

Low Voltage Switchgears Specification

Specification 26 23 00

Revision 01
Date: March 2023

Low Voltage Switchgears Specification

Specification 26 23 00

Publication Date: August 2018

Revision Date: March 2023

COPYRIGHT © 2018

Metrolinx,

an Agency of the Government of Ontario

The contents of this publication may be used solely as required for and during a project assignment from Metrolinx or for and during preparing a response to a Metrolinx procurement request. Otherwise, this publication or any part thereof shall not be reproduced, re-distributed, stored in an electronic database or transmitted in any form by any means, electronic, photocopying or otherwise, without written permission of the copyright holder. In no event shall this publication or any part thereof be sold or used for commercial purposes.

The information contained herein or otherwise provided or made available ancillary hereto is provided "as is" without warranty or guarantee of any kind as to accuracy, completeness, fitness for use, purpose, non- infringement of third party rights or any other warranty, express or implied. Metrolinx is not responsible and has no liability for any damages, losses, expenses or claims arising or purporting to arise from use of or reliance on the information contained herein.

Amendment Record Sheet

Amendment in Clause No.	Date of Amendment	Description of Changes
Cover page	March 2023	Removed 'Capital Projects Group'
1.2.3, 1.3.3, 2.5	March 2023	Added 'the latest version of' and Updated numbering for Electrical Identification and Nomenclature specification
1.5.3, 2.2.9, 3.3.7	March 2023	Updated spare parts requirements, rating requirements and testing requirements for commissioning

LIST OF CONTENT

1. GENERAL.....	2
1.1. SCOPE OF WORK	2
1.2. DESIGN REQUIREMENTS	2
1.3. RELATED WORKS	3
1.4. REFERENCE STANDARDS	4
1.5. SPARE PARTS	4
1.6. TRAINING	5
1.7. WARRANTY	5
1.8. DELIVERY, STORAGE AND HANDLING	5
1.9. SUBMITTALS	5
1.10. QUALITY ASSURANCE.....	7
2. PRODUCTS.....	7
2.1. GENERAL.....	7
2.2. COMPONENTS	8
2.3. FABRICATION.....	17
2.4. FINISHING	17
2.5. IDENTIFICATION	18
3. EXECUTION	18
3.1. FACTORY TESTING	18
3.2. INSTALLATION	19
3.3. COMMISIONING	20

1. GENERAL

1.1. SCOPE OF WORK

- 1.1.1. Labour, products, equipment and services necessary for low voltage switchgears.

1.2. DESIGN REQUIREMENTS

- 1.2.1. The equipment furnished and the equipment installation, wiring methods and materials used shall conform to the latest edition of the Ontario Electrical Safety Code, Electrical Safety Authority (ESA) Bulletins and Supplements issued by the Electrical Safety Authority, and the applicable Metrolinx Standards. In case of any conflicts, the more stringent requirement shall apply.
- 1.2.2. Design electrical equipment and systems to all applicable standards of CSA, ULC, IEEE, ESA.
- 1.2.3. Design electrical equipment and systems to the latest version of the GO DRM.
- 1.2.4. Design electrical equipment and systems to standards and codes to be latest editions adopted by and enforced by local authorities having jurisdiction (AHJ).
- 1.2.5. Switchgear shall be designed, built and tested to ANSI C37.20.1, UL 1558, CSA-C22.2 No. 31.
- 1.2.6. Design shall provide switchgear assemblies that are floor mounted on housekeeping pad, minimum 103mm high with 53 mm of pad overlap outside the equipment's perimeter.
- 1.2.7. Design shall provide all equipment ratings shown on Contract Documents. Provide a minimum short circuit capacity of 50 kA.
- 1.2.8. Design shall include spare unequipped feeders for future use amounting to at least 25% of total switchgear assembly space.
- 1.2.9. Design shall include spare equipped feeder units for future use amounting to at least 25% of total installed feeder units in switchgear assembly.
- 1.2.10. For main incoming service, design shall provide equipped feeder units rated to 100% of the maximum switchgear amperage rating.
- 1.2.11. Design shall allow for future extension at both ends.
- 1.2.12. Design shall for front and rear access.
- 1.2.13. Double-ended substations will have a manual transfer system between main and tie breakers using physical key interlocks.

- 1.2.14. Design to provide circuit breakers including and above 400 A to be draw-out type complete with include electronic trip units. In addition, these circuit breakers shall be monitored by the remote supervisory system (refer to paragraph 1.2.19 of this Specification).
- 1.2.15. Circuit breakers shall be electrically operated as follows:
 - a) Circuits breakers 2000 A and above;
 - b) Circuits breakers for emergency circuits; and
 - c) Main breakers (incomer circuits).
- 1.2.16. Main breakers (incomer circuits) shall have electronic metering similar to PowerLogic ION 7650 or approved equivalent.
- 1.2.17. SPD (surge protection device) will be provided on each 600 V bus of each substation. SPD equipment and disconnect to be mounted in a separate section within the switchgear with its own access door that can be serviced without entering a live section of the switchgear. SPD to come complete with a remote display located on the front of the switchgear.
- 1.2.18. Design shall provide ground fault unit as per OESC and Contract Documents.
- 1.2.19. Design shall allow for the Switchgear to be monitored by a remote supervisory system (BAS, SCADA, PLC, etc.). The details of the remote supervisory system shall be indicated on the Contract Documents, the interface may be hardwired contacts, digital communications or any system as on the Contact Documents. The design shall include all systems required for a complete interface. At minimum statuses of all breakers, switches, protection devices, and alarms shall be communicated.
- 1.2.20. Design shall verify that dimensions of switchgear assembly do not exceed spaces provided in Contract Documents.

1.3. RELATED WORKS

- 1.3.1. Section 26 05 00 - Electrical General Requirements.
- 1.3.2. Section 26 05 21 - Electrical Conductors and Cables.
- 1.3.3. Section 26 05 23 - Electrical Identification and Nomenclature
- 1.3.4. Section 26 12 16 - Dry Type Transformer.
- 1.3.5. Section 26 13 26 - Metal Clad Switchgears.
- 1.3.6. Section 26 24 13 - Switchboards and Panelboards.
- 1.3.7. Section 26 24 19 - Motor Control Centres.

- 1.3.8. Section 26 28 00 - Circuit Breakers and Fuses.
- 1.3.9. Section 26 28 23 - Disconnect Switches.
- 1.3.10. Section 26 29 10 - Motor Starters and Contactors.

1.4. REFERENCE STANDARDS

- 1.4.1. Ontario Electrical Safety Code (OESC).
- 1.4.2. Ontario Building Code (OBC).
- 1.4.3. Metrolinx Standards, Drawings and Specifications.
- 1.4.4. GO Design Requirement Manual (DRM).
- 1.4.5. Metrolinx Electrical Safety Document.
- 1.4.6. CSA Z462, Workplace Electrical Safety.
- 1.4.7. CAN3 C235, Preferred Voltage Levels for AC Systems, 0 to 50,000V.
- 1.4.8. EEMAC G8 3.3, Metal Enclosed Interrupter Switchgear Assemblies.
- 1.4.9. CAN/CSA-C22.2 No.31, Switchgear Assemblies.
- 1.4.10. CSA C22.1, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations.
- 1.4.11. CAN/CSA-C22.2 NO. 60947, Low-voltage switchgear and controlgear - Part 1: General rules (Tri-national standard, with UL 60947-1 and NMX-J-515-ANCE)
- 1.4.12. CSA C22.2 No. 0, General Requirements - Canadian Electrical Code, Part 2.
- 1.4.13. ANSI/IEEE C37.20.1 - IEEE Standard for Metal Enclosed Low Voltage Switchgear.
- 1.4.14. ANSI/IEEE C37.13 - IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
- 1.4.15. UL, Underwriters' Laboratories.

1.5. SPARE PARTS

- 1.5.1. Provide one set of spare control fuses for each set installed.
- 1.5.2. Provide one set of spare power fuses for each set installed.
- 1.5.3. Provide 25% spare breakers inside the switchgear circuit breaker compartment. Provide at least one spare breaker with frame and trip unit ratings to match main breaker ratings.

1.6. TRAINING

- 1.6.1. Contractor shall train Metrolinx personnel, including training on transfer switch components, operations, safety, and troubleshooting.
- 1.6.2. Contractor shall allow for two separate training sessions to fully train Metrolinx personnel in all the equipment provided in the Contract.
- 1.6.3. The training session shall be conducted by a manufacturer's qualified representative. Training program shall include instructions on the assembly, circuit breaker, protective devices, and other major components.

1.7. WARRANTY

- 1.7.1. The contractor shall provide a manufacturer warranty for the work of this section with a minimum warranty period of two years after acceptance by Metrolinx.

1.8. DELIVERY, STORAGE AND HANDLING

- 1.8.1. Contractor to protect equipment from weather and moisture by covering with heavy plastic or canvas and by maintaining heat within enclosure in accordance with manufacturer's instructions.
- 1.8.2. Provide energized strip heater in each cell to maintain dry condition during storage.
- 1.8.3. Manufacturer responsible to ship product to site once approval to ship has been given by the Contractor.
- 1.8.4. Contractor to accept equipment on site and inspect for shipping damage.
- 1.8.5. When shipped separately, load-break switch, power fuses, breakers and other equipment shall be individually crated and tagged with their proper unit number and the equipment number to which they belong.
- 1.8.6. Relays shall be shipped installed in the stationary structures and shall be adequately blocked and braced to prevent damage during shipment.

1.9. SUBMITTALS

- 1.9.1. Product Data Package:
 - a) Submit manufacturer's Product Data indicating:
 - 1) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists;
 - 2) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol;
 - 3) Product transportation, storage, handling, and installation requirements;

- 4) Time-current characteristic curves for air circuit breakers; and
- 5) Product identification.

1.9.2. Shop Drawings Package

- a) Submit manufacturer's shop drawing indicating:
 - 1) Elevations, sections and details of operating components, dimensions, gauges, finishes, and relationship of operating components to adjacent construction;
 - 2) Complete electrical wiring diagrams including electrical schematics and sequence of operation;
 - 3) Floor anchoring method and foundation template;
 - 4) Dimensioned [cable] entry and exit locations;
 - 5) Dimensioned position and size of bus;
 - 6) Overall length, height and depth of complete switchgear;
 - 7) Dimensioned layout of internal and front panel mounted components;
 - 8) Identification; and
 - 9) Mimic-bus diagram

1.9.3. Commissioning Package:

- a) Submit the following:
 - 1) Commissioning Plan;
 - 2) Commissioning Procedures;
 - 3) Certificate of Readiness;
 - 4) Performance criteria and maintenance data;
 - 5) Safety precautions;
 - 6) Test Reports: factory tests report;
 - 7) Manufacturer's installation Instructions; and
 - 8) Manufacturer's Field Reports: commissioning report on field tests, including test forms and confirming proper installation prior to energization.

1.9.4. Record Documents

- a) As built drawings including any field modifications.
- b) As built drawings to be submitted in printed and electronic format in accordance with Metrolinx standards.
- c) Operation and Maintenance Data: As built product data including any field modifications.

1.10. QUALITY ASSURANCE

1.10.1. See Section 26 05 00.

1.10.2. Manufacturers Qualifications: Company specializing in low voltage switchgear with at least five years documented experience. The manufacturer of the switchgear must be the same as the manufacturer of the circuit breaker.

1.10.3. Regulatory Requirements: Furnish Products listed and classified by CSA and ULC, as suitable for application, and shall be stamped accordingly

2. PRODUCTS

2.1. GENERAL

2.1.1. The equipment shall be able to withstand the environmental conditions stated in Section 26 05 00 without damage or degradation of operating characteristics.

2.1.2. The switchgear assembly shall be a free standing dead front steel structure. It shall be floor mounted on a level concrete pad. The assembly shall withstand the effects of closing, carrying and interrupting currents up to the assigned maximum short circuit rating.

2.1.3. The switchgear assembly shall be arc-resistant. Vendor shall provide details describing the arc-resistant testing of equipment.

2.1.4. The switchgear assembly shall include all switching devices and the necessary accessory components as required for a fully functional system.

2.1.5. The switchgear assembly shall be fully factory assembled except for necessary shipping splits and be operationally checked as an assembly.

2.1.6. The switchgear assembly shall include mimic diagram on front exterior surface showing all main internal components.

2.1.7. The switchgear assembly shall be either indoor or outdoor type.

- a) Indoor assembly

- 1) The switchgear enclosure shall be minimum CSA Type 3R sprinkler proof when installed indoor.
 - 2) Provide space heater complete with thermostat in each cubicle suitable for 120 V AC operation where indicated on Contract Documents.
 - b) Outdoor assembly
 - 1) The switchgear enclosure shall be minimum CSA Type 4X when installed outdoor.
 - 2) Outdoor assembly can be non-walk-in type, walk-in front aisle or outdoor common aisle double row.
 - 3) Provide gaskets on all covers and doors.
 - 4) Provide space heater complete with thermostat in each cubicle suitable for 120 V AC operation.
- 2.1.8. System voltage shall be as per Contract Documents, three-phase 60 Hz. Either 120/208V or 347/600V.
- 2.1.9. Main Bus continuous ampacity shall be as per Contract Documents.
- 2.1.10. Momentary current ratings shall be equal to the circuit breaker close and latch rating.
- 2.1.11. The switchgear assembly shall be suitable for either solid grounding or high-resistance grounding as per local Hydro requirement and Contract Documents.
- 2.1.12. The switchgear assembly shall be grounded in accordance with the OESC.
- 2.1.13. All components at the completed assembly shall be CSA approved and bear a CSA label.
- 2.1.14. The switchgear assembly shall be configured for top entry or bottom entry as indicated on the Contract Documents.
- 2.1.15. Each shipping section of stationary structures shall be furnished with removable lifting angles and/or plates suitable for crane hooks or slings so lifting and erection can be done without danger of dropping or damaging the equipment.
- 2.1.16. Each shipping section shall also be furnished with removable steel channel base plates that will permit using pipe rollers or dollies without damaging the frame steel to the equipment.
- 2.2. COMPONENTS**
 - 2.2.1. Stationary Structure

- a) The switchgear shall consist of compartment required to achieve design noted on Contract Documents that includes switch compartments, breaker compartments and auxiliary compartments assembled to form a rigid self-supporting completely enclosed structure providing steel barriers between sections.
- b) The sections shall be divided by metal barriers into the separate compartments including:
 - 1) Circuit breaker compartment(s);
 - 2) Disconnect switch compartment(s);
 - 3) Bus compartment(s);
 - 4) Potential transformer compartment(s);
 - 5) Control transformer compartment(s);
 - 6) Control compartment(s); and
 - 7) Cables termination compartment(s).
- c) A common steel base frame in a single length shall be provided for the full switchgear assembly.

2.2.2. Doors and Covers

- a) Front doors to be provided for all compartments and include latching handles and a locking mechanism.
- b) Rear doors to be provided for all rear compartments and include latching handles and a pad-locking mechanism.
- c) All doors shall be formed, and vertically hinged.
- d) Relays, meters, control switches, etc., shall all be mounted on a door associated with each switch or circuit breaker compartment.
- e) Provide a metal pocket complete with weatherproof envelope and one full set of drawings and diagram prints on inside surface of front door.
- f) Each cable termination section to have separate door.
- g) Where ventilating louvers are provided they shall be vermin and insect proof with easily replaceable fiber glass filters.

2.2.3. Main Breaker Compartment(s)

- a) Main breaker refers to the incomer breaker for a given switchgear assembly.

- b) Section shall contain:
 - 1) Circuit breaker;
 - 2) Digital meters; and
 - 3) Surge Protection unit.

2.2.4. Feeders Compartment(s)

- a) Feeders refers to the outgoing distribution circuits for a given switchgear assembly.
- b) Feeder sections to contain:
 - 1) Circuit breaker(s) sized as indicated with minimum frame size of 1600 A; and
 - 2) Digital meters where indicated on Contract Documents.
- c) Spare unequipped feeders for future use shall include all draw out accessories ready to accept future draw out breakers.

2.2.5. Cable Compartment/Ground Bus

- a) Sufficient space must be provided to permit installation of stress cones, conduit seals, current transformers, and surge arrestors and for proper training of cables.
- b) Cable supports shall be provided for top entry or bottom entry as indicated on the Contract Documents.
- c) Provision shall be made for two-hole long barrel compression type cable lugs
- d) Provide an inspection and viewing window shall be furnished for all cable terminations compartments.
- e) The ground bus shall extend through this compartment for the full length of the switchgear.
- f) Auxiliary bus, if needed, and load bus support NEMA Class A-20 standoff insulators shall be epoxy.
- g) Provide insulated ground studs on each phase at each cable connection point.
- h) Furnish, for complete phase isolation, phase to phase and phase to ground isolating barriers in cables termination compartment(s).

2.2.6. Main Bus Compartment

- a) Access to this compartment is gained from the front or rear of the structure by removing a steel barrier.
- b) Provide standard provisions for future extension without requiring any cutting or modification of the structure.

2.2.7. Busbars

- a) Three-phase with continuous current rating as per Contract Document, self-cooled, extending full width of switchgear, suitably supported on insulators.
- b) Neutral bus where required shall be fully rated.
- c) Busbars and main connections: 99.30% conductivity copper.
- d) Main connections between bus and major switching components to have continuous current rating to match major switching components.
- e) Provision for extension of bus on both sides of unit without need for further drilling or preparation in field.
- f) Tin surfaced plated joints, secured with non-corrosive bolts and Belleville washers.
- g) Identify phases of busbars by suitable marking.
- h) Bus bars shall be fully insulated with all connections to be provided with insulated boots that cover all current carrying parts. Bus bars to be insulated with a CSA approved permanent insulation. A taped bus is not acceptable.
- i) Busbar connectors shall be provided when assembly is shipped in more than one section.
- j) Brace bus bar system including ground bus to withstand stresses resulting from short circuit currents
- k) Where a bus connection is required to external equipment the switchgear Manufacturer is responsible to coordinate the design requirements of the bus connection.

2.2.8. Grounding

- a) Copper ground bus minimum 50 x 6 mm extending full width of switchgear and situated at bottom.
- b) Copper ground bus shall allow connection to all units and equipped with solderless #2/0-4/0 cable connectors at each end.
- c) If identified within the Contract Documents, provide a complete operating high resistance ground system as follows:

- 1) The grounding system shall be part of the switchgear assembly with the resistor units mounted on top in separate enclosures;
- 2) All components shall be completely front accessible;
- 3) A separate grounding system shall be provided for each transformer feeding the switchgear assembly;
- 4) The high resistance grounding system shall limit the ground fault current through the transformer neutral to a maximum of 5 A;
- 5) The grounding resistor resistance value shall be adjustable and rated for continuous ground fault current;
- 6) A traceable pulsing signal shall be provided to permit locating a ground fault. The pulsing equipment shall consist of a pulse timer relay, pulse contactor, pulse initiating switch and 1 to 20 A adjustable clip-on current transformer; and
- 7) Each grounding system shall include:
 - i) Alarm relay (64X) (for ground fault) with dry contacts for Metrolinx use, wired to terminal blocks;
 - ii) Loss of control power alarm relay (27) with dry contacts, for Metrolinx use, wired to terminal blocks;
 - iii) Voltage sensing relay (64) measuring voltage across the resistor;
 - iv) Normal, alarm and pulsing indicator lights on front panel; and
 - v) 0 -10 A analogue ammeter and CT.

2.2.9. Circuit Breakers

- a) General circuit breaker requirements are provided in Section 26 28 00 for low voltage applications. Additional requirements that pertain to circuit breakers within low voltage switchgear are provided in this Specification.
- b) The circuit breakers shall be rated for the maximum voltage of the switchgear, 60 Hz, with a continuous current rating as shown on the Contract Documents and a maximum symmetrical interrupting rating to match the rating of the switchgear.
- c) The main incoming circuit breaker shall be rated for maximum voltage and amperage of the switchgear, 60 Hz, and a maximum symmetrical interrupting rating to match the rating of the switchgear.
- d) Circuit breakers of same type and rating shall be completely interchangeable.

- e) Circuit breakers shall be fixed or withdrawable as indicated on the Contract Documents and this Specification.
- f) Either air circuit breakers or molded case circuit breakers are acceptable.
- g) A minimum of 4 auxiliary contacts (2 N.O. and 2 N.C), shall be provided for external use by Metrolinx. Contacts shall be wired to a terminal block.

2.2.10. Control Voltage

- a) The control voltage for protection and control functions shall be 120 V dc unless indicated otherwise on Contract Documents.
- b) A 120/208 VAC3 phase 4 wire voltage source for auxiliary devices such as lighting, heaters and receptacles shall be supplied from an external AC panel by Others. A terminal strip and circuit breaker shall be provided to accept this source.
- c) DC control voltage shall be supplied through an external DC power battery cabinet. A terminal strip and circuit breaker shall be provided to accept this source.
- d) The DC power battery cabinet shall be supplied under this scope of work. Provide pre-manufactured battery charger and batteries in accordance with CSA and Metrolinx standards.

2.2.11. Instrument Transformers

- a) Potential and current transformers shall be selected with a sufficient insulation to withstand a 5-minute dielectric proof test as specified by ANSI C57.13.
- b) Current transformers
 - 1) Each switchgear circuit bay shall have provision for front-accessible mounting of current transformers as indicated on the Contract Documents.
 - 2) The current transformer assembly shall be insulated for the full voltage rating of the switchgear.
 - 3) All current transformers shall be selected to meet or exceed the short-time rms current requirements for mechanical rated current and thermal rated current as shown on the Contract Documents.
 - 4) Relaying and metering accuracy shall conform to ANSI and the local utility Standards.

- 5) Each current transformer shall have a short-circuiting device (shorting type terminal block) located remote from the main busbar compartment(s).
 - 6) Current transformers shall be securely mounted on a metal support with the polarity marking towards the bus, the non-polarity side of the secondaries shall be wired together and grounded at the first terminal block (and not at the CT) to be in the control compartment.
- c) Potential Transformers (Voltage transformers)
- 1) Potential transformers shall be draw out type. On opening the compartment, the contacts shall automatically withdraw for inspection and maintenance. PT compartments and drawers shall be padlockable in the open or drawn out position.
 - 2) Potential transformers shall be protected with current limiting primary fuses and secondary breakers and shall be designed to withstand the basic impulse level of the switchgear.
 - 3) Potential transformers shall have 120V secondary.
 - 4) Potential transformers shall be grounded at first terminal block and not at the Potential transformers directly.
 - 5) Potential transformers shall have mechanical rating equal to the momentary rating of the circuit breakers
 - 6) Potential transformers shall have metering accuracy per ANSI and the local utility standards.

2.2.12. Control Wiring

- a) All secondary and control wiring shall be isolated completely from main buses, cables and connections by means of metal conduit, armour or other suitable barriers. There shall be no exposed low voltage wiring in high voltage compartments.
- b) All wiring shall be firmly fixed in place with clamps of a type which will not injure the insulation. Wiring shall be neat with all wires grouped as much as possible.
- c) Terminal blocks with marking strips shall be provided for all secondary and control circuits leaving the switchgear or passing to other bays in the assembly.
- d) Wiring and terminal shall be identified as per Identification requirements in this Specification. Adhesive wire labels are not acceptable.

- e) Control wiring shall be 600 V rated Type SIS copper, 90 deg. C, minimum #14 AWG, minimum Class B stranded, except for wires crossing hinged joints and swinging panels which shall be flexible Class K stranded.
- f) Terminal blocks shall be provided for all control wiring. Terminal blocks shall be grouped by function. External wiring shall be provided with dedicated terminal blocks. 20% spare, used terminal blocks shall be provided for each control compartment.
- g) All wiring shall have insulated compression type terminal lugs with fork type tongue lugs, except CT secondary circuits which shall be provided with non-insulated ring type lugs.
- h) All terminal blocks shall be rated 600 volts minimum and shall be screw pressure clamp type.
- i) A maximum of two wires shall terminate at any one terminal.

2.2.13. Control & Auxiliary Devices

- a) Auxiliary relays associated with protective protection, control or metering functions may be surface mounted inside the switchgear, except lockout relays, which shall be mounted on the door.
- b) Duplex receptacles shall be furnished in each switchgear control compartment for 120V AC operation of small tools or portable lamps as an aid to inspection and maintenance.
- c) LED lamp shall be furnished in each switchgear control compartment for 120V AC complete with an easily accessible control switch.

2.2.14. Metering

- a) Where the switchgear assembly serves as a service point for the Utility incoming supply metering bay shall be provided with revenue accuracy CTs and PTs in accordance with Utility requirements. These devices shall be sent to the Manufacturer prior to shipping to be factory installed. The CT and PT data shall be included in the manufacturer's final drawings for record purposes.
- b) Provide a digital power meter for each cell, both incoming or feeder circuits. Digital metering system shall measure true RMS current and voltage and display per phase volts and amps, kW, kVA, kVAR, PF, Hz, MWh and kW demand. Communication port shall be provided per Contract Documents. Digital metering system shall be monitored by a remote supervisory system (BAS, SCADA, etc.).
- c) Digital power meters shall have provisions for testing and calibrating using an external power supply without disconnecting permanent wiring.

- d) Meters shall be installed using multi-pole test switches. Each meter element shall be wired to current test switches, such that the meter can be isolated and taken out of service without interrupting the connection to the other devices in the current loop."
- e) Digital power meters shall be mounted at a readable level (approx. 1675 mm A.F.F.).

2.2.15. Lightning Arrestors

- a) Provide lightning arrestors in the equipment as shown on Contract Documents, at the incoming cells and at the cells feeding transformers.
- b) Manufacturer shall perform and provide insulation co-ordination study to verify system is suitably protected.

2.2.16. Infrared Windows

- a) Provide infrared windows in the switchgear to provide view of all bus bar and cable connections, circuit breaker connections as well a full view of the breaker or switch mechanism and fuse holders.
- b) The window lens shall be compatible with most popular IR cameras, fusion capable and shall transmit electromagnetic radiation in:
 - 1) Short, Mid and Long Wave Infrared;
 - 2) Visual; and
 - 3) UVA and UVB Ultraviolet
- c) Label each window to provide the thermographer with full information necessary to properly set and aim the infrared camera and correctly interpret readings. The information shall include but not be limited to:
 - 1) IR window location and number;
 - 2) Lens material, range and the effective wavelength;
 - 3) Lens Transmission Rate and proper compensation values; and
 - 4) Target(s): name, location (in respect to window) and target(s) emissivity.
- d) Infrared windows shall be CSA approved, UL/cUL listed, comply with IEEE Std. C37.20.2. Range, size, NEMA/IP and voltage rating suitable for the application.
- e) Acceptable manufacturers include: Hawk IR International Limited/Fluke, FLIR, Lumasense Technologies Inc or approved equivalent.

2.2.17. Accessories

- a) For all switchgear with draw out circuit breakers or switches provide one circuit breaker lifting device. It shall be portable, floor-supported with a roller base. All four wheels are to be swivelling type to allow the lifting device to be moved in any direction. Also provide same portable lifting device with each outdoor non-walk-in line-up(s). Provide one lifting device in each room containing draw out circuit breakers.
- b) Provide one manual racking handle(s) with switchgear assembly.
- c) Provide one motorized remote-control racking accessory with switchgear assembly.
- d) Provide charging handle for each breaker mechanism.
- e) Provide one test cabinet with one test jumper cable.
- f) Provide maintenance tool for manually charging the breaker closing spring and manually opening the shutter.

2.3. FABRICATION

- 2.3.1. Each equipment bay shall be a separately constructed cubicle assembled to form a rigid freestanding unit.
- 2.3.2. Minimum sheet metal thickness shall be 11-gauge steel on all exterior surfaces.
- 2.3.3. Adjacent bays shall be securely bolted together to form an integrated rigid structure.
- 2.3.4. The rear covers shall be removable to assist installation and maintenance of bus and cables.
- 2.3.5. Each individual unit shall be braced to prevent distortion.
- 2.3.6. Large line-ups shall be split to permit normal shipping and handling as well as for ease of re-joining at the job site.

2.4. FINISHING

- 2.4.1. All steel parts, except galvanized (if used), shall be cleaned and a zinc-phosphate (outdoor equipment) or iron phosphate (indoor equipment) pre-treatment applied prior to paint application.
- 2.4.2. Paint colour shall be ANSI-61. TGIC polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard and durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in colour and free from blisters, sags, flaking and peeling.

- 2.4.3. Adequacy of paint finish to inhibit the build-up of rust on ferrous metal materials shall be tested and evaluated per paragraphs 5.2.8.1-7 of ANSI C37.20.2. Salt spray withstand tests in accordance with ASTM #D-1654 and #B-117 shall be performed on a periodic basis to provide conformance with the corrosion resistance standard of at least 2500 hours minimum (outdoor equipment) or 600 hours minimum (indoor equipment).

2.5. IDENTIFICATION

- 2.5.1. Furnish colour coding in accordance with Metrolinx Electrical Identification and Nomenclature Specification 26 05 23.
- 2.5.2. Provide identification for equipment and the sub-components in accordance with Metrolinx Electrical Identification and Nomenclature Specification 26 05 23.
- 2.5.3. Provide continuous mimic bus applied to the front of the switchgear, arranged in single line diagram format.
- 2.5.4. Provide nameplates, warning signs and labels as required by the AHJ.

3. EXECUTION

3.1. FACTORY TESTING

- 3.1.1. All standard factory testing shall be witnessed by the Metrolinx.
- 3.1.2. The Manufacturer shall notify Metrolinx two (2) weeks prior to the date the tests are to be performed.
- 3.1.3. The switchgear shall be fully assembled, inspected and tested at the factory prior to shipment.
- 3.1.4. Protection devices shall be set-up as per coordination study.
- 3.1.5. The following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of CSA or ANSI standards:
- a) Alignment test with master cell to verify all interfaces and interchangeability;
 - b) Circuit breakers operated over the range of minimum to maximum control voltage;
 - c) Factory setting of contact gap;
 - d) One-minute dielectric test per ANSI standards;
 - e) Final inspections and quality checks;
 - f) Alignment test with master breaker to verify interfaces;

- g) One-minute dielectric test per ANSI standards on primary and secondary circuits;
- h) Operation of wiring, relays and other devices verified by an operational sequence test;
- i) Final inspection and quality check; and
- j) Perform low frequency withstand (Hi-Pot) tests according to ANSI/IEEE C37.20.2.

3.2. INSTALLATION

- 3.2.1. The Contractor shall install all equipment per the Manufacturer's recommendations and Contract Documents.
- 3.2.2. Once equipment is on site, the Contractor must take appropriate provisions for the equipment to remain clean and dry. If equipment is stored in an un-heated area, temporary heat is to be provided in the enclosures to prevent moisture build-up and corrosion.
- 3.2.3. Touch-up paint all chips and scratches with manufacturer-supplied paint and leave remaining paint with Metrolinx.
- 3.2.4. Prior to installation the Contractor shall visually inspect switchgear for evidence of damage and ensure that surfaces are ready to receive work.
- 3.2.5. The switchgear manufacturer shall provide vibration and noise isolators using soft (maximum 40 durometer) multi-layer rubber pads sized for a minimum static deflection of 12.7 mm at no more than 2/3 of the manufacturers maximum load rating for the pad material. The pads shall be installed at the corners of each individual vertical section.
- 3.2.6. Complete all field wiring and bus connections identified by the manufacturer. All connections to be torqued as per manufacturer's recommendations. Check factory made connections for mechanical security and electrical continuity.
- 3.2.7. Prior to commissioning and prior to turning the equipment over to Metrolinx, the equipment shall be cleaned thoroughly to ensure there are no traces of construction materials or dust.
- 3.2.8. Visually inspect to confirm that all items and accessories are in accordance with Specifications, Contract Documents and Shop Drawings.
- 3.2.9. Verify field measurements are as shown on Shop Drawings and instructed by Manufacturer.
- 3.2.10. Verify that required utilities (e.g., control voltage for heater circuits on outdoor switchgear) are available, in proper location, and ready for use.

3.2.11. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

3.2.12. Check factory made connections for mechanical security and electrical continuity.

3.3. COMMISIONING

3.3.1. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under Contract. The Manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

3.3.2. The protection device settings shall be verified in the field and tested by the Contractor as defined in the coordination study.

3.3.3. A qualified factory-trained Manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the Manufacturer's recommendations.

3.3.4. When the Contractor is ready for final inspection, set-up and testing to begin, the Contractor is to provide in writing that the equipment has been installed and include the Manufacturer's certification.

3.3.5. Field inspection, final set-up and testing will be performed by the Contractor.

3.3.6. All final site testing to be witnessed by Metrolinx or it's representative(s).

3.3.7. Testing shall be conducted in accordance with the latest edition of ANSI/NETA ATS - Standard for Acceptance Testing for Electrical Power Equipment and Systems, .

3.3.8. Contractor to perform:

- a) Visually inspect all equipment for physical damage;
- b) Confirm that all wiring has been connected as per the manufacturer drawings;
- c) Perform start-up tests in accordance with manufacturer's instruction manual;
- d) Verify interlock operation;
- e) Confirm operation of all relays and any control sequences. Adjust relays and settings and document changes made;
- f) Repeat all factory testing performed on the equipment;
- g) Check insulation of switchgear assembly with suitable megger. If values not satisfactory, clean, and dry switchgear and repeat tests until readings acceptable to Engineer's Representative;

- h) Check phase rotation of each feeder; and
- i) If any test fails, Metrolinx is to be notified immediately.

END OF SECTION