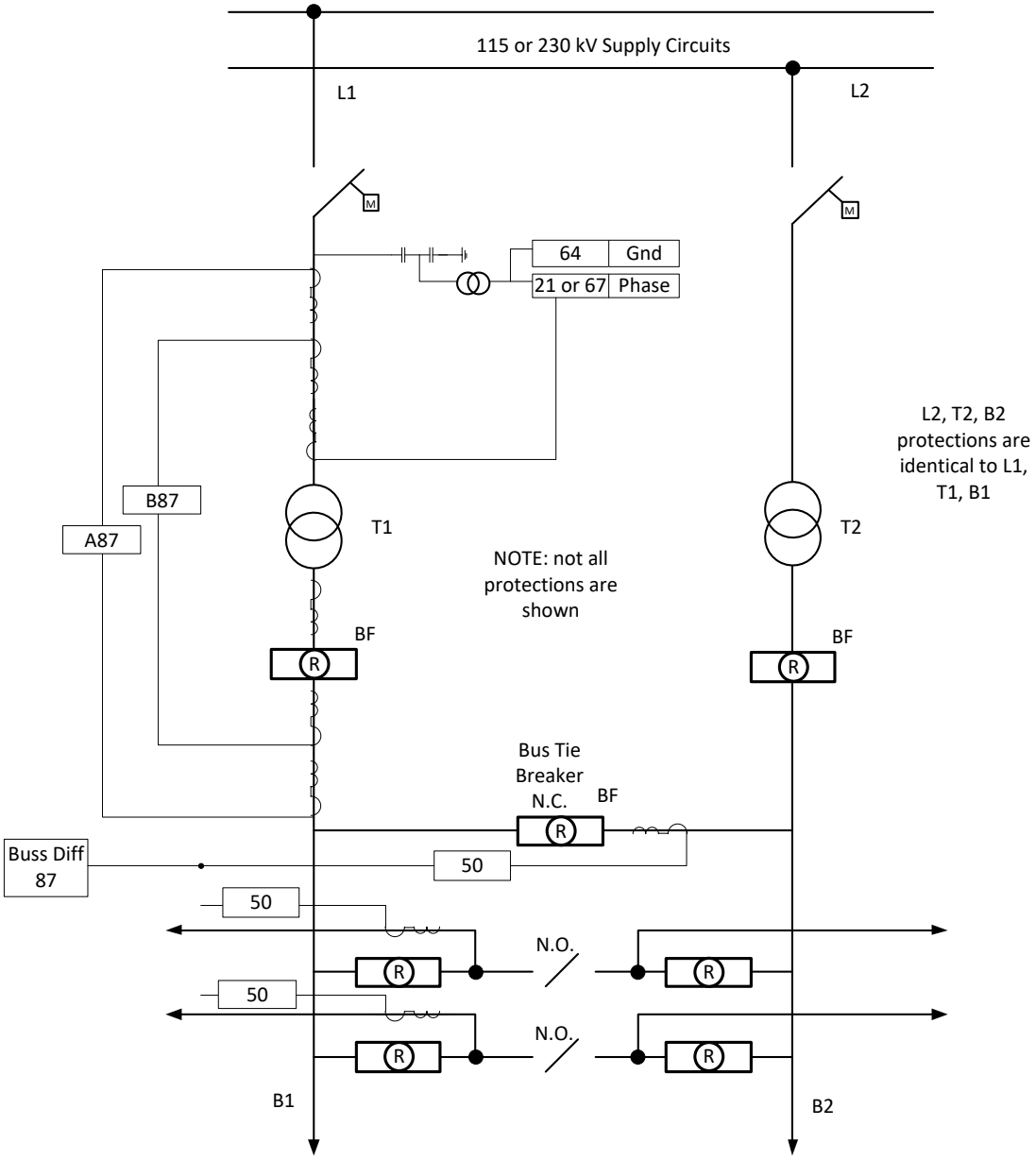

Figure 7 - DESN Load Connection Facility with no HVI

In the case where there is no HVI, the Transfer Trip (TT) is the main protection that sends a trip to the line terminal breakers for Transformer Zone faults and BF of the LV breaker, and receives a trip signal from the line terminal protections in order to trip the transformer low voltage breaker(s) at the connection site. Two TT channels are required for tones on leased circuits. The two transfer trip signals at the Load Connection Facility are typically not route diversified (leased circuits cannot provide guaranteed diversity) as the Load Connection Facility will rely on its line backup protection in the event of a communication failure. In addition, transfer trip from the Load Connection Facility is typically sent to the closest terminal station from where it is then sent (cascaded) to other DESN(s) and remote terminal(s).

The backup protection consists of distance (21) or directional overcurrent (67) for phase faults and residual voltage 3V0 (64) for ground faults.

In cases where a Remote Trip (RT) or Transfer Trip signal is sent as a result of a transformer fault, the Load Connection Facility shall open a motor operated disconnect switch to isolate the transformer from the HONI system. This shall be done after a suitable time delay. When the disconnect switch is fully open, RT/TT shall be blocked. RT/TT must be sent for 20 sec or until the disconnect switch is open whatever is later. For RT/TT being sent as a result of Breaker Failure (BF), the BF signal must be sent for 45 sec.

Transfer Trip[2] send-signals shall be supervised by a pallet switch from the motor operated disconnect switch in cases where two transformer differential protections are used. For such cases, the TT signals shall be supervised by the disconnect switch pallet only when one of the two protections operate. The logic shall be such that if both operate, no supervision is used.

Table 3 summarizes the basic line protection requirements for a Load Connection Facility where there is no HVI present.

Table 3 - Basic Line Protection Requirements – No HVI

Protection Device	Device Number	HONI owned	Customer owned
Phase Distance or Directional Overcurrent – "A" protection	A21 or A67	X	X
Ground Residual Voltage or Over/Under Voltage or non-directional overcurrent	64 or 64-27/59 or 64B-50	X	X
Transfer Trip		X	X

Scenario B – With HVI

In the second scenario, the Load Connection to the HONI system is by means of a disconnect switch and an HVI device. Refer to Figure 8 below for an example of a DESN station with an HVI. Figure 8 shows the power system elements as well as some of the various protection elements.

[2] Transfer trip and remote trip generally apply to the same thing; however, remote trip refers to a dc connection between points, whereas a transfer trip refers to some other form of communication media such as microwave or SONET.

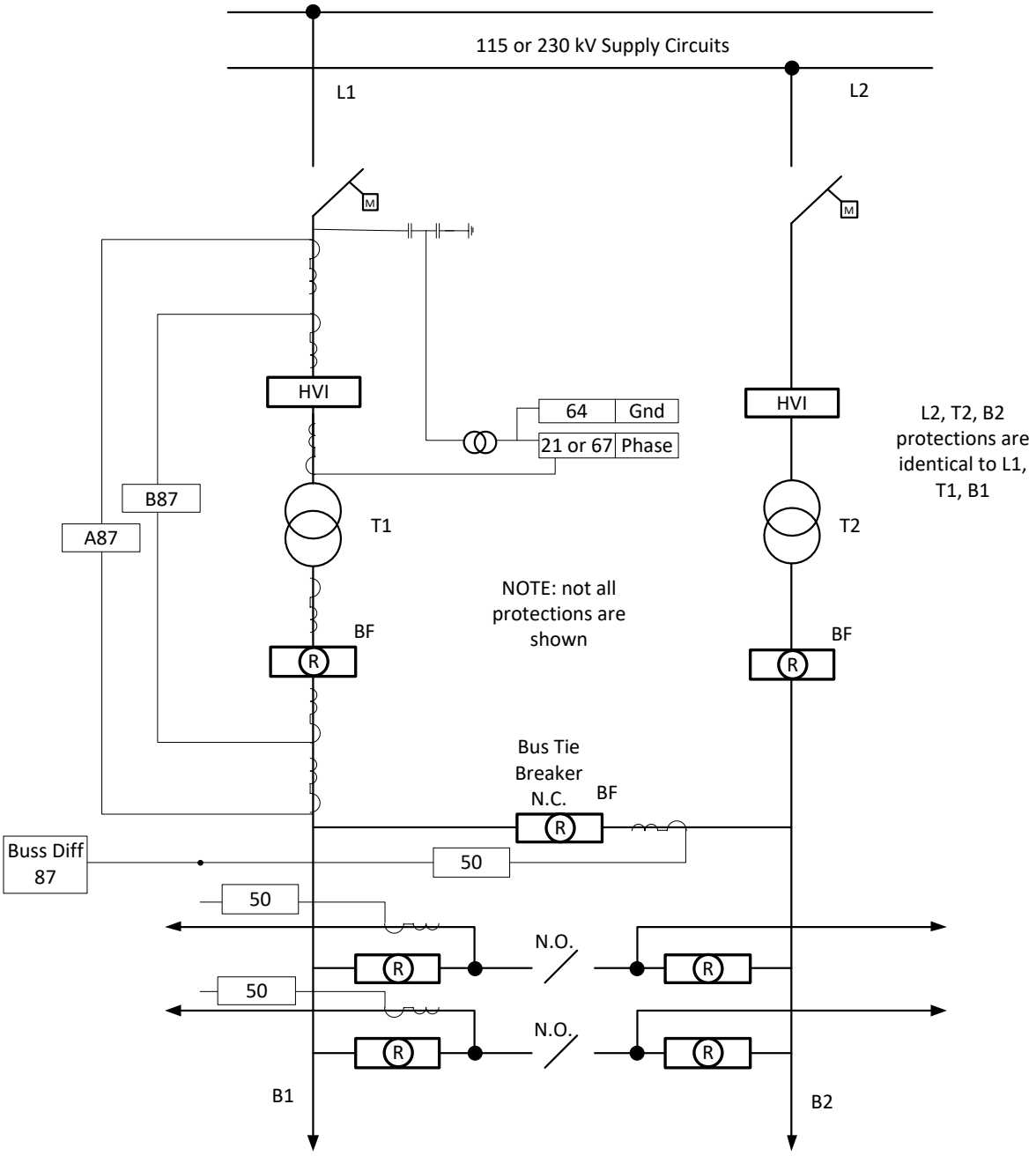

Figure 8 - DESN Load Connection Facility with HVI

Wherever there is a HVI connecting to the HONI system, there must be a motor operated disconnect switch in series with it on the line side of the HVI.

HVI devices must have trip coil monitoring for all Load Connection Facilities. For HONI-owned stations, the HVI device must have a Test/Normal switch in order to remove the HVI control from SCADA operation and place the device in local (Test) control. HVI devices must have two inputs; one for tripping the interrupter where the two are in one unit (for example, the S&C Circuit Switcher) and one for opening the disconnect switch. This requirement is necessitated as normally no transfer tripping facilities are provided for this type of arrangement, and the disconnect switch is the backup device to the HVI.

In cases where Transfer Trip capabilities are not required (such as the case when there is an HVI device), dual line protections ("A" protection and redundant "B" protection) using either a distance relay or directional overcurrent relay are required for phase faults. Ground fault protection requires redundant 27 and 59 or 3Vo (64) or 64B-50, depending upon system parameters and the transformer connection.

Table 4 summarizes the basic line protection requirements for a Load Connection Facility where there is an HVI present.

Table 4 - Basic Line Protection Requirements - With HVI

Protection Device	Device Number	HONI owned	Customer owned
Distance or Directional Overcurrent – "A" protection	A21 or A67	X	X
Ground Residual Voltage or Over/Under Voltage or non-directional overcurrent – "A" protection	A64 or A64-27/59 or A64B-50	X	X
Distance or Directional Overcurrent – "B" protection	B21 or B67	X	X
Ground Residual Voltage or Over/Under Voltage or non-directional overcurrent – "A" protection	B64 or B64-27/59 or B64B-50	X	X

Scenario C – HVI with LV tie open

This third scenario is a slight variant of the second scenario with the HVI. In this case the LV tie breaker is open. Refer to Figure 9 below for an example of a DESN station with an HVI and the LV bus tie open. Figure 9 shows the power system elements as well as some of the various protection elements.

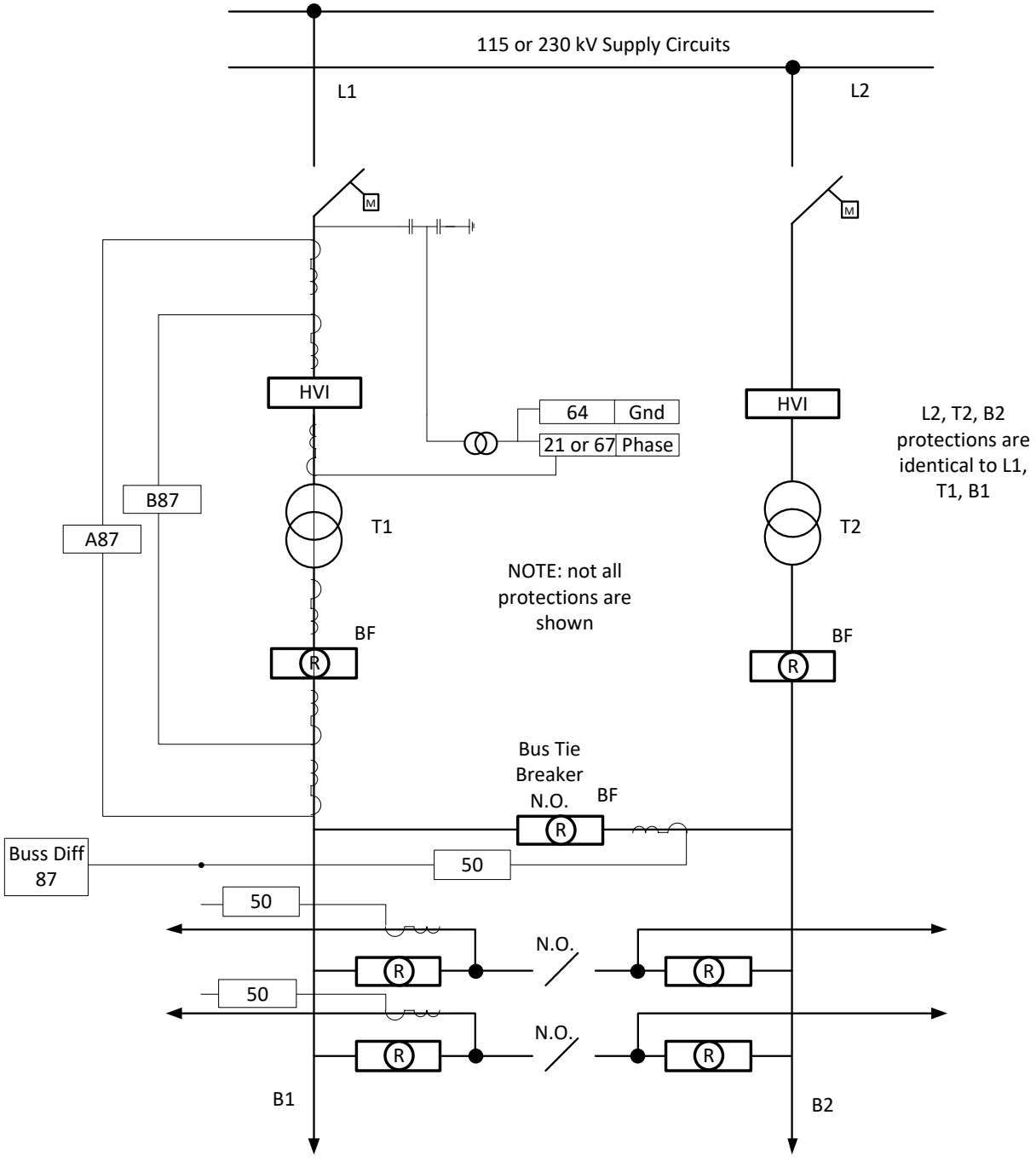

Figure 9 - DESN Load Connection Facility with HVI - Bus Tie Open

Transformer and Bus Requirements

The transformer and bus protection required are the same for each of the various configurations (with and without HVI device). The following Tables (Table 5, Table 6, and Table 7) summarize the general protection requirements.

Table 5 - Basic Transformer Protection Requriements

Protection Device	Device Number	HONI owned	Customer owned
Transformer Differential – "A" protection	A87	X	X
Transformer Differential – "B" protection (>50MVA)	B87	X	X
Transformer backup (<50MVA)	51, 64		X (or redundant "B" diff)
Ground overvoltage (For primary ungrounded wye or delta transformers)	64-59	X	X
Ground undervoltage (For primary ungrounded wye or delta transformers)	64-27	X	X
Ground directional overcurrent or transformer neutral (For primary grounded wye)	64B-50	X	X
Restricted ground fault if high impedance transformer reactor (neutral) grounded (7.5 ohm) for one group only	A87N	X	X
Master Ground(for low voltage bus with high impedance grounding)	64M	X	X

Table 6 - Basic Bus Protection Requirements

Protection Device	Device Number	HONI owned	Customer owned
Bus Differential – "A" protection	87	X	X
Bus Backup – "B" protection	51B/51NB (ph/gnd)	X	X
Breaker Failure (bus tie, if applicable)	50BF	X	X
Under frequency (Load Shed)	81U	X	X

Table 7 - Basic LV & Bus Tie Breaker Failure Requirements

Protection Device	Device Number	HONI owned	Customer owned
Breaker Failure	50BF	X	X
Breaker Reclose *	79	X	
* Not provided for bus tie breaker			

9.3 TRANSMISSION LINES AND TRANSMISSION LINE TAPS

The function of "supply" transmission lines is to transport electricity between electrical transformer stations over long distances. Transmission line taps are shorter transmission lines "tapped" from a transmission line to supply electricity to the load stations. The transmission lines and transmission line taps are generally 230 kV or 115 kV.

The current carrying capability of the transmission lines and taps depends on system requirements and electrical load. Overhead transmission lines on structures are commonly used for the supply transmission lines and the transmission line taps. Such transmission lines must be designed to carry rated electrical current under different weather conditions, and at the same time meet electrical requirements for safe operation (e.g. insulation level), as

well as be capable of withstanding harsh weather related conditions including snow, ice, certain level of tornados, high winds among other factors.

Specific project requirements will be provided by HONI, such as the requirements for insulation requirements (BIL), conductor spacing and line tension for the interface structure. The transmission line connecting the Customer-owned Load Connection Facility to the HONI grid must be constructed using good utility practices and the applicable standards, including ESA, CSA, IEEE, ANSI and IEC. Lines shall have overhead shielding conductors.

Refer to the following document links for more specific requirements:

For 230 kV Line requirements refer to [LINK]

Adobe Acrobat Document

For 115 kV Line requirements refer to [LINK]

Adobe Acrobat Document

Where a Customer plans to sell or turnover a transmission line to HONI, HONI requires a LiDAR line clearance survey to be conducted. The survey must be certified by a Professional Engineer from Ontario and must be included with commissioning documentation.

10.0 PROTECTION SYSTEM REQUIREMENTS

The provisions of the TSC apply. Additional project specific requirements may also be applicable. The following is intended to provide further clarification of requirements as defined by the TSC.

10.1 TELECOMMUNICATIONS

Each transmission Load Connection Facility shall have a working voice communications system in place that functions reliably and is not dependent upon local ac supply. The purpose of this communications system is for the use of protection and control personnel as well as operating personnel.

In a multi-terminal protection scheme, it may be necessary from time-to-time to install equipment at the Customer's site to accommodate or enhance reliable operation of the protection scheme. It is expected that Customer owned Load Connection Facilities will accommodate such activity, given reasonable notice of the need to access the site and that the Customer will participate in any cost sharing necessary in such an endeavor.

10.1.1 Telecom Requirements

The following minimal requirements shall be met with respect to HONI-owned or connected telecommunication equipment:

1. The teleprotection equipment shall be reliable (dependable and secure) and shall be consistent with the requirements of the protection system and be compatible with existing HONI-owned equipment. The telecommunications system shall be dedicated for protection purposes only.

2. All 802.11 wireless communication must be secured using:
   a. 802.11i or
   b. Public Key Infrastructure (PKI) or
   c. 802.1x device registration

3. Control system commands and control system data must be authenticated.

10.1.2 Telecom Design Considerations

The following considerations will be adhered to for teleprotection facilities connected to HONI-owned equipment where applicable:

1. The Customer's equipment must be compatible with HONI facility equipment.
2. The Customer will provide separate "A" and "B" battery supply circuits corresponding to "A" and "B" protection relays.
3. The Customer will provide two communication circuits for the transmission of protection commands such that failure of one circuit will not result in the loss of both "A" and "B" teleprotections.
4. Route diversity in communication circuits is encouraged to minimize single point failure and potential of forced power outage to the load.
5. Transfer trip from the Load Connection Facility is typically sent to the closest terminal station from where it is then sent (cascaded) to other DESN(s) and remote terminal station(s).
6. HONI will suggest communication circuit options available for a particular site.

10.1.3 Telecom Protection

Where solid wire connections are used to communicate remote trip or transfer trip signals to the Customer, the Customer is required to install any specific protection equipment to protect against ground protection rise or induced voltages. This protection may take the form of neutralizing transformers and/or gap protection on incoming communication lines.

The Customer must satisfy requirements set by the telephone services provider for installation of telephone cable facilities. Examples of these requirements may include GPR (ground potential rise) study, suitable optical isolation equipment, neutralizing transformer, carbon blocks, gas discharge tubes etc.

10.2 TEST SCHEDULE FOR RELAYING COMMUNICATION SYSTEMS

Telecom equipment necessary for correct operation of protective functions between HONI and Customer sites must be maintained on a routine basis. Teleprotection equipment should be considered an integral part of protection equipment and systems. As such, its test intervals should correspond to those used for protection equipment and the two should be tested simultaneously.

Table 8 - Communication Systems

Maintenance Activity	Attribute	Intervals for Components subject to NERC criteria[(ii)]	Intervals for Components not subject to NERC criteria
Functional Communication Channel (i.e. signal adequacy test/check)	Unmonitored	3 calendar months	6 calendar months
Functional Communication Channel (i.e. signal adequacy test/check)	Monitored[(i)]	None	None

Communication System Performance / Terminal equipment (i.e. input/output)	Unmonitored	5 calendar years	5 calendar years
Communication System Performance / Terminal equipment (i.e. input/output)	Monitored(i)	10 calendar years	10 calendar years

Notes:

- (i) Communications system with continuous monitoring or periodic automated testing for the presence of the channel function, and alarming for loss of function.
- (ii) Protection systems that are installed for the purpose of detecting faults on BES Elements (lines, buses, transformers, etc.), underfrequency load-shedding systems part of the Ontario UFLS program, undervoltage load-shedding systems part of the UVLS program and Remedial Action Schemes (RAS). The IESO identifies the BES, UFLS program, UVLS and RAS lists.

10.3 VERIFICATION AND MAINTENANCE PRACTICES

In addition to the provisions in the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

10.3.1 Testing and Maintenance Requirements

Sufficient documentation must be provided to HONI in order that test personnel have a clear understanding of the intent of each protection system. This applies to all protection and telecommunication schemes that will be surrendered to HONI, or are necessary for the reliable operation of the HONI system. HONI-owned protection schemes shall have test facilities for isolating (and shorting, where necessary) secondary current and voltage signals. Provision must also be made for monitoring critical relay outputs. Where communication channels are being utilized, it must be possible to open or put these channels into a loop-back state.

Transmission Load Connection Facility protection and control equipment must be installed such that routine and emergency maintenance can easily be performed. This includes, but is not limited to the following:

1. Local access to input protection related voltages via FT-1 switches or equivalent.
2. Local access to input protection related currents via current links.
3. Local access to output trip, blocking, or control signal via FT-1 switches, or equivalent.
4. Local access to configuration and diagnostic ports on Intelligent Electronic Devices (IEDs).
5. Remote indication from protection equipment failure alarms.
6. No protection equipment shall be installed such as to make it permanent and not capable of being removed, or replaced, in the event of equipment failure.

Routine maintenance is required on all transmission Load Connection Facility protection equipment. For HONI-owned stations, routine maintenance shall be performed on protection equipment as per HONI specifications and NERC requirements.

The following table shows the current regulatory and non-regulatory maintenance activities and maintenance intervals that must be followed. The regulatory requirements are based of NERC standard PRC-005-6, “Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance.” It should be noted that this table is subject to change due to NERC revisions. The most current NERC approved standard PRC-005-6 should be used to determine NERC maximum maintenance intervals.

Table 9 - For Substation Components

Maintenance Activity	Attribute	Intervals for Components subject to NERC criteria[(ii)]	Intervals for Components Not subject to NERC criteria
Protective relays and associated current and voltage sensing devices (except feeder protections)	Unmonitored	5 calendar years	12 calendar years
Protective relays and associated current and voltage sensing devices (except feeder protections)	Monitored[(i)]	10 calendar years	12 calendar years
Feeder protective relays and associated current and voltage sensing devices	Unmonitored	N/A	8 calendar years
Feeder protective relays and associated current and voltage sensing devices	Monitored[(i)]	N/A	12 calendar years
Control circuitry (i.e. zone test trip)	-	8 calendar years	8 calendar years
Breaker Trip Coil (BES only)	-	4 calendar years	N/A

Notes:

- (i) Monitored microprocessor protective relay with the following:
  - Internal self-diagnosis and alarming.
  - Voltage and/or current waveform sampling three or more times per power cycle, and conversion of samples to numeric values for measurement calculations by microprocessor electronics.
  - Alarming for power supply failure.
- (ii) Protection systems that are installed for the purpose of detecting faults on BES Elements (lines, buses, transformers, etc.), underfrequency load-shedding systems part of the Ontario UFLS program, undervoltage load-shedding systems part of the UVLS program and Remedial Action Schemes (RAS). The IESO identifies the BES, UFLS program, UVLS program and RAS lists.

The maximum allowable tolerances on calibration or test results are listed in the Table below.

Table 10 - Maximum Tolerances

Quantity	Maximum Allowable Tolerance
Current	±10 %
Voltage	±10 %
Time	±10 %
Impedance	±0.05 %
Phase Angle	±0.05 %
Frequency	±0.05 Hz

For Customer-owned Load Connection Facilities, Customers must provide HONI with their proposed commissioning plans. HONI maintains the right to review maintenance, calibration, and operational records for all protective equipment for the purpose of safeguarding HONI equipment and other HONI customers.

Design and construction of any HONI Load Connection Facility shall be so constructed that maintenance can be easily conducted on all equipment. Specific maintenance plans, in accordance with HONI specification shall be provided to HONI for review at least one month prior to commissioning.

Maintenance plans shall include, but not be limited to the following:

1. Location of test points for each test.
2. All equipment affected by the test.
3. List of required test equipment and a copy of the calibration certificate for each device used in the initial testing/maintenance. Non-calibrated or out-of-calibration test equipment shall not be used for testing or maintenance purposes.
4. Conditions under which the test must be conducted, including outages, test trips, injected qualities, expected outputs (operate levels and timing, for instance) and points to be blocked.
5. Number and qualifications of staff required for each test.
6. Approximate length of each test.
7. Recommended frequency for maintenance.
8. Required supporting documentation (such as manufacturer manuals) and required supporting items (such as special cables or interface software) required to perform any maintenance.
9. HONI uses standardized test equipment for protection and control. All maintenance procedures for HONI-owned equipment shall be developed in order to be compatible with existing tools, techniques, and procedures, as provided by HONI.

10.3.2 **Pre-Energization Inspection**

HONI may require that transmission Load Connection Facilities be inspected by qualified HONI personnel. This includes, but is not limited to, the following protection and control related activities:

1. Proper wiring and cabling.
2. Proper cable terminations, including the application of EMC glands were required.
3. Proper grounding of cables sheaths.
4. Proper grounding of CTs and PTs circuits.
5. Proper fusing of DC buses.
6. Proper access to protection equipment and protection equipment interfaces.
7. Proper security features and passwords for cyber intrusion protection.
8. Proper labeling of devices, panels, switches, controls, target indications, communication channels, mimic panels, cables, etc.
9. Proper practices for wiring, construction, grounding.
10. Proper clearances for access during maintenance.
11. Proper targets, test points, and injection points for maintenance.
12. Check values of resistors external to relays.
13. Proper taps and ratios used on CTs, PTs, auxiliary CTs and PTs.
14. Check that pallets, test/normal switches, and other interlocking devices are properly connected and adjusted.
15. Verify that proper settings have been applied to protective devices.
16. Ensure that proper fire and physical security annunciation and alarming has been implemented.
17. “Ring out” cables/wires.

18. Ensure that voice communication channels work properly.
19. Check TT/RT channels.

HONI may elect to inspect the site during construction at their discretion based on mutually agreeable times with the customer. Specific details and requirements of the inspection will be determined by HONI.

All commissioning documents shall be surrendered to HONI upon completion of commissioning procedures. HONI shall be notified in advance of any commissioning tests and may at its discretion verify such tests. Commissioning tests shall be conducted by qualified individuals only and all commissioning test reports shall be certified by a professional Engineer licensed in the province of Ontario. Evidence of appropriate qualification may be required by HONI.

For HONI-owned Load Connection Facilities, a summary of all protection test results shall also be provided to HONI. For Customer-owned Load Connection Facilities, a summary of only the interconnection protection test results shall be provided to HONI.

10.3.3 **Commissioning**

Once HONI approves the design/settings, the COVER (Confirmation of Verification Evidence Report) form will be sent to the Customer. The completed form should be returned to HONI along with the commissioning plans. Once the commissioning tests are performed, the Customer must submit the final COVER form to HONI along with the commissioning test reports.

Commissioning test reports shall be provided to HONI for the following protection and control related activities and equipment:

1. CT polarity and ratio tests.
2. CT excitation tests.
3. Phase rotation on PT secondary inputs to relays.
4. Relay commissioning data for of all protection, control and alarm functions.
5. Relay trip tests, including primary equipment tripping.
6. Verification of all annunciation and SCADA points.
7. Verification of all TT or RT channels.
8. Verification of voice channels.

All commissioning reports shall be dated with the date that the commissioning procedure was executed and shall be signed with the name of the person responsible for conducting the procedure. The test equipment along with model and serial number and last date of calibration shall also be included in the commissioning reports. All commissioning reports shall be sealed by a Professional Engineer (P. Eng.). Information showing adequate test equipment calibration, with reference to a national standard, and date of calibration for all test equipment is required by HONI.

Notification of commissioning tests shall be passed onto HONI with at least three business days of notice. All commissioning tests shall be completed at least 7 days prior to the planned in-service date to allow or remediation in the event of some difficulty. Based on HONI's discretion, the verification of commissioning tests may be waived in lieu of document review only.

"As left" setting files must be downloaded from each relay and provided to HONI as a final record of the settings applied and tested on the protective relaying equipment.

10.3.4 **On-Potential and On-Load Checks**

Once the station is energized, various on-potential checks must also be completed for all Load Connection Facilities. These include the following:

1. Proper phasing of voltage transformer secondaries applied to relays.
2. Verification of SCADA readings.
3. Verification of actual quantities displayed by line protection and transformer protection relays.

Following successful on-potential tests, on-load testing must also be performed in order to verify the following:

1. Proper phasing of current transformer secondary's applied to relays.
2. Verification of SCADA readings.
3. Verification of actual quantities displayed by line protection and transformer protection relays.

Detailed reports indicating what on-potential and what on-load testing was performed and the results obtained must be provided to HONI for all substations connected to the HONI system.

10.3.5 **Feeders**

Provision must be in place for both HONI and Customer owned Load Connection Facilities to enable system operators to place a Hold-Off on all feeders. This is essential for the safety of crews working on feeders.

Instantaneous and timed phase and ground overcurrent relays should be provided on all radial feeders. Phase and ground backup relaying on the busses provides backup relaying, where this exists. In the case where phase and ground relaying on the bus is not present (for instance, where duplicate bus protections are used), a second form of feeder protection, such as distance, may be required.

10.4 FUNCTIONAL TESTS AND PERIODIC VERIFICATION

In addition to the provisions under the TSC, the requirements covered in Section 10.3 of this document apply. Additional project specific requirements may also be applicable.

10.5 FAILURE PROTECTION FOR HIGH-VOLTAGE INTERRUPTING DEVICES (HVIS)

The provisions under the TSC apply for the purposes of this section. Additional project specific requirements may also be applicable.

10.6 INSTRUMENT TRANSFORMERS

A detailed record must be provided to HONI of all nameplate data for all current and voltage transformers. This includes, but is not limited to manufacturer, date of manufacture, ratios, BIL, physical dimensions, accuracy class(es), thermal ratings, temperature ratings, and voltage/current ratings.

All potential transformers (wire wound PTs, capacitive CCVTs, or optical voltage transformers) used for transmission Load Connection Facility protection purposes for HONI-owned Load Connection Facilities must be approved by HONI. All potential transformers shall have adequate volt-ampere capacity for designed loads. Potential supplies from PTs or CCVTs shall be individually fused. PTs and CCVTs should have factory installed ferroresonance suppression circuitry.

Each potential device should have a minimum of two secondaries.

Each Load Connection Facility must have three HV PTs, or with special approval by HONI, three LV PTs. If LV PTs are used, consideration must be given to standard 30 degree phase shift and transformer impedance must be

considered when using LV PTs for line protection. Zapp (phase) will typically be equal to 1.25 times the number of DESN stations on the line times the line impedance plus the transformer impedance.

Minimum CT ratios for primary protection equipment shall be rated at 10L400 (C400) on the LV side of the transformer and 10L800 (C800) on the HV side of the transformer. Current transformers shall be designed with a continuous current rating of 125% of the maximum expected circuit loading. CT's shall not saturate for worst case faults with full DC offset. Unused CT outputs shall be shorted at the CT or at the earliest possible point thereafter and grounded.

A minimum of three CT cores are required on each bushing and phase of each transformer. A minimum of two CT cores are required for each phase of bus tie breakers and each phase of transformer secondary breakers. Either wire wound current transformers or optical current transformers or Rogowski coils can be used subject to approval by HONI.

For HONI-owned Load Connection Facilities, all specified nameplate ratios shall have fully distributed windings about the iron core.

Potential transformer and current transformer secondary circuits must be grounded in one location only (typically at the first point of termination within the relay building). Ground connections shall be easily opened, or removable, for maintenance and testing, if required. For potential transformer and current transformer secondary circuits terminated at some point in the yard, the grounding should be at the first point of the termination.

10.7 BATTERY SYSTEM AND DIRECT CURRENT SUPPLY

In addition to the provisions under the TSC, the following requirements apply. Additional project specific requirements may also be applicable.

The DC supply to the protection and control system, and other apparatus shall be designed to have a high degree of reliability and dependability.

The DC station service shall be a 125 volt (for Customer built and transferred to HONI) system providing enough ampacity on loss of the battery charger or AC station service to allow the station to operate to comply with the TSC.

Normally, two protected (fused) and monitored DC cabinets are required for load connection stations.

The dc distribution systems shall utilize molded-case breakers and fuses in low voltage distribution panels adequately rated for the purpose. Separate 125 Vdc circuits shall be provided to each HV breaker and motor operated switch.

Battery

The batteries shall be sized in accordance with IEEE-485.

For Customer built and transferred Load Connection Facilities the following specific minimum requirements are necessary:

- The batteries shall be flooded cell.
- The batteries shall have a 20 year rating.
- The batteries shall be designed and rated for utility and /or switchgear applications.
- The DC battery shall be connected to the main DC distribution panel without any protective devices in between. Thus the connection distance must be minimized to reduce the possibility of failure.

The battery charger must be sized for carrying the continuous load plus eight hour recharge.

The specific loading of the battery system, as well as the battery charger, for sizing purposes and performance requirements will be provided as part of the project specific requirements.

The DC battery voltage levels when out of normal range must be integrated into an alarm system and be monitored by an operator.

11.0 EMBEDDED GENERATION AND BYPASS COMPENSATION

The provisions under the TSC apply. Generation Facilities are outside the scope of this document.

12.0 DISPUTE RESOLUTION

Refer to Hydro One's OEB-approved Transmission Connection Procedures for Hydro One's dispute resolution process.

13.0 COMING INTO FORCE

This section of the TSC applies only to the TSC.

14.0 FUNCTIONAL REQUIREMENTS NOT ADDRESSED BY THE TSC - FOR CUSTOMER BUILT AND TRANSFERRED LOAD CONNECTION FACILITIES TO HONI (Additional Requirement for Option 2)

This Section provides further clarification not specifically identified in the TSC. The focus is for customers who select Option 2, that is, customer who build and transfer ownership to HONI.

System Planning Specifications and more detailed Technical Requirements will be provided as part of the specific project requirements.

14.1 DESCRIPTION OF DESIGN CONCEPTS FOR LOAD CONNECTION FACILITIES

HONI requires that Load Connection Facilities owned by HONI, or Customer built and transferred to HONI be designed and built with a life expectancy of 40 years. The station design, construction, and equipment procurement requirements must be such to support this requirement.

14.1.1 HONI Load Connection Facility (DESN Design)

Figure 7 depicts a diagram of a typical HONI Load Connection Facility of the Dual Element Spot Network (DESN) type design.

The arrangement of a DESN station has two supply circuits with one transformer connected to each circuit. The transformers have electrical interruption equipment on the high voltage side and are connected to a common low voltage bus through circuit breakers. Each half of the station and the associated supply circuit is designed to carry the total station load in an emergency. This arrangement ensures that no load is interrupted during an outage to a transmission line or a transformer. However, a fault on the low voltage bus or bus tie breaker will result in a temporary interruption until load is restored by switching operations.

The HONI DESN Load Connection Facilities embody the concept of reliability of supply by redundancy. The bus tie breaker for the DESN station is normally closed. The design of the HV system shall provide for continuous supply or restoration of supply to the load by switching the LV system for any of the following first contingency conditions:

(a) Outage to a power transformer

(b) Outage to a main bus

(c) Outage to an LV transformer circuit breaker, bus tie circuit breaker, or feeder circuit breaker

(d) Outage to a station service transformer

The design minimizes coincident outages (common mode failure) which would result in an interruption to all or part of the load. In addition, two independent AC station service supplies are provided for DESN auxiliaries and connected so that outage to a single element will not result in the loss of station service.

In addition to the standard configuration presented in Figure 7 other configurations may be considered.

14.1.2 Standardization for DESN Facilities

Customer built and transferred Load Connection Facilities shall use equipment and parts that meet HONI's electrical and physical requirements recognizing that, HONI retains an inventory of strategic spares to cover emergency replacement of failed major equipment, such as power transformers and circuit breakers. Requirements such as ratings, limiting dimensions, configurations, accessibility for maintenance and replacement have been standardized to facilitate effective maintainability, including interchangeability. Failures of major components which do not comply with these requirements can result in extended outages and may require dedicated spare coverage, thus increasing the life cycle cost of a transferred DESN Load Connection Facility. HONI replacement and maintainability requirements, including complete interchangeability of all major components, including but not limited to power transformers, circuit breakers, capacitors and switches, shall be incorporated into the design and construction of DESN Load Connection Facilities.

HONI's normal requirements are for outdoor type Load Connection Facilities. However, HONI may at its discretion require an indoor Facility recognizing constraints related to, but not limited to, land, space, and integration into urban settings.

Specific technologies for equipment are used by HONI, and information regarding these will be provided as part of specific project requirements.

14.1.3 Transformer Requirements

The power transformers must meet HONI requirements.

In the DESN Load Connection Facilities, the power transformers have the function of electrically transforming electricity from high voltage at the primary windings to electricity at low voltage at the secondary windings. The primary winding voltages are normally 115 kV or 230 kV.

HONI DESN Load Connection Facilities have certain transformer sizes, as well as specific voltage requirements for secondary windings. The transformers sizes are noted in the table below, with the possible nominal secondary winding voltages for the power transformers.

Table 11 - Transformer Requirements

Transformer Size – MVA	No of secondary windings	Nominal Output – kV
45/75	2	13.8
50/83	1	27.6 or 44
60/100	2	13.8
75/125	2 or 1	27.6 or 44 respectively

In some cases, transformers may require two secondary windings which have different voltages.

This ensures that HONI transformers are capable of operating in HONI Load Connection Facilities under normal and emergency current, voltage and fault conditions. The transformer must also be built to meet the physical requirements in terms of footprint, bushing placement, cooler location and other criteria so the unit can be replaced with a system spares unit, or be relocated to another station without unnecessary reconfiguration of other assets.

The Limited Time Ratings (LTR) are provided by HONI to permit the second transformer in a DESN Load Connection Facility to carry the full load under emergency conditions for a single transformer failure contingency.

HONI will provide the requirement for the transformer winding configuration and grounding. Transformer installations for Load Connection Customers usually do not have grounded primary winding neutrals due to the impact on system protection.

Customer transformers shall be capable of under-load tap changer (ULTC) capability on either the high voltage or low voltage winding, with particulars to be provided by HONI.

Outdoor transformer installations require heat/fire activated devices to provide an alarm signal to the Facility control system. Indoor transformers require a fire protection (deluge) system to be triggered by the heat/fire activated devices.

The secondary winding configuration is required to be grounded through a reactor or grounding transformer.

Transformers must be specified to allow for noise control devices such as vibration isolation springs and acoustic enclosures. The use of such noise limiting devices will be subject to application and location and such requirements will be provided by HONI.

Additional requirements for transformers will be provided as part of specific project requirements.

14.1.4 HV Circuit Interrupters/Circuit Breakers Requirements

A high voltage interrupting device shall provide clearing of faults on the Customer's system and remove electrical system fault infeed currents. Such HVI's shall be provided with appropriate back-up protection.

A motor operated disconnect switch is required for electrical isolation. The motor operated disconnect switch serves as a backup function to the HVI. The function of the disconnect switch is primarily for isolation of electrical equipment, and generally, this equipment is not intended to break load current, except when equipped with specific auxiliary devices.

The HVI shall be a suitably rated circuit breaker, or a circuit switcher as required by HONI, located at the connection point, unless HONI authorizes other devices or locations.

14.1.5 Insulation Coordination and Grounding Requirements

Section 8.3 and 8.4 of this document notes the functional insulation coordination and grounding requirements. Specific project requirements will be provided by HONI.

14.1.6 Surge Protection

The function of surge protection in the form of surge arrestors, in an electrical power system is to protect equipment such as power transformers against the effects of overvoltages resulting from lightning, switching surges or other disturbances. Without surge arrestors, equipment can be damaged or destroyed.

The function of the surge arrestor is to limit the magnitude of voltage on the equipment being protected by diverting current through itself. Such a current causes a voltage drop across the source impedance, to limit the voltage across the equipment being protected.

HONI requires the use of station class, gapless, metal oxide surge arrestors to provide the primary overvoltage protection to the power transformers supply side. These should be located as close as possible to the transformer primary bushings.

HONI requires the use of station class metal oxide arresters on transformer secondary windings, conventional metalclad switchgear, cables, SF6 gas equipment and shunt capacitors, and shunt capacitors to protect against overvoltage.

The surge protection equipment shall be located as close as practical to the equipment being protected, factoring in safety, operability, maintainability and system considerations.

14.1.7 LV Transformer Breakers, Bus Tie-Breaker, and Feeder Breakers

In the DESN Load Connection Facility, circuit breakers are mechanical devices that are capable of enabling, carrying, breaking electrical current under normal electrical circuit conditions, and also, making, carrying for specified time, and breaking currents under specified abnormal conditions such as electrical short circuits.

The typical DESN concept employs low voltage, outdoor, dead-tank circuit breakers at 27.6 kV or 44 kV. The circuit breaker interrupting medium may be SF6, or vacuum with integral bushing current transformers, with capability for remote operation, including local trip and maintenance controls and monitoring.

All breaker and current transformer components irrespective of their environment and location in the breaker assembly shall be designed to operate as specified in a temperature range of -40 °C to +40 °C for outdoor equipment.

HONI also accepts, at their discretion, indoor or outdoor metalclad LV switchgear: except at 13.8 kV where only indoor metalclad switchgear is permissible.

Where LV shunt capacitors are installed at a station, only gas insulated or vacuum interrupter circuit breakers shall be used to reduce switching surges. The selection of the technology shall be at the discretion of HONI consistent with meeting the requirements to mitigate the switching surges.

Specific technology will be specified by HONI as part of specific project requirements.

14.1.8 Three and Four Wire System

The 44 kV low voltage system is a 3 wire system. The 27.6 kV and most 13.8 kV systems are 4-wire systems.

14.1.9 Shunt Capacitors

Shunt capacitor are used to ensure adequate system voltages and efficient operation of the power system. HONI, at its discretion, may require the installation of low voltage shunt capacitor banks on the 13.8 kV, 27.6 kV and 44kV systems at the DESN Load Connection Facilities. Capacitor bank ratings range from 10.8 to 32.4 MVAR and they are generally outdoor, rack mounted, apart from some metal-enclosed installations on the 13.8 kV and 27.6 kV systems. All capacitor bank configurations are double “Y” ungrounded. Outdoor metal-enclosed type capacitor banks are intended for use on 14.4 kV and 28.8 kV systems only.

Additional requirements, including but not limited to size, configuration, grounding, and weather protection will be provided by HONI as part of the specific project requirements.

14.1.10 Circuit Switchers

The function of circuit switchers, which are mechanical switching devices used for frequent operation. It is capable of enabling, carrying, breaking electrical current under normal electrical circuit conditions, and also, making,

carrying for specified time, and breaking currents under specified abnormal conditions such as electrical short circuits. Unlike circuit breakers, these devices are not capable of high-speed electrical re-closing. These devices may include an integral isolating device.

Specific technology and specific project requirements will be provide by HONI.

14.1.11 **Station AC Service**

The function of the station AC service system is to provide adequate AC power to meet the needs of auxiliary systems within the DESN Load Connection Facility which support the equipment such as transformers (e.g. cooling fans); lighting including outdoor lighting to facilitate worker investigation and switching work during nighttime operation.

HONI requires that Load Connection Facilities provide a 120/208 volt 4 wire system. A single supply is adequate for Facilities having one transformer. A DESN designed Facility will have a dual supply (one from each bus), with an automatic transfer scheme. Each supply shall be capable of carrying the full station service load. The station service transformers will have high voltage fuses to remove a faulted transformer from the bus.

The installation must meet the requirements of the Ontario Electrical Safety code. High quality equipment is specified by HONI to achieve the required 40 year life expectancy reliability and performance requirements - equipment must meet CSA, ESA and NEMA standards.

14.1.12 **Environmental**

All applicable Federal, Provincial, Municipal, Regional and Conservation Authority approvals and compliance with regulations must be addressed by the customer or authorized representative. These shall include and are not limited to any environmental assessment approvals under the Ontario Environmental Act.

The Customer shall ensure that HONI does not incur any future environmental or other liabilities during the procurement of site, materials and equipment acquisition and construction of the facility including, but not limited to oil spills, existing soil contamination, sedimentation egress from site during construction, archaeological issues, noise, electrical interference, SF6 gas release to atmosphere or other hazardous material releases to the environment.

Transformers and other equipment must have oil spill containment. Oil spill containment systems will generally follow the design criteria specified in IEEE 980-1994. Specific project requirements for such systems will be provided by HONI. The Ontario Ministry of the Environment Certificate of Approval for the system may require specific provisions that may affect design, construction and operation of such systems.

14.1.13 **Safety by Design**

HONI will require that specific clearances to live electrical buses and equipment are incorporated in to the design and construction for worker and public safety and for use of vehicles and work equipment.

Refer to Section 8.3 for strike clearances.

Hard wired telephone systems must have isolation transformers rated and installed, and water pipes from municipal systems must have isolation links to ensure that the ground potential rise of the station under fault conditions is not transferred to the offsite. Other specific project requirements will be provided by HONI.

14.1.14 **Ancillary System Requirements**

HONI will require the following:

1. **Water and sewage**
   Water and sewage connections to municipal system are generally required at DESN stations. At HONI's discretion installation of wells and sewage facilities may be required at rural stations.

2. **Drainage**
   A drainage system is required to remove water from the site so that dry, firm subgrades are maintained to support foundations and roadways.

3. **Backfill and grading**
   Rough and final grading on the site is necessary to provide for worker and public step and touch potential safety, erosion control, aesthetics, vehicle use, equipment movement, and minimum maintenance. Crushed stone is required for personnel protection against touch and step voltage hazards.

4. **Foundations**
   Foundations are required for all structural assemblies, transformers, buildings, and other equipment. The foundations shall be designed based on the geotechnical and soil reports. The foundations must resist movement from loading, settlement, frost heaving, and overturning moments. The power transformer foundation and the oil containment system must be designed to permit the installation, operation, and removal of the transformer and its accessories.

5. **Structures and Buildings**
   Outdoor steel structures will be designed and built to support all equipment loads and withstand wind, ice, short circuit and switching stresses imposed on the structures.

   Constructed on-site and prefabricated buildings are acceptable. Building will require fire detection and security, fire protection, battery room hydrogen detection, battery ventilation (where applicable), lighting, HVAC systems, and must allow space for operation and maintenance work. All buildings shall be designed to meet the limits and requirements of the relevant building codes and standards.

6. **Electrical Hardware**
   Customer built and transferred stations shall use electrical hardware and parts that meet industry proven performance, and shall be highly reliable. Such equipment shall be reviewed by HONI.

7. **Oil Containment Systems**
   Transformer oil containment systems are required and generally designed using IEEE 980-1984 criteria. The gravity drained oil/water separator design is preferable. The ultimate goal is to ensure that all oil within the station remains safely contained on site.

8. **Barriers/Fences**
   The primary means of ensuring public safety and site security at a transformer Load Connection Facility is the erection of a suitable barrier, such as a metal fence. The type of fence depends on such factors as aesthetic considerations and municipal By-Laws. The fence is required to meet the minimum requirements of the Electrical Safety Code.

   The security fences required by HONI are normally of chain link construction, a minimum of 2.4 m high and topped with three strands of barbed wire sloping outwards. However, in those stations where aesthetic requirements are to be met, fences of concrete, masonry or wood construction types will also be considered.

   Where masonry or other wall type fence is considered, it shall be designed according to applicable building codes. The location of the fence must take into account public safety, vehicle and personnel accessibility, infringement on private property, environmental requirements, municipal road setback requirements, and natural ground contours.

Provision for entry and egress from the Load Connection Facility is by suitable gates, of equivalent fence material and construction. The station gate must be lockable in order to provide controlled access.

9. Station Expansion Including Land

All DESN Load Connection Facilities shall be designed to allow for expansion based on ultimate planning requirements. Layout arrangements for the complete Facility shall provide the required bus configurations, adequately rated initial installation, and with space and other provisions for future expansion to meet ultimate planning requirements.

In the ultimate arrangement of the LV switching area, the circuit breaker positions are:

- Transformer secondaries — two or four
- Bus tie — one or two
- Feeders — maximum twelve (or fourteen if shunt capacitor banks are not required)
- Shunt capacitors — maximum two

The specific project requirements will be provided by HONI.

10. Air Break Switches

Customer built and transferred Load Connection Facilities shall use electrical hardware and parts that meet industry proven performance, and shall be highly reliable. Such equipment shall be reviewed by HONI.

Air break switches come in various configurations and are built to industry IEEE, ANSI and NEMA standards. HONI generally uses vertical or double break switches.

14.1.15 **DESN and Equipment Performance Requirements**

The DESN Facilities and related electrical facilities shall meet the requirements of the OEB's TSC requirements in Appendix 2, titled Transmission System Connection Point Performance Standards.

DESN Facility and equipment reliability and maintainability requirements will be provided by HONI.

14.2 DOCUMENTATION

HONI requires documentation from the Customer for due diligence, operation and maintenance of the Facility and for archiving. All project related documentation, such as applications & permits; any planning & technical studies (including those identified in the TSC); engineering documentations including engineering-procurement-construction related specification, drawings, inspection & testing; commissioning reports; instructions, operating and maintenance manuals; is to be provided to HONI as part of the transfer of the facilities by the Customer to HONI. Listed below are various technical documents that HONI expects to receive as a minimum.

Also, for HONI to easily integrate the document into its document management systems, drawing and documentation naming convention and standard are listed where applicable. All relevant documents associated with the design, procurement, construction, maintenance, and operation must be transferred to HONI at their request.

Contractual, legal and financial documents such as the CCRA and land lease and other such types of documents are also required to be transferred.

14.2.1 **Applications and Permits**

These documents include:

1. Environmental Assessment applications and approvals.
2. Certificate(s) of Approval.
3. (IESO) SIA application and approvals.
4. ESA Application permits.
5. Municipal permits (building, fire etc.).

14.2.2 **Planning and Studies**

An explicit format for the following studies is not specified, but it is essential that the studies are signed and stamped by a qualified professional engineer:

1. Feasibility studies
2. Geotechnical studies/reports
3. Topographical surveys
4. Grounding studies
5. Insulation coordination studies
6. Lightning studies
7. Power factor studies
8. Settings and setting calculations
9. Logic diagrams
10. DC and AC station service drawings and calculations

14.2.3 **Engineering Documentation**

For all drawings produced it is required that HONI's drawing standards and numbering conventions are followed. HONI has an index and numbering convention (TSSI) based on voltage level and discipline. HONI AutoCAD drawing templates and symbols will be provided. Drawings and documentation must be signed and stamped by qualified professional engineer.

For stations, the lists of drawings shall include but not limited to:

1. Site:
    a. Basic layout
    b. Site and fencing
    c. Grounding
    d. Station mechanical, drainage
    e. Roads
    f. Lightning protection towers and skywire

2. Station structures and foundations:
    a. Footings and containment
    b. TX fire separation walls (if applicable)
    c. Structures
    d. Buildings

3. Electrical Arrangement drawings:
    a. Station layout
    b. All outdoor high voltage electrical switchgear, bus structures and facilities
    c. Control cable trenches and ducts

4. Station 1-Line and 3-Line drawings:
    a. 1-Line showing all HV equipment and buses, CTs and PTs, protections and telemetry
    b. Engineering and Operating nomenclature
    c. 3-line showing transformer, CT and PT phasing

5. AC and DC Distribution Elementary Wiring Diagrams (EWD) and Connection Wiring Drawings (CWD)

6. All Protection and Control drawings:
    a. All Elementary Wiring Diagrams and Connection Wiring Diagrams for Protection, Control and Metering Schemes
    b. All AC drawings showing AC current and AC voltage from primary devices to protection, control or metering devices.

7. Equipment Lists and Bills of Materials

8. Consolidated Cable Lists

For Transmission Lines, the lists of Drawings include, but not limited to:

1. Line survey data, suitable for PLS_CADD structure spotting program.
2. Line layout design using PLS_CADD program; including the "backup" files generated by the program.
3. Plan and profile data and drawings. Drawings will include conductor profile at maximum sag, structure type, height and adjustment, ruling span, insulator type and rating, design tension of conductor and overhead ground wire under combined ice and wind condition for each line section, etc.
4. Sag and tension calculations including stringing data for conductor and overhead ground wire for each line section.
5. Hardware assembly drawings with material lists.
6. Insulator technical specifications.
7. Structure design, fabrication and erection drawings and design calculations.
8. Geotechnical reports.
9. Footing drawings and design calculations.
10. Guy anchor drawings and design calculations.
11. Grounding design data including measured soil resistivities and structure footing resistance at each line structure location.
12. Phasing arrangement drawings.
13. Vibration damper application data.
14. Records of signs and markers installation. Design and drawings of markers as per Clause 5.9.4., if applicable.
15. Approved crossing drawings for railway, navigable water-way, highway and pipeline crossings, where applicable (drawings shall include stamp from approving authority).
16. Other "As built" information for the new line including GPS co-ordinates at each line structure location.
17. Quality assurance documentation identifying all field checks conducted and results of those checks.

Additional specific project requirements will be provided by HONI.

14.2.4 **Training Material**

If there are any manufacturer-based training materials provided during the design, construction or commissioning of a HONI-owned Load Connection Facility, these must be passed on to HONI upon transfer of ownership of the Facility to HONI. This includes, but is not limited to, text books, binders, PowerPoint presentations, audio recordings, or anything else that was used for the purpose of providing training material to the Customer prior to transfer to HONI.

14.3 MAINTENANCE CONSIDERATIONS

HONI is required to conduct maintenance of its assets on a routine basis. The Facilities should be designed to facilitate this maintenance requirement without undue interruption to system elements. This requirement should be reviewed as part of the design package.

Customer built and transferred to HONI Load Connection Facilities must have all relevant manufacturers' maintenance requirements and commissioning documentation transferred with the asset for amalgamation into the HONI maintenance system.

HONI maintains a spare parts inventory for critical components based primarily on the manufacturer's recommendations. Spare parts provided with the purchase of major station equipment must also be transferred with the asset including maintenance related components.

14.4 QUALITY/ TEST REQUIREMENTS

14.4.1 **Quality Program**

The following information shall be provided from the IED Vendor regarding their Quality Assurance program:

a. Design qualification, including hardware, firmware, and software.
b. Manufacturing quality.
c. Repair forensics.

Full environmental and functional type tests shall be periodically conducted by the Vendor on a statistically significant sample of production units to verify that the device meets all the specified design, functionality and performance requirements.

Type tests should preferably include Accelerated Life Testing (ALT) and Highly Accelerated Life Testing (HALT) to ensure designs meet quoted reliability data (MTBF).

The production test shall be conducted on every production unit to check its calibration and functionality.

A sheet summarizing and certifying the initial factory production calibration and test results shall also be shipped with each IED.

14.4.2 **Firmware Quality Assurance**

HONI will provide specific power system real-time simulation model test cases for Vendor or third party test agency nominated by the Vendor to implement to further verify and demonstrate satisfactory device performance under simulated power system conditions of interest to HONI.

All aspects of IED firmware Quality Assurance shall comply with IEEE C37.231-2006.

14.4.3 **Type Tests**

In addition to the HONI-specified tests, the IED Vendor shall submit Type Test data including:

1. AC and DC input ranges, burdens, and withstands including power supply maximum ratings and supply variations.
2. Measurement accuracy, including the effect of non-ideal AC signals.
3. Protection element static and dynamic performance.
4. Behaviour on Power Up/Power Down, loss of DC supply.
5. Dielectric strength.
6. EMC (surge withstand, radiated interference, ESD, power frequency magnetic field).
7. General service conditions (temperature, vibration).
8. Digital input performance.
9. Contact and SSR output performance.

The IED platform hardware shall be tested and shown to comply with Series 'C' of Section 8 of IEEE C37.90.

The IED platform hardware shall be tested for Oscillatory transient withstand of 2.5 kV (common-mode and differential) at a frequency of 1 MHz per IEEE C37.90.1, 2.5 kV (common-mode) and 1.0 kV (differential) at a frequency of 100 kHz as per IEC 61000-4-18.

The IED platform hardware shall be tested for fast transient withstand of ±4.0 kV (common-mode and differential) at a frequency of 5 kHz per IEEE C37.90.1.

The IED platform hardware shall be tested and shown to comply with levels for Zone A installation as defined in Section 7 of IEEE 1613.1.

The IED platform hardware shall be tested for ESD contact discharge of 8 kV and air discharge of 15 kV per IEEE C37.90.3 (Severity Level 4 per IEC 60255-22-2). Testing shall include rear communications (LAN, serial, teleprotection) ports as well as time synchronization (IRIG-B) ports.

The IED platform hardware shall be tested at Level 4 for continuous and pulsed magnetic fields per IEC 61000-4-8.

The IED platform hardware shall be tested and shown to comply with IEC 60068-2-1 (-40 °C, 16 hours), IEC 60068-2-2 (+85°C, 16 hours) and IEC 60068-2-30 (Variant 2).

The IED platform hardware shall be tested to run for 72 hours at the maximum operating temperature, during which nominal currents and/or voltages are to be applied and the I/O continuously being exercised (On/Off transitions). The Vendor shall monitor and record the analogue measurements over the test period and provide error measurements in analogue values.

The IED platform hardware shall correctly power up, initialize and begin functioning after being completely de-energized and cold-soaked at the minimum storage temperature for 48 hours, then brought back to the minimum operating temperature over 4 hours.

The dielectric, surge withstand, and electrostatic discharge tests shall be repeated on the cold-soaked unit(s).

The IED platform hardware shall be tested for Vibration Class 1 Endurance and Class 1 Response per IEC 60255-21-1.

The IED platform hardware shall be tested for Shock Class 1 Endurance and Class 1 Response, and Bump Class 1 per IEC 60255-21-2.

The IED platform hardware shall be tested for Seismic Class 1 per IEC 60255-21-3.

15.0 REFERENCE SOURCES

NERC references are the currently enforceable NERC standards at the time of publication.

1. IEEE Standard for Electrical Power System Device Function Numbers and Contact Designations, IEEE Standard C37.2, 2008.

2. IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus, IEEE Standard C37.90, 2005.

3. IEEE Standard for Withstand Capability of Relay System to Radiated Electromagnetic Interference from Transceivers, IEEE Standard C37.90.2, 2004.

4. IEEE Standard Electrostatic Discharge Tests for Protective Relays, IEEE Standard C37.90.3, 2001.

5. IEEE Guide for Protective Relaying of Utility-Consumer Interconnections, IEEE Standard C37.95, 2002.

6. IEEE Recommended Practice for Microprocessor-Based Protection Equipment Firmware Revision Control, IEEE Standard C37.231, 2012.

7. IEEE Standard Requirement for Instrument Transformers, IEEE Standard C57.13, 2016.

8. IEEE Standard Graphic Symbols for Electrical and Electronic Diagrams, IEEE Standard 315, 2002.

9. IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications, IEEE Standard 485, 2010.

10. IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications, IEEE Standard 450, 2010.

11. IEEE Standard for Electrical Safety Requirement for Employee Workplaces, IEEE Standard 1584, 2002.

12. IEEE Standard for Substation Intelligent Electronic Devices (IED) Cyber Security Standards, IEEE Standard 1686, 2013.

13. Ontario Hydro, C-5047-77 Specification For Testing Susceptibility of Electronic Equipment to Radiated Interference, Ontario Hydro General Tendering Documents, 1977.

14. Ontario Hydro, Connection Procedure & Requirements for Customers above 50 kV, Ontario Hydro, 1989

15. NERC Standard PRC-005-1.1b, Transmission and Generation Protection System Maintenance and Testing, NERC Document, 2013.

16. NERC Standard COM-001-2.1, Communications, NERC Document, 2015.

17. NERC Standard CIP-002-5.1, Cyber Security – BES Cyber System Categorization, NERC Document, 2016.

18. NERC Standard CIP-003-6, Security Management Controls, NERC Document, 2016.

19. NERC Standard CIP-004-6, Personnel & Training, NERC Document, 2016.

20. NERC Standard CIP-005-5, Electronic Security Perimeter(s), NERC Document, 2016.

21. NERC Standard CIP-006-6, Physical Security of BES Cyber Systems, NERC Document, 2016.

22. NERC Standard CIP-007-6, System Security Management, NERC Document, 2016.

23. NERC Standard CIP-008-5, Incident Reporting and Response Planning, NERC Document, 2016.

24. NERC Standard CIP-009-6, Recovery Plans for BES Cyber Systems, NERC Document, 2016.

25. NERC Standard CIP-010-2, Configuration Change Management and Vulnerability Assessments, NERC Document 2016.

26. NERC Standard CIP-011-2, Information Protection, NERC Document, 2016.

27. NERC Standard CIP-014-2, Physical Security, NERC Document 2015.

28. NERC Standard PRC-001-1.1(ii), System Protection Coordination, NERC Document, 2015.

29. NERC Standard PRC-002-2, Disturbance Monitoring and Reporting Requirements, NERC Document, 2016.

30. NERC Standard PRC-005-2(i), Protection System Maintenance, NERC Document, 2015.

31. IESO Market Rules for the Ontario Electricity Market, 2016

32. Inshaw, C. & Wilson, R. (2005), Arc Flash Hazard Analysis and Mitigation, Presented at the 2005 58th Annual Conference for Protective Relay Engineers, Texas A&M.

33. Buff, J. & Zimmerman, K. (2006), Application of Existing Technologies to Reduce Arc-Flash Hazards, Schweitzer Engineering Publication.