

# **ELECTRICAL DESIGN STANDARDS**

## **Introduction**

The following are the University of Toronto Electrical Design Standards. The information contained within these Standards must be followed unless:

1. They cannot be applied to the specific design work planned. If this is a problem, the design consultant must present the information to the U of T Project Manager to point out the problem and receive permission to implement the alternative solution.
2. If an alternate product or system is available, which is the recommended standard of the consultant for the project; they may request approval for such an alternate through the U of T Project Manager.
3. If there is a conflict between these Standards and the Codes, such issues should be brought to the attention of the U of T Project Manager for a decision on what to use.
4. If there is a substantial cost savings to be realized by changing from a standard and the consultant is recommending such a saving, the U of T Project Manager will consider such a request. The consultant might be requested to prove the cost savings compared to long term maintenance costs.
5. The consultant is encouraged to point out any problems with the Standards, and to provide alternates that may have a significant cost savings. The consultant is also encouraged to comment on the appropriateness of the Standards as compared to general industrial standards.
6. These Standards are intended to be competitive standards. However, the consultant should understand that the University would like to achieve more permanence and lower long term maintenance in the products that are purchased and installed. Therefore, the Standards might be slightly higher than the normal commercial standards.

# Electrical Design Standards (Division 16)

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## Conversion Table

Previous U of T Electrical Design Standard		Master Format (MF95)	Canadian Master Spec. 2004 (MF04)
Item	Description		
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16.2	Wiring Devices	16140	262726
16.3	Wires and Cables	16123	260519
16.4	Ductbanks and Cable Chambers	16118	260537
16.5	13.8 kV Indoor Switchgear for 13.8 kV Loop Network	16346	262813
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16.9	Low Voltage Distribution System Equipment (600 Volts Maximum)	16426	262413
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16.18	Fire Alarm	13860	283100
n/a	Colour Codes for Junction Boxes and Cover Plates on Various Systems	16130	260534
n/a	Numbering System for Electrical Panels	16195	260553

## Electrical Design Standards - Checklist

The Design Team is required to read and comply with the full Design Standard as it applies to this project. A completed copy of this checklist must be submitted by the Design Team to the University's Project Manager at the end of the Design Development Phase. In all cases, if a "NC" has been noted, please indicate why. Attach additional sheets as necessary.

		<u>C</u>	<u>NC</u>	<u>N/A</u>
<b>16</b>	<b>ELECTRICAL</b>			
16111	<b><u>Conduits (Electrical Distribution, Telephone, Computer and Control Wiring)</u></b>			
.1	All conduits inside the building shall be electrical metallic tubing (EMT) unless specified otherwise.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Conduits exposed to the weather, in wet locations, subject to mechanical injury, or in any hazardous locations or where required by Code, shall be rigid threaded, galvanized steel conduit.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Conduits in ceiling plenums shall be EMT.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Motor feeder drops shall be in rigid threaded galvanized steel conduit with a maximum 3'-0" (1m) and of flexible liquid-tight conduit for final connection to motor. Rigid conduit for the drops shall start at least 3'-0" (1m) ahead of the actual bend and have two additional clips over normal requirements. The minimum conduit size for the drops shall be 3/4"(19mm).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Branch wire conduits in finished areas shall be concealed and those in unfinished areas shall be surface mounted unless otherwise noted.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Conduits shall be installed so that the conductors can be drawn in without strain or damage to the conductors.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Expansion fittings shall be installed in conduits crossing expansion joints.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Conduits shall be installed to allow for expansion and expansion fittings shall be provided where required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	The use of running threads shall not be permitted. Ericson couplings shall be used where required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Connectors for EMT conduit shall be steel, compression type, nylon insulated. Steel set screw type is acceptable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	Fish wires shall be installed in all empty conduits, including telephone and computer conduits.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	A separate insulated ground wire shall be installed in all conduits, except computer telephone/control conduits.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	Joints in conduits installed underground, in concrete slab on grade or in a concrete duct bank shall be made completely watertight.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.14	Minimum concrete thickness over or around a conduit in a concrete slab shall be 3" (75mm).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.15	Conduits for computer systems shall comply with Enterprise Infrastructure Solutions (EIS) Standards.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16118 **Ductbanks and Cable Chambers**

.1	Duct banks shall consist of parallel conduit(s) encased in concrete. At the supply end, bell end couplings shall be used to terminate the ducts.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	The ducts shall be CSA certified, PVC Type 2 with an internal diameter of 6" (150mm), and shall include the duct manufacturer's watertight couplings, duct bends and duct supports.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Adjacent duct couplings shall be staggered by at least 8" (200mm) with a duct support within 24" (600mm) either side of the furthest couplings.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Duct bends shall be paralleled sweeping type, with minimum bending radius of the inside bends sized to suit the recommended bending radius of the largest cable that will be installed in the duct bank.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	The ducts shall be laid with a minimum spacing of 8" (200mm) centre to centre, both horizontally and vertically, or as the duct manufacturer's duct supports for concrete encasement dictate.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	The duct run shall be reinforced with minimum 1/2" (13mm) diameter PVC coated steel reinforcing rods laid longitudinally on top, bottom and sides of duct bank and secured to the duct manufacturer's duct supports. Where reinforcing rod overlap occurs between duct supports, they shall be overlapped a minimum of 12" (300mm) and tied together.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	The ducts shall be encased with minimum 2,000 psi concrete with a minimum cover of 3" (75mm) on all sides.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	To prevent any displacement of the duct structure during pouring, the duct structure shall be braced down every 10 feet (3m) and the concrete shall be deflected down alongside the ducts to the bottom and up through the duct assembly.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	The duct bank elevations shall be arranged to slope downwards towards the termination points (building or manhole) such that water cannot accumulate anywhere along the length of the duct bank. In no case shall the highest elevation of the duct bank be less than 36" (900mm) below grade.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	The ducts entering into buildings, substations or manholes shall be bell shaped and sealed.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.11	When completed, the ducts shall be cleaned. Cleaning shall include a properly sized steel brush mandrel pulled through each duct, followed by swabbing to ensure removal of all dirt and other debris that could damage cable insulation. A test piece of the largest cable to be installed in the duct bank shall be pulled through <u>each</u> duct to ensure no cable insulation damage will occur. When each duct has been proven, the ends shall be plugged.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	One continuous length of ½" (13mm) diameter polyethylene rope shall be installed in each duct to facilitate the installation of the cables in the duct.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	<b>Cable Chamber</b>			
.1	Cable chamber cover shall be minimum 33 inches (840 mm) in diameter.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Cable chamber shall be minimum 6 feet x 8 feet (or 1.8m x 2.4m).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Cable chamber shall be provided with means of drainage.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Cable chamber floor shall be sloped into a sump pit.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Provide cable pulling eyes cast into the walls. Cable pulling eyes shall be located opposite to ductbanks entering cable chamber.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Bottom of cable ductbanks entering cable chamber shall be at least 2 feet (600mm) from cable chamber floor.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Cables inside cable chamber shall be properly supported by cable racks.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Height of cable chamber shall be minimum 6' – 6" (2m).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16121 **Loop Feeder High Voltage Cables (15 kV)**

.1	<b>Materials</b>			
.1	Cables shall be 750 kcmil copper conductor, triplexed, rated 15 kV, 133% insulation level, manufactured and tested to ICEA Publication S-93-639, and shall be CSA or UL approved* and bear evidence of same. (* where accepted by Code)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	The cable shall be Class "B" stranded copper with 61 strands, extruded semi-conducting polyethylene shield, Exelene insulation, extruded semi-conducting polyethylene shield, wire shielding composed of 29 #10 AWG soft tinned copper strands for a short circuit rating of 10,500 Amps for 8 cycles covered with a separator and an overall PVC jacket. Insulation shall be tree retardant TRXL and shall bear evidence of same. Cables to be supplied in continuous lengths, free from kinks and defects.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.2	<b>Installation</b>			
.1	Before pulling the cable into a duct, clean the duct by pulling through a stiff wire brush, and a swab to remove all water, mud, sand, earth and other foreign matter. A test piece of the cable shall be pulled through the duct to ensure cable insulation will not be damaged.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Install cables in continuous lengths without splices, unless specifically indicated otherwise.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Use pulling eyes to install the cables.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Use a good quality, cable manufacturer's approved lubricant in sufficient quantity for the pulling operation. The lubricant shall possess the following characteristics: <ul style="list-style-type: none"> <li>• No harmful effect on cable jacket.</li> <li>• Percentage of water content (if water based) shall be minimal.</li> <li>• Retention of lubricant qualities over a long period of time.</li> <li>• Shall not freeze in cold weather (above 0 °F).</li> <li>• Shall be approved by C.S.A. for the cables being installed.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Terminate and splice cables in accordance with the cable manufacturers' recommendations, using only the methods, materials and compounds recommended.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Each splice and stress cone termination shall be a built-up type, generally consisting of approved compression type connector, insulating tape, semi-conducting tape, self-amalgamating polyethylene tape, insulating shielding and a copper braid cover connecting at both ends to the shield, equal to shielding of cable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Splicing and stress cone termination shall be performed by a trained and qualified splicing and testing company approved by the U of T, experienced in preparing the cable and the type of splicing work called for by the nature of this work and in accordance with the cable manufacturer's recommendation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Hi-pot the complete cable installation, including terminations, in accordance with the applicable CSA and ICEA Standards, and submit written report of Hi-pot test.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Install cables in accordance with the manufacturer's recommendations for the specific type of cable and installation conditions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Cables in HV Substations or cable chambers shall be properly identified with permanent labels.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



		<u>C</u>	<u>NC</u>	<u>N/A</u>
16123	<b><u>Wires and Cables</u></b>			
.1	Wires and cables (120/208V to 347/600V systems) unless otherwise noted, shall be minimum size #12 AWG, stranded, copper conductor, type RW90 (90°C) or THHN, minimum 600 Volt insulation. ALUMINUM CONDUCTOR CABLES SHALL NOT BE USED.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Type AC90 (BX) armoured cable shall only be used for fixture down drops above accessible drop ceilings with a maximum down drop not to exceed 3 metres (10 feet) from ceiling junction box to fixture. Armoured cable may be used for single drops from the junction box to supply wiring devices in drywall partitions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	M.I.C.C. cables shall have solid copper conductors insulated with magnesium oxide and enclosed in a seamless copper sheath with a protective jacket where required. M.I.C.C. cables shall be identified with colour codes (see section 16130) every 10ft. (3m) of cable run.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	M.I.C.C. cables shall be terminated with moisture proof connectors.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Size wiring for a 2% maximum voltage drop to farthest outlet based on circuit rating. Home runs to lighting and receptacle panels which exceed 75 ft. (25m) shall be minimum No. 10 AWG. For -80°C Freezer wiring: if longer than 50ft. (15m), use minimum No.10 AWG; if longer than 100ft. (30m), use minimum No.8 AWG; if longer than 150ft. (45m), not recommended.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Termination lugs for feeder cables shall be compression type.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	All outdoor wiring shall have copper conductors with RWU-90, X-Link, minus 40°C, 600 Volt insulation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	When a project is to include new wiring, wiring upgrades or rewiring, all the existing wiring that is no longer in service shall be removed as part of the project. New panel and equipment names shall be approved by the Manager of Electrical Systems.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16130 **Colour Codes for Junction Box Cover Plates on Various Systems**

System	Colour Code	Written Code
120/208V	-Normal lighting and power	White
	-Emergency power	White / Red
	-UPS	White / Blue
240/416V	-Normal lighting and power	Pink
	-Emergency power	Pink / Red
	-UPS	Pink / Blue
346/600V	-Normal lighting and power	Yellow
	-Emergency power	Yellow / Red
	-UPS	Yellow / Blue
Fire Alarm		Red
Telephone		Orange
Cable TV		Purple
Data		Brown
Control	-HVAC	Green
	-L.V. Lighting control	Green / Black
Security		Grey
Surveillance, CCTV		Grey / Black
Public Address		"PA"
Audio Visual		"AV"
Paging		"PG"
Intercom		"ICOM"

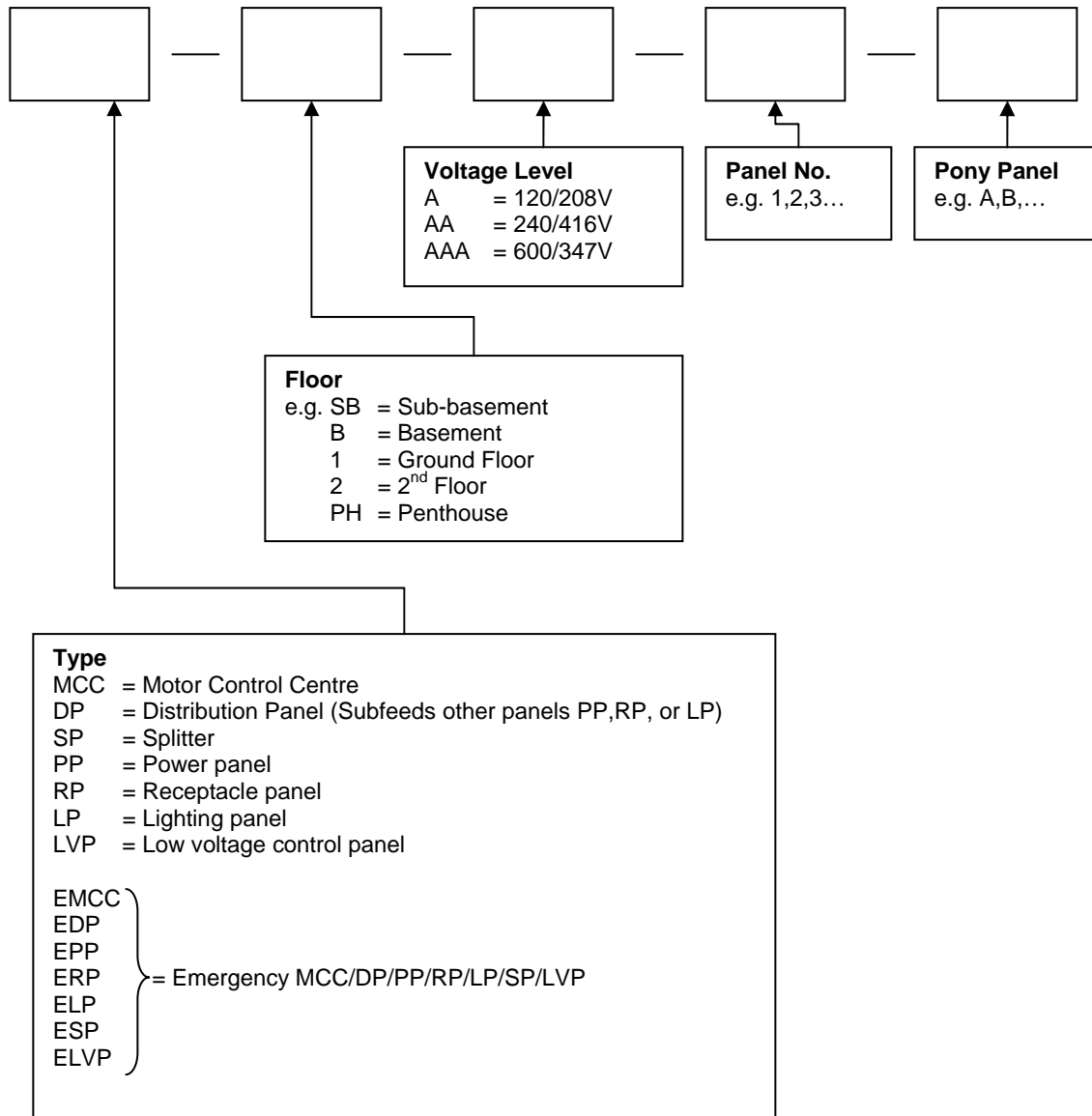
Note: Light colours shall be chosen for Green, Blue, Brown, and Grey.

- .1 All junction box cover plates on various systems shall be colour coded according to the Table shown above.
- .2 Mark in black on the colour coded cover plates the year when this colour code was applied. Use 4-digit numbers to represent the year.

16140 **Wiring Devices**

- .1 Light switches on 120 Volt circuits shall be rated 20 Amp.
- .2 Light switches in all areas shall be premium specification grade, A.C., toggle type switches, except where required in washroom or corridors which shall be key operated.
- .3 Receptacles shall be premium specification grade.
- .4 Light switches and receptacles on normal power shall be white.
- .5 Light switches and receptacles on emergency power shall be red.
- .6 Isolated ground receptacles shall be orange.
- .7 Wall plates for flush mounted devices shall be multiple gang, super stainless steel type 302.

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.8	Wall plates for surface mounted devices in unfinished areas shall be metal covers for F.S. type boxes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Weatherproof plates shall be cast aluminium with lift cover for F.S. type boxes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	The A.V. and computer outlet wall plates shall be provided as required by Enterprise Infrastructure Solutions (EIS).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	The telephone outlet wall plates shall be provided as required by Enterprise Infrastructure Solutions (EIS) standards.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	The dimmers up to 1500W shall have linear slide control, white finish and lamp debuzzing coil in aluminium enclosure, equal to Lutron 'Nova' series. For low voltage dimming, use 'Nova NLV' series.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	Mounting heights are referred to finished floor or finished ceiling unless related to bench mark elevations.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.14	Provide cover plates for flush mounted manual starters.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.15	Light switches, except where noted, shall be mounted 4'-0" (1,200mm) above finished floor, on the lock side of the door.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.16	Telephone, intercom, etc., wall outlets shall be spaced 4" (100 mm) from power outlets.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.17	Opposing outlets on partition walls shall have a 6" (150 mm) horizontal separation. They shall not be mounted back to back.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.18	All Receptacle outlets shall be permanently identified indicating the circuit number and source of supply (e.g. Panel board designation).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Example: LP3A1A (or LP – 3 – A – 1 – A )

		<u>C</u>	<u>NC</u>	<u>N/A</u>
16270	<b><u>13.8 kV Liquid Filled Power Transformers (Indoor Type)</u></b>			
.1	Power transformers shall be silicone oil liquid filled, sealed tank, self cooled, type LNaN-LNAF, 2 winding, step down, with a temperature rise at rated self-cooled load of 55°C over an ambient of 40°C maximum and 30°C average.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Transformers shall comply with the applicable standards of CSA, CEMA, ANSI and NEMA.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	The capacity of each transformer shall be: <ul style="list-style-type: none"> <li>• 100% kVA at 55°C rise without fans;</li> <li>• 112% kVA at 65°C rise without fans, with no loss of transformer life;</li> <li>• 133% kVA at 65°C rise with fans, with no loss of transformer life. Fans shall be provided.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	High voltage windings shall be 13.8 kV, delta connected, with four 2.5% rated kVA taps, two above and two below nominal voltage.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Low voltage windings shall be wye connected, with the wye connection solidly grounded outside the tank.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	The basic impulse insulation (BIL) level shall be 95 kV.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	The impedance shall be between 5.5% and 6.3%, including all tolerances.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Transformers shall be complete with all standard accessories, including, but not limited to, the following: <ul style="list-style-type: none"> <li>• Off load circuit tap changer operable from ground level by a single external wheel, with provision for padlocking in any position.</li> <li>• Tap position indicator.</li> <li>• High internal tank pressure relief device.</li> <li>• Hermetically sealed dial type oil temperature thermometer, three stages: fan start, alarm and trip contacts.</li> <li>• Liquid level gauge with alarm contact.</li> <li>• Bottom drain valve and sampling device.</li> <li>• Two tank grounding studs for No. 4/0 AWG conductor in diagonally opposite positions.</li> <li>• Lifting eyes, welded bottom corner jacking steps and provision for skidding.</li> <li>• Diagrammatic nameplate of non-corroding material in an accessible location.</li> <li>• Sudden gas pressure relay with trip and alarm contacts. Seal-in or lockout relays shall operate on 125V DC.</li> <li>• Winding temperature sensors with winding temperature alarm contacts for remote connection.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



		<u>C</u>	<u>NC</u>	<u>N/A</u>
16346	<b><u>13.8 kV Indoor Switchgear for 13.8 kV Loop Network</u></b> Note: Toronto Hydro requirements are quoted for Short Circuit Levels and Ratings.			
16346.1	<b>General</b>			
.1	The switchgear shall consist of an assembly of incoming loop and tie circuit breakers, fusible and non fusible load break switches, protective relaying, metering and ancillary equipment, configured as shown on the drawings. Cells shall be numbered from left to right when facing the front of the switchgear. Bus A shall be the left hand bus, and bus B the right hand bus.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	The completed assembly shall comply with the requirements of all Authorities having jurisdiction and including Canadian Standards Association C22.1, C22.2 Nos. 31, 94, 193 and CAN3-C13; EEMAC G8-3.2; IEEE Standard 48-1975; ANSI Standard C37.85-1972; Ontario Electrical Safety Code; ANSI C37.04 to C37.18 and C37.20. Where U of T requirements exceed those of the foregoing Standards, those U of T requirements shall be met.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	The switchgear shall include the required number of cells, bolted together on a common channel steel base to form a self-contained, self-supporting, dead front assembly.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	The switchgear shall comply with the following minimum ratings (as per Toronto Hydro requirements): <ul style="list-style-type: none"> <li>• Continuous current rating: 1200 A rms (main bus);</li> <li>• Max Short Circuit rating: 500 MVA;</li> <li>• Symmetrical Max Ground Current rating: 11,000 amps;</li> <li>• Rated Nominal Voltage: 13.8kV rms;</li> <li>• Rated Max Voltage: 15kV rms;</li> <li>• Rated Frequency: 60 Hz;</li> <li>• Power Frequency Withstand Voltage: 36 kV;</li> <li>• BIL: 95 kV;</li> <li>• Rated Momentary Current: 37 kA rms;</li> <li>• Asym Corona Extinction Voltage to Ground: 10.5 kV rms.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	The integrated assembly shall be designed to withstand any internal pressures that may be created when a switch or breaker opens, carrying full rated current, or is closed on a fault or when the fuses operate or a breaker trips under full rated fault conditions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	All electrical and mechanical interlocks required for the protection of equipment and personnel shall be included.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Provide Arc Flash calculations and Arc Flash warning labels on switchgear front panel.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
16346.2	<b>Construction</b>			
.1	The enclosure shall be sprinkler proof, minimum #11 MSG for the enclosure and barriers between compartments, and all other covers, barriers, panels and doors not less than #14 MSG.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Circuit breaker cells shall be metalclad construction and divided into 4 separately grounded steel compartments for each of the following: 1) Breaker compartment; 2) Cable entry and termination compartment; 3) Main bus and current transformers compartment; 4) Metering, relaying and auxiliary devices compartment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Load break switch and bus transition cells shall be metal enclosed construction. Cells and compartments within cells shall be designed such that failure of any device within a cell or compartment shall not cause damage within adjoining cells and compartments.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Mounting channels and hardware shall be supplied by the switchgear manufacturer for concrete pad installation in order to ensure proper levelling of the switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Doors on the front of the switchgear shall be full height, formed type, with 3 point latches, concealed left hand hinges, stops and provision for multiple padlocking. A separate door for access to the breaker compartment and separate door for access to the upper compartment above the breaker compartment shall be provided on circuit breaker cells. Outer access door swings on all cells shall be minimum 135 degrees.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	A hinged steel panel with provision for padlocking shall be provided on the rear of each cell for access into the rear of the cell. For incoming HV cables into circuit breaker cells, a separate hinged panel shall be provided for the upper incoming cable compartment and for lower rear breaker compartments. Opening panels shall require unsecuring knurled 25mm head captive bolts on the opening side of panel and removal by the owner of his padlock. Hinged panels shall open a minimum of 135 degrees.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Openings each c/w bolted sheet steel cover plate shall be provided at each end of the switchgear, to permit extension of the main bus and ground bus for future cells. Main bus openings shall be sized to allow for installation of bus and feed through insulators.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	The exterior finish shall be factory finished ANSI 61 grey and the interior finish shall be white enamel. A sufficient quantity of touch-up enamel shall be furnished to repair minor damage to the finish after installation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



		<u>C</u>	<u>NC</u>	<u>N/A</u>
16346.3	<b>Buses</b>			
.1	Buses shall be high-conductivity copper with silver-plated joints and tap connections.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Buses shall be fully insulated using bed fluidized process. Through-bushings where buses pass through metallic barriers shall be fully rated for the insulation level of the switchgear and provide full cell separation between cells. Insulation and bushings shall be flame resistant and track retardant.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Bus joints shall be secured with cadmium plated steel bolts, nuts and washers to ensure maximum pressure and even current distribution. Bolts shall be tightened to required torque with a minimum of two bolts at each joint or as per bracing requirements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Joint covers shall be non-flammable, non tracking, and flexible, sized to suit the joint. Joint covers having to be shipped loose shall be installed at the site by qualified personnel. Cover fastenings (e.g. nylon bolts and nuts) shall be reusable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Field connections on the buses shall be made using materials and methods supplied or recommended by the manufacturer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	The main bus shall be rated 1200 amps at 50°C ambient temperature and shall extend throughout the switchgear, complete with all required insulators and through- bushing supports. Bus shall be predrilled to allow for all HV cable terminations in the incoming HV cable compartments.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	A 600 amp copper ground bus shall be run the full length of the switchgear. The ground bus shall be installed immediately inside the bottom lower rear of each circuit breaker cell and immediately inside the bottom lower front of each load break switch cell, allowing the owner to attach external grounds for owner maintenance testing and maintenance grounding requirements without interference from the main bus. Provide a pressure connector at each end of the switchgear ground bus for connecting a #4/0 AWG station grounding conductor. The switchgear framework and the bases and enclosures of all equipment shall be bonded to the ground bus.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Ground bus extensions with lugs shall be provided in the incoming HV cable compartments to allow the stress cones on the incoming cables to be grounded with short leads.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Provision shall be made for extending the main bus and ground bus at each end of the switchgear for extension to future switchgear cells. This shall include main bus predrilled bus stubs and insulating boots over the stubs, and predrilled ground bus.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
16346.4	<b>Wiring and Connections</b>			
.1	Provision shall be made for incoming HV cables entering the top of the switchgear, and outgoing HV cables leaving the top of the switchgear. A removable non ferrous cable entry plate shall be provided on the top of each cell for incoming or outgoing HV cables.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Secondary wiring (including control, metering and relaying wiring) shall be run in grounded steel compartments or shall be otherwise suitably isolated from the high voltage bus and wiring.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Secondary wiring shall be identified at each point of connection and termination by non-metallic wire markers, Brady or equal, to agree with the wiring diagrams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Secondary wiring shall be terminated with solderless lugs. Wiring shall be free of splices.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Terminal blocks shall be provided to terminate non current transformer wiring within cells and between cells of the HV switchgears. Terminal blocks shall be barriered type, clearly identified with permanent markers. Terminal blocks shall have no more than one wire under each terminal connection. Providing manufacturer's jumper connections between terminals as required to comply.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Secondary wiring shall be minimum #12 AWG copper, switchboard type; 7 strand for fixed wiring and 41 strand for wiring to hinged panels.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16346.5	<b>Control, Metering and Relaying</b>			
.1	Circuit breaker control switches, status and trip indicating lights, lamp test switches, meters and associated switches, relays, and all associated current transformer test blocks, shall be mounted on formed front hinged doors of the switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Circuit breaker control switches shall be pistol grip type, 3 positions (close-open-trip) with target indication of the last operation and spring return to the open position. Target indication shall be red for breaker closed and green for breaker open. The control switch contact arrangement shall be arranged such that when a breaker trip occurs under fault conditions, the control switch must be operated from the "open" to "trip" position in order to extinguish the fault trip indicating LED (LED is separate from the control switch)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.3	All Indicating lamps shall be LED type and provided with external resistor to prevent inadvertent tripping of circuit breaker if the LED short circuits, rated nominal 125 VDC with operating range from 90 to 140 VDC. LED indication shall be provided on the respective circuit breaker cell for circuit breaker closed, open and fault trip indications, transformer sudden gas trip indication, transformer oil-temperature trip indication, and circuit breaker low SF6 pressure indication (if applicable). Push to test switch(es) shall be provided to test the integrity of all LEDs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Meters shall be semi-flush mounted, switchboard type, and not to exceed 5' – 4" (1.6m) above finished floor.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Ammeters shall be thermal demand and instantaneous analogue indicating type, minimum 250 degree full scale. Provide 3 ammeters for each of the buses 'A' and 'B'.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Voltmeter shall be switchboard type, analogue indicating type, and minimum 250 degree full scale c/w 4 position voltmeter switch (off – A – B – C ).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	The totalizing type kilowatt-hour and kW demand meter shall be polyphase type, with indicating demand register, connected to measure the total consumption and demand with currents derived from the metering current transformers on Buses "A" and "B".	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Digital meters are acceptable. Refer to Section 16426.6 (Metering) for requirements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Relays shall be semi-flush mounted, drawout type, with built-in test facilities and targets to indicate operation. Relay contacts shall be self-aligning and shall be visible to permit ready inspection.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Phase overcurrent relays (device 50/51) shall be induction type, moderately inverse time characteristic with instantaneous element with tap ranges 4-12 amp inverse time and 20-80 amps instantaneous.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	Residual overcurrent relays (device 50/51N) shall be induction type, moderately inverse time characteristic with instantaneous element with tap ranges 0.5-2.5 amp inverse time and 4-16 amp instantaneous.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	The sending and receiving pilot wire relay (device 87) shall match the existing loop relays. Verify with the owner the existing sending and receiving type relay manufacture and type. Where it is not possible to match the new switchgear relays with the existing pilot wire relays, supply and install a new sending and receiving relay c/w associated check relays in the owners existing switchgear in order to match the new switchgear relays.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	Relay tap ranges shall correspond with the co-ordination study.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.14	Digital and electronic relays with equal or better functionality may be accepted. Submit detailed specification to U of T Project Manager for approval.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16346.6 Instrument Transformers</b>				
.1	Provide all necessary instrument transformers to operate the metering and relaying.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Current transformers shall have ratios as indicated. They shall have withstood rating equal to the momentary rating of the circuit breakers. They shall be insulated for the full voltage rating of the switchgear. Metering CTs shall be revenue grade (0.3% accuracy). Relaying accuracy shall be provided for all relaying CTs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Separate sets of current transformers ( 3 CTs per set ) for <u>each</u> of Bus A and Bus B shall be provided for <u>each</u> of the following: 1) one set for metering; 2) one set for overcurrent relaying; 3) one set for pilot wire relaying.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	One set of potential transformers configured for 120/240 Volt secondary rating shall be provided, drawout type, protected by S&C fused fault limiters type FFL-1 or GE current limiting fuses Type EJ-1B on both the primary and secondary windings. Transformers shall be kVA rated to provide switchgear metering requirements and 120 Volt station battery supply requirements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	All current circuits shall be provided with dead front shorting type test blocks located on the front of the switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Any auxiliary devices needed to complete the meter, relay and instrument equipment shall be included as required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16346.7 Accessories</b>				
.1	Nameplates, engraved lamacoid, with black letters on white background, fastened with stainless steel screws.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Nameplates for the cell doors and switchboard designation shall have letters minimum 25 mm high. Nameplates for meters, relays, test blocks, indicating lights and controls shall have letters 6 mm high.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Nameplate engraving requirements will be marked by the Owner on the shop drawings.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Suitable warning nameplates, with white letters on red background on the front and back of each cell door and hinged panel having access to HV equipment. Name plates shall be fastened using stainless steel screws.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Mimic bus, installed on the front of the switchgear clearly identifying the internal electrical arrangement of the equipment in each cell. The mimic bus shall be securely fastened using stainless steel screws. Mimic bus shall show all devices in white	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
	on red background, including but not limited to circuit breakers, loadbreak switches, fuses, PTs, CTs, and grounding points.			
.6	Breaker test plug and control power source for testing breakers outside of the switchgear and mounted in a separate EEMAC I wall-mounted enclosure, suitable for operating from 120 Volt, 60 Hz, single phase supply.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Control jumper for testing breaker in disconnected position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Hand crank for withdrawing breakers into the test and fully disconnected positions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Complete set of non standard tools as required, and one insulated HV hook stick for HV fuse holder removal.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Tow bar if required for manoeuvring truck mounted breaker outside of cell.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	One dozen spare LED type indicating lamps.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16346.8	<b>13.8 kV Load Break Switches</b>			
.1	Loadbreak switches shall comply with CSA Standard C22.2 No. 193 and shall be of the loadbreak interrupter type, quick make, quick break, group operated, with chain coupled mechanism and operating handle on the front of the cell. Provision shall be made for padlocking the operating mechanism with the switch in the open or closed position, with positions clearly labelled. Interrupters shall be rated : <ul style="list-style-type: none"> <li>- 600 Amps rms continuous</li> <li>- 600 Amps rms interrupting</li> <li>- 40 kA rms asym momentary,</li> <li>- 40 kA rms asym fault closing</li> <li>- 25 kA rms sym 2 sec current</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Switches shall be of North American manufacture.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Switches shall be 3 pole group operated by a handle mounted external to the switch compartment and arranged such that operating the switch does not require the operator to stand directly in front of the cell door.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Switches shall have all required phase to phase and phase to ground barriers, with horizontal barrier between switch and fuses and between switch and potential transformers. Barriers shall be white flame retardant insulating material complying with NEMA requirements for grade GPO-3 and shall be minimum 5mm thick.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Switch contacts shall be silver plated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.6	Chain operated switches shall have chain guard designed to prevent contact of chain with live parts in the event of chain failure.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Fusible switches shall be provided with fuse holders and fuses, and 3 spare fuse refill units. Fuse holders shall be S&C Electric Disconnect Style or approved equal, disengaged from the closed to open position by use of an insulated hook stick, and shall not require any other tool to disengage. In the open position, fuse holders shall be capable of being manually lifted out of the switch assembly without use of any special tools. Similar reinstallation requirements shall apply.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Fuses shall be non-deteriorating, refillable power type, type SM-5S, as manufactured by S & C Electric Disconnect Style or approved equal, complete with S & C mufflers. Fuses shall have minimum ratings of 14.4 kV, BIL rating of 95 kV, and interrupting capacity of 500 MVA sym, 21 kA rms sym, and 33.6 kA rms sym. Fuse ratings shall be as shown on the drawings or as specified later.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Switches shall be installed at the top of each cell and fuses at the bottom. Inverted switches shall not be used.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Voltage indicators shall be provided, one per phase for all three phases, on load side of each switch and shall be visible through the viewing windows. Voltage indicators shall be TEDC YZ-2 as supplied by THIES Electrical Distributing Co. of Cambridge, Ontario or approved equivalent.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	Three spare fuse refill units shall be provided for each fused switch in a suitable holder mounted on the back of the cell door giving access to the fused switch.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	Hinged safety screens painted black shall be installed in front of the interrupter units and all live parts, with padlock provision. The hinged safety screen shall be mechanically interlocked with the cell door to prevent closing the cell door with the hinged panel unsecured. The fuse and PT compartments shall be inaccessible, except when the switch is in the open position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	Viewing windows shall be provided for visual inspection of each switchblade position and each voltage indicator. Viewing windows shall be 13mm Lexan clear polycarbonate bolted to the inside of the door with minimum 13mm overlap with gasket in between. Viewing windows shall not restrict infrared scanning of the switchblades through the windows with the switch in the closed position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.14	Grounding studs shall be provided on the load side of each switch, one per phase, ball type c/w insulating boots requiring a hook stick for removal. With the insulating boots removed, the spacing between grounding studs shall not reduce the spacing requirements between phases. Grounding stirrups are also acceptable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- |     |  | <u>C</u>                 | <u>NC</u>                | <u>N/A</u>               |
|-----|--|--------------------------|--------------------------|--------------------------|
| .15 | Each fused load break switch shall be provided with a Kirk key interlock where the switch supplies a dry type transformer having hinged access doors to HV components within the transformer enclosure. The switch must be in the open position to release the Kirk key to enable opening the Kirk key interlock on the transformer. Co-ordinate keying with the transformer manufacturer. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .16 | Switches shall be provided with operations counter.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

16346.9 **13.8 kV Circuit Breakers**

- |    |   |                          |                          |                          |
|----|---|--------------------------|--------------------------|--------------------------|
| .1 | Circuit breakers shall be horizontal truck mounted drawout, air magnetic, SF6 or vacuum type, 3 pole, single throw, electrically operated, trip free, with self-aligning disconnecting contacts for power and control. Circuit breakers shall be of one type and readily interchangeable with other circuit breakers in the switchgear.   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .2 | <p>Circuit breakers shall have the following minimum ratings:</p> <ul style="list-style-type: none"> <li>• 13.8 kV nominal, 15 kV maximum design;</li> <li>• 1200 Amps continuous current rating;</li> <li>• 500 MVA sym interrupting capacity;</li> <li>• 36 kV power frequency withstand voltage;</li> <li>• 95 kV BIL;</li> <li>• 3 kA rms sym max interrupting;</li> <li>• 3 kA rms sym 3 second short time current;</li> <li>• 37 kA rms asym closing and latching;</li> <li>• 5 Hz rated interrupting time;</li> <li>• Operating duty CO-15 second-CO;</li> <li>• Control voltage rating 125 VDC nominal, 90-140 VDC closing, 70-140 VDC tripping.</li> </ul> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .3 | Circuit breakers shall be of North American manufacture.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .4 | Breakers shall be withdrawable to "test" and "fully disconnected" positions. Self-aligning disconnecting contacts shall be provided for power and controls. Primary disconnecting contacts shall automatically engage in the operating or fully connected position, and secondary contacts shall automatically engage in the operating and test positions.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .5 | Air circuit breakers shall have efficient non asbestos arc extinguishing devices with blowout coils to produce transverse flux during interruption of the circuit.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .6 | Breakers shall be operated by a stored energy mechanism which is normally charged by a DC motor, but which can also be charged by a manual handle for emergency closing or testing.   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.7	The closing speed of the contacts shall be independent of both control voltage and the operator. Interrupting time shall be uniform, and shall not exceed 5 Hz.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Air circuit breaker movable contacts shall be mounted so that they are easily accessible for inspection. SF6 and vacuum type circuit breakers shall be provided with readily readable contact wear indicators.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Each circuit breaker shall have two type "a" and two type "b" auxiliary contacts wired out to a terminal strip in the cell front upper compartment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Breakers shall have a hand crank means for horizontal racking into the fully connected and out to the test and fully disconnected positions. Provision shall be made for padlocking the breaker in the fully disconnected and test positions. Operating personnel shall not have to enter the breaker compartment to rack out the breaker to the test and fully disconnected positions. The cell door must be capable of being closed with the breaker in fully disconnected position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	The breaker control voltage shall be nominal 125 Volts DC.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	Breakers of the same rating shall be interchangeable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	Circuit breaker cells shall match the fused switch cells in general appearance.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.14	Automatic shutters shall separate all HV circuit breaker contacts from the breaker compartment when the breaker is in the test and fully disconnected positions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.15	Mechanical interlocks shall ensure that a breaker is open before it can be racked into or out of the "connected" position, and to prevent closing a breaker unless it is in the "fully connected", "fully disconnected" or "test" positions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.16	A mechanical position indicator shall be provided at the front of each breaker cell to indicate the racked position of the circuit breaker.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.17	Sliding ground contact shall be provided to ensure that breaker frames are grounded before the primary or control disconnecting contacts are made.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



	<u>C</u>	<u>NC</u>	<u>N/A</u>
16346.10 <b>Typical Switchgear Configuration for a Building Double Ended ( 2 Power Transformers T1 and T2 ) Substation Switchgear Based on HV Cable Top Entry and Connected into the U of T 13.8 kV Loop System</b>			
The following shall be included in each cell:			
.1 <u>Cells #1 and # 8</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- 1 fused load break interrupter switch in Cells # 1 and # 8 for supply of transformers T1 and T2 respectively. Each cell c/w voltage indicators and grounding studs.			
.2 <u>Cells #2 and # 7 (Transition)</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- 3 current transformers, revenue metering accuracy, 1200/5 Amps, wired to Cell #4 to the respective CT shorting type test block for ammeters and totalizing kW-hour and demand meter on front of Cell #4.			
.3 <u>Cell #3 (Incoming Circuit Breaker for Bus A)</u>			
<u>Cell #3 Front Door of Upper Compartment</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- 3 phase induction overcurrent relays, 50/51;			
- 1 residual induction overcurrent relay, 50/51N;			
- 1 pilot wire check relay 85 and pilot wire sending relay 87;			
- 1 circuit breaker control switch;			
- 5 LED type indicating lights: red "closed", green "open", white "fault trip", white "transformer gas trip" and white "transformer over temperature trip";			
- LED type indicating light, white for low SF6 pressure where SF6 type circuit breaker is supplied;			
- Push to test lamp test switch to test integrity of all indicating lamps on this door;			
- Dead front shorting type current transformer test blocks for relays on this door, wired to relays and to respective current transformers in the lower rear compartment of this cell;			
- Wire out all protective relay trip contacts, pilot wire relay non CT wiring, breaker control switch, and all indicating LEDs and LED push-to-test switch to terminal block(s) in the inside upper compartment of this cell.			
.4 <u>Cell #3 Inside Upper Compartment</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- This compartment shall contain all terminal blocks and auxiliary relays for wiring interconnections between all relaying and control and LED annunciation and test devices on the front door of this compartment, and wiring and auxiliary relays for the trip and control circuits of this cell circuit breaker;			

- This compartment shall contain a 2 pole knife switch and deadfront DC fuse holder c/w fuses and all wiring and connections to this cell circuit breaker control circuit. DC supply wiring shall be provided from the switch to the station battery supply terminal block in Cell #4;
- This compartment shall contain a 2 pole knife switch and deadfront DC fuse holder c/w dummy fuses and all wiring and connections to this cell circuit breaker trip circuit. DC supply wiring shall be provided from the switch to the station battery supply terminal block in Cell #4;
- This compartment shall have a terminal block from which shall be connected all non CT pilot wire relay wiring between the pilot wire relays on the front door of this compartment and the pilot wire relay terminal block in Cell #4;
- This compartment shall have a terminal block with wiring from the trip circuit of this cell circuit breaker to the terminal block, and wired to the remote transformer T1 sudden gas trip contacts and over temperature trip contacts connected to the remote alarm terminal block in Cell #4;
- This compartment shall contain auxiliary DC relays wired into the trip circuit of this cell circuit breaker and connected to the terminal block provided for incoming remote transformer T1 sudden gas and over temperature trip contacts. Wire to trip and annunciate this cell circuit breaker and wire to Cell #4 circuit breaker trip circuit to trip breaker. Wire a set of auxiliary relay contacts to the remote alarm terminal block in Cell #4 for remote alarm indication to separately indicate transformer T1 sudden gas trip and transformer over temperature trip;
- This compartment shall contain an auxiliary DC relay wired into the trip circuit of this cell circuit breaker, wired to pickup when trip is initiated by this cell protective overcurrent or pilot wire relaying. Wire a set of contacts via a terminal block in this compartment to the remote alarm terminal block in Cell #4 for remote alarm indication;
- This compartment shall contain an auxiliary DC relay wired into the SF6 low pressure alarm circuit. Wire a set of contacts to the remote alarm terminal block in Cell #4 for remote alarm indication;
- This compartment shall have a circuit breaker type 'a' contact wired from a terminal block in this cell to the remote alarm terminal strip in Cell #4.

.5    Cell #3 Lower Front Compartment

- 1 circuit breaker

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.6	<u>Cell #3 Upper Rear Compartment</u> - Termination for incoming HV cables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	<u>Cell #3 Lower Rear Compartment</u> - Incoming and outgoing HV bus and HV bus terminations for circuit breaker. Provide a grounding ball type stud on the circuit breaker load side of each phase c/w insulating boot for maintenance grounding. Where this is not possible, provide in adjoining transition cell; - 3 current transformers, relaying accuracy, 1200-5 amps, mounted on the line side of the breaker, wired to shorting type test block and overcurrent relaying on door of upper front compartment; - 3 current transformers, relaying accuracy, 1200-5 amps, mounted on the load side of the breaker, wired to shorting type test block and pilot wire relay on door of upper front compartment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	<u>Cell # 5</u> - Bus transition cell from tie breaker to load side of incoming circuit breaker feeding Bus B.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	<u>Cell #6</u> (Incoming Circuit Breaker for Bus B) - This cell shall be identical to Cell #3 with the exception of the pilot wire relay 87, which shall be a receiving relay and the transformer being T2.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	<u>Cell #4 (Tie Breaker)</u>  <u>Cell #4 Front Door of Upper Compartment</u> - 6 ammeters, for measurement of Bus "A" and Bus "B" currents (3 per bus) including CT connections to the CT test blocks on this door; - 1 voltmeter; - 1 voltmeter switch, 4 position, for measurement of line voltages; - 1 totalizing kilowatt-hour and demand meter with CT connections to the CT test blocks on this door; - 2 current transformer test and shorting type test blocks for the metering (one set for Bus A and one set for Bus B) including connections to the metering current transformers in Cell # 2 and Cell # 7; - 1 circuit breaker control switch; - 3 LED type indicating lights, red "closed," green "open" and white "fault trip";	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

C    NC    N/A

- LED type indicating light, white for low SF6 pressure where SF6 type circuit breaker is supplied;
- Push-to-test lamp test switch to test integrity of all indicating lamps on this door.

.11 Cell #4 Inside Upper Compartment

- This compartment shall contain all terminal blocks and auxiliary relays and wiring for interconnections between:
  - This cell circuit breaker control switch and LED lamps & LED test switch on front of door and this breaker close and trip and alarm circuits; and
  - Kilowatt hour and demand meter on front of door and PT deadfront fuse holders in this compartment.
- This compartment shall contain a 2 pole knife switch and deadfront DC fuse holder c/w fuses, and all wiring and connections to this cell circuit breaker control circuit. DC supply wiring shall be provided from the switch to the station battery supply terminal block in this compartment.
- This compartment shall contain a 2 pole knife switch and deadfront DC fuse holder c/w dummy fuses and all wiring and connections to this cell circuit breaker trip circuit. DC supply wiring shall be provided from the switch to the station battery supply terminal block in this compartment.
- This compartment shall contain a DC station battery supply terminal block with wiring from this block to the 2 pole knife switches in this compartment and to the upper compartment 2 pole knife switches in Cell #3 and Cell #6 for respective circuit breaker close and trip circuit supply. This terminal block shall have provision for terminating incoming 125 Volt DC supply from the remote Station Battery Supply power source.
- This compartment shall contain a pilot wire relay terminal block for termination of two incoming sets of 6 pair pilot wire cables, and connection of pilot wires to terminal blocks in Cell #3 and Cell #6.
- This compartment shall contain a PT isolating switch and deadfront fuse holder and connection to the voltmeter and voltmeter switch on the front door, and deadfront fuse holder and connection to the KW/hr and Demand meter on the front door.
- This compartment shall contain a remote alarm terminal block with connections from the auxiliary relay trip alarm contacts in Cells #3 and #6 for remote trip indication, connection provision for each transformer sudden gas and over temperature trip contacts with wiring to respective Cell #3 and Cell #6 trip circuits, connection provision for each transformer

low liquid level alarm contacts for remote alarm indication, connection provision for each transformer sudden gas alarm contacts for remote alarm indication, connection provision for each transformer high temperature winding alarm contacts for remote alarm indication, connection provision from station battery supply common alarm form 'c' contacts for remote alarm indication, connection from Cell #3, #4 and Cell #6 circuit breaker low SF6 pressure auxiliary relay alarm contacts for remote alarm indication.

- This compartment shall contain an auxiliary DC alarm relay wired into the SF6 low pressure alarm circuit. Wire a set of contacts to the remote alarm terminal block in this compartment for remote alarm indication.

.12 **Cell #4 Lower Compartment**

- 1 circuit breaker, identical to incoming circuit breakers in Cell #3 and Cell #6.

.13 **Cell #9 (Potential Transformers)**

- 1 non-fusible, load break interrupter switch.
- 2 potential transformers, each rated 14400-120 Volts, with each secondary connected 120 Volts to ground, metering accuracy, primary and secondary fusing, for supply of metering and remote Station Battery Supply requirements, and including 2 spare sets of fuses.
- All PT wiring to Cell #4:  
PT's shall be readily accessible fused drawout type and shall permit safe fuse replacement. Provide all horizontal and vertical barriers between the PT compartment and the load break switch.

**16346.11 Switchgear Control Power Source ( Station Battery Supply )**

.1 The power source shall be 120 Volt AC input, nominal 125 Volt DC output, in a free-standing, minimum #14 MSG, free standing sprinkler proof reinforced formed steel cabinet, housing batteries, charger, controls and alarms. Provide an internal transfer switch for the AC power source, suitable for switching from the preferred source (switchgear PTs) to the substation emergency AC (backup) power source in the event of failure of preferred source. Transfer switch shall be CSA approved for transfer duty. Transfer switch shall have adjustable 0-60 second transfer from preferred source to standby source and 0-60 second transfer from standby source to preferred source. Provide LED type indicating lights c/w push to test lamp test switch on front of cabinet to indicate which power source is supplying the charger. Provide a power source transfer alarm contact for connection to switchgear.

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.2	Two lifting eyes shall be provided. All interior and exterior surfaces shall factory finished white enamel interior and ANSI 61 grey exterior.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Batteries shall be mounted in the lower compartment, on welded angle iron steel supports, stepped to ensure that electrolyte levels of all cells are clearly visible. Two doors shall be provided, complete with 3 point latch and provision for padlocking.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Batteries shall be arranged for easy access and maintenance.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Station batteries shall be ventilated by an exhaust fan leading the exhaust air to the outside of the building. Exhaust under the door is not acceptable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	The battery bank shall consist of single nickel-cadmium cell units, 125 Volts DC output, to operate the closing, tripping and spring charging mechanisms of the HV switchgear circuit breakers, indicating lights and relays. Maintenance-free sealed type lead acid batteries of the same rating are acceptable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	The battery capacity shall be such that after 24 hours operation without the charger, operating two simultaneous trippings followed by two consecutive closings of all 13.8 kV circuit breakers, the output voltage shall not be lower than 105 Volts.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	The battery shall be capable of supplying the loads to an end voltage of 1.14 Volts per cell at 25°C.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	The battery containers shall be made of polypropylene, complete with flame arrester caps. Maximum and minimum electrolyte levels shall be indicated on the cell jars.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	The charger shall be self-regulating, current limited, automatic dual rate, with indicating, control and protective devices. The charger and its controls shall be such that the charging rate decreases as the battery approaches full charge and provides a trickle charge to maintain the battery at fully charged state.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	The charger shall be removable without removing the control and power harnesses.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	Provide the following: <ul style="list-style-type: none"> <li>- AC input breaker, 1 pole;</li> <li>- DC breaker for battery power output, 2 pole DC breaker for charger output;</li> <li>- DC charge rate ammeter and output voltmeter, 2% accuracy;</li> <li>- 28 day equalize timer;</li> <li>- float-equalize switch;</li> <li>- float and equalize adjustments independent of each other;</li> <li>- lockable;</li> <li>- LED type "AC on" lamp.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.13	Provide the following alarms, each with visual LED type lamp annunciation on the charger control panel: Each alarm shall be sealed in through a latching relay or equal means of seal in, with a manual reset switch (common reset switch for all alarms is acceptable). <ul style="list-style-type: none"> <li>- AC failure with a 0 to 60 second adjustable time delay on pickup;</li> <li>- High or low output voltage;</li> <li>- Rectifier failure;</li> <li>- Ground fault (5 mA sensitivity).</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.14	Provide a lamp test pushbutton and associated circuitry for testing all LED indicating lamps.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.15	Provide one common alarm form “c” contact for remote indication of all alarms, wired to a terminal block for connection of external wiring to the main switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.16	All control and power cables shall be neatly laid in conduit duct. Harnesses to the door control panel shall be neatly bundled and suitably tie wrapped, to achieve maximum reliability and enhance the overall appearance. All control and alarm cards shall be of the plug-in type.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.17	Wiring and terminal blocks shall be as specified for the switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.18	Provide the following battery accessories: <ul style="list-style-type: none"> <li>- Hydrometer;</li> <li>- Plastic filler bottle;</li> <li>- Insulated wrench;</li> <li>- Instructions, including WHMIS MSDS;</li> <li>- All necessary intercell connectors;</li> <li>- Komoline non-corrosive grease.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**16346.12 Substation and Installation Requirements**

.1	Means of egress shall be minimum two exit doors at opposite ends of the substation. The 2 exit doors must be at least three quarters (3/4) of the length of the diagonal distance of the room from each other, with one exit door exiting directly to outside the building and via a dedicated staircase where the substation is below grade. The door exiting to the exterior of the building and associated staircase shall be of sufficient height and width to enable removal of the largest piece of substation equipment. Exit doors shall be fitted with panic type hardware on the substation side and fitted with a keyed cylinder and handle on the opposite side of the door. Type of cylinder and keying, and type of panic hardware will be specified by U of T (check with lock shop). Access to Electrical room shall not be through janitor rooms or	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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		<u>C</u>	<u>NC</u>	<u>N/A</u>
	washrooms.			
.2	Ventilation for the substation shall be dedicated to the substation only. Provide filtered supply air in quantities as required by Code and taking into account the heat build up from transformer losses. Dampers shall be electrically operated with local temperature control within the substation. Fans, filters and dampers and associated controls shall be readily accessible within the substation and shall not require standing on nor leaning on or over any electrical equipment to maintain, and shall be accessible using only a step ladder. Substation ventilation shall be designed to maintain a positive pressure within the substation. Ventilation power supply and control shall be from the substation emergency supply panelboard and on-off-auto control shall be within the substation (fan starters). Provide automatic closing fire dampers for ventilation openings to the indoors of the building.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Provide dehumidification in the substation. Dehumidification shall be dedicated to the substation and all dehumidification equipment and controls shall be within the substation. Dehumidification equipment and associated controls shall be readily accessible within the substation and shall not require standing on nor leaning on or over any electrical equipment to maintain, and shall be accessible using only a step ladder. Dehumidification power supply and control shall be from the substation emergency supply panelboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Substation heating shall comply with applicable Codes and shall consist of unit heaters with integral fans, wall mounted or ceiling hung, with wall mounted control thermostat. Heaters and associated controls shall be readily accessible within the substation and shall not require standing on nor leaning on or over any electrical equipment to maintain, and shall be accessible using only a stepladder. Heaters shall be electric and shall be supplied from the substation emergency supply panelboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Provide a high temp low temp room thermostat with alarm contacts for remote alarming of high and low temp substation condition.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Adequate substation drainage shall be provided. Where the substation is sprinklered, floor drains shall be provided with capacity to prevent flooding in the substation when all sprinkler heads are operating. Each drain shall be provided with a backflow preventer. Each drain shall also be provided with self priming.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Provide housekeeping pads for all high and low voltage switchgear, station battery supply, and any other floor mounted equipment. Install switchgear manufacturer's floor channels in the switchgear concrete pads. Height of the concrete pads shall not be less than 4 inches above finished substation floor.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



		<u>C</u>	<u>NC</u>	<u>N/A</u>
.8	Provide concrete ramp in front of each high voltage switchgear circuit breaker cell sloped per switchgear manufacturer's recommendation to allow removing truck mounted circuit breaker from the cell to the substation floor. Ramps shall be painted yellow.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Provide concrete cast-in- place dyke around each liquid filled transformer in the substation, with perimeter and height of dyke sized to contain the total liquid volume of the transformer in the event of a transformer leak. Waterproofing of the contained area and dykes shall be non- conductive and compatible with the transformer liquid.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Provide a dry sump pit c/w pump, float and alarm switch connected back to CCMS. Sump pump shall be supplied by emergency power.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	The substation concrete floor and all switchgear, switchboard, station battery power supply cabinet, and other equipment concrete housekeeping pads and concrete ramps shall be completely sealed and finished with an epoxy based high wear non conductive concrete finish, minimum two coats or as otherwise recommended by the manufacturer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	The substation ceiling height shall be such as to allow for high voltage cable entry into the top of the high voltage switchgear using recommended bending radius, based on the cable being 750kcmil 3 conductor 15kV XLPE, with the horizontal run suspended 0.5 meter below the ceiling.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	Provide clearances around high and low voltage equipment as required by Code. Code requirements are minimums and in certain situations clearances should be increased. Special attention shall be paid to the following: clearance in front of the high voltage switchgear shall provide adequate clearance to permit the removal of the circuit breakers and maneuvering them to the breaker test plug facility; clearance behind the high voltage switchboard shall allow for 1 meter clearance between the wall (or other obstruction) and the widest rear cell door when that door is at the 90 degree open position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.14	Lighting for the substation shall be fluorescent, industrial type 4foot long fixtures, c/w electronic 120 Volt ballasts and 32 watt T8 or T5HO lamps. Lighting shall provide a minimum lighting level of 70 Foot-Candle at floor level in front of, to the sides of and behind all electrical equipment. Placement of lighting fixtures shall allow easy access for lamp replacement, accessible only by stepladder and not requiring standing on nor leaning on or over electrical equipment. One half of the substation lighting shall be on normal building supply and one half supplied from the substation emergency supply panelboard. Lighting shall be controlled from illuminated light switches located on the substation latch side of the exit doors. Lighting in the substation dedicated staircase where staircase is required shall be supplied from the substation emergency supply panelboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.15	Wall mounted battery operated self contained emergency lighting units of the battery rechargeable type shall be provided and plugged into emergency receptacles supplied from the substation emergency supply panelboard. Provide the required number of lighting units to illuminate all aisle ways and exits and dedicated staircase to exterior of building in the event of a power failure.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.16	Illuminated LED type exit signs shall be installed over exit doors and shall be supplied from the substation emergency supply panelboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.17	Provide duplex receptacle outlets around the perimeter of the substation spaced as required by Code but in no case more than 12 feet apart. Outlets shall be mounted in type FS outlet boxes with matching steel cover plates. One half of the total outlets shall be supplied from the substation normal supply panelboard and one half from the substation emergency supply panelboard. Outlets shall be circuited such that a minimum of two circuits supply all outlets and no two adjacent outlets are on the same circuit. Receptacles supplied from emergency power source shall be red.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.18	Provide a substation normal supply panelboard rated 120/208 Volt ac, 3 phase, 4 wires, with copper mains rated as required but no less than 100 Amps. Panelboard shall be supplied from the building main low voltage switchboard. Panelboard shall be surface mounting type, sprinkler proof construction, c/w main bolt- on circuit breaker and bolt-on branch circuit breakers sized as required to supply the substation non-emergency lighting and receptacles.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.19	<p>Provide a substation emergency supply panelboard rated 120/208 Volt ac, 3 ph, 4 wires, with copper mains rated as required but no less than 100 Amps. Panelboard shall be supplied from the building emergency generator main emergency supply distribution panelboard. Panelboard shall be surface mounting type, sprinkler proof construction, c/w main bolt- on circuit breaker and bolt-on branch circuit breakers sized as required to supply the following:</p> <ul style="list-style-type: none"> <li>-Substation Battery Power Supply for switchgear</li> <li>-Substation ventilation</li> <li>-Substation heating</li> <li>-Substation lighting (minimum 2 circuits)</li> <li>-Substation battery emergency lighting units receptacles</li> <li>-Substation exit lighting</li> <li>-Substation perimeter receptacles (minimum 2 circuits)</li> <li>-13.8 kV Circuit Breaker Test Plug</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.20	All low voltage conduit and wiring in the substation shall comply with the U of T requirements for same. Special attention shall be made to the termination of conduits entering the tops of sprinkler proof equipment so as to not defeat the sprinkler proofing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.21	Provide non ferrous cable tray for the support of all HV cables in the substation and ground as required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.22	Provide cable pulling eyes cast into the walls of the substation for pulling incoming HV cables into the substation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.23	Provide substation perimeter copper bus grounding system and all high and low voltage equipment grounding to same as required by the Ontario Electrical Safety Code.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.24	Provide all conduit and wiring from the transformer control panels and station battery supply cabinet to Cell #4 in the high voltage switchgear for termination of all alarm and trip wiring on to remote alarm terminal block in upper compartment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.25	Provide all conduit and remote alarm wiring from the remote alarm terminal strip in the HV switchgear Cell #4 upper compartment to a U of T supplied Remote Alarm Control Panel mounted on the wall next to the HV switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.26	Provide all conduits and alarm wiring from the dry sump float alarm contact to a U of T supplied Remote Alarm Control Panel.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.27	Provide all conduits and wiring from the substation alarm high temp low temp thermostat to the U of T supplied Remote Alarm Control Panel.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.28	Install the 13.8 kV circuit breaker test plug on a wall near the HV switchgear and with sufficient and level floor area for moving around and testing the circuit breaker. The test plug shall be wired to the substation emergency supply panelboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.29	Provide a substation combined single line diagram and substation equipment block diagram for the substation. Size of the diagram shall be minimum Size D and shall be installed under non glare glass with UV inhibitor, and framed in wood. The framed diagram shall be securely fastened to a wall of the substation near the HV switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.30	Set and secure all equipment in place on the housekeeping pads or floor where pads are not required, plumb and square. Connect all equipment at the shipping splits, using the manufacturer's hardware and torque to the manufacturer's recommendations. Ensure all sprinkler proofing is in place and properly installed. No foreign pipes shall be allowed to pass through the substation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.31	After installation and levelling, all switchgear, switchboards and other equipment shall be caulked to prevent bottom entry of vermin.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.32	Install a minimum 1" thick plywood backboard on a wall close to the HV switchgear for mounting all tools necessary for the safe maintenance and testing of the HV switchgear. Board shall be primed and painted with minimum two coats of high quality enamel paint, grey.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.33	Check factory-made connections for mechanical security, electrical continuity and current phasing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.34	After finishing work, remove foreign material, including dust, and thoroughly clean the switch gear before energizing equipment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.35	Electrical room space shall not be shared with communication equipment, such as telephone, data, server, router or hub. Provide separate room for communication equipment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.36	Door sweeps shall be installed on the bottom of all HV Substation and electrical rooms.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
16346.13	<b>Testing</b>			
.1	After installation is complete, but prior to energizing, test all mechanical and electrical components for proper operation and function in accordance with the manufacturer's recommendations, including but not limited to the following:			
.1	Perform resistance measurements on bus, phase-to-phase and phase-to-ground with all switches and breakers in the normal operating position, with the contacts open.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Measure control circuit insulation resistance to ground.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Employ the service of an independent testing company to inspect all protective relays and overcurrent devices, and verify or reset the settings to comply with the coordination study.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Inspect all current transformers and relays for correct polarity connections and installation of jumpers in unused current transformer circuits.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Make logic check of the controls and interlocks, simulating operating and fault conditions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Check that all ground connections have been securely made.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Manually close and trip each breaker and close and open each load break switch and adjust main contact alignment and wiping action in accordance with the manufacturer's instructions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16426 **Low Voltage Distribution System Equipment (600 Volts Maximum)**

16426.1 **Main Switchboard**

.1	The main switchboard shall be a complete, metal enclosed, factory assembly, tested and shipped ready for installation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	The switchboard shall comply with the applicable standards of CSA, ANSI, EEMAC and NEMA.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	The voltage, current and short circuit rating of the switchboard shall be discussed with the U of T Project Manager.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Provide Arc Flash calculations and Arc Flash warning labels on switchboard front panel.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	The switchboard shall be of the size and number of sections indicated, and shall not exceed the dimensions shown on the drawings or specified.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.6	The entire switchboard shall be shipped in one section unless written approval is given by the U of T Project Manager. Field connections of bus work shall be limited to reconnection of these sections with factory predrilled and prefabricated components.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16426.2 Construction</b>				
.1	The enclosure shall be sprinkler proof, made up of steel frames bolted and welded together to form a rigid, free-standing, dead front structure. All sections shall be of uniform dimension and appearance.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Front panels or doors shall be formed type, fabricated from cold rolled sheet steel and supported by concealed hinges. Flat, bolt-on panels shall be supplied on the top and on the sides. Hinged doors shall be provided at the rear of the assembly.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Each cubicle shall be divided vertically into two sections. The front section shall be further divided by sheet steel barriers into compartments containing instrument transformers, circuit breakers, fused switches and other equipment. The rear section shall include buses and provision for connecting external wiring entering from the top or bottom as required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Circuit breaker compartments shall be equipped with primary and secondary disconnecting contacts, breaker mounting pan complete with integral rails, instrument transformers, stationary disconnecting mechanism parts and a mechanical interlock which prevents moving the removable unit into or out of the connected position while the circuit breaker is closed.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Compartments for future breakers shall be complete with bus connections, disconnecting contacts and supporting rails, ready for the insertion of a breaker and with insulating covers for the disconnecting contacts.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	The structure shall be mounted on a channel base supplied by the manufacturer. The structure shall be suitable for lifting from a truck and being rolled and jacked into position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Hardware shall be steel with non-corroding plating.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	The switchboard shall be factory finished white enamel interior, ANSI 61 grey exterior.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Provision shall be made for cables and/or bus ducts entering the top of the switchgear.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16426.3 Buses</b>				
.1	Buses shall be high strength, high conductivity, tin plated copper. Provision shall be made for extending the buses to future cubicles at each end of the switchboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.2	Buses and connections shall be designed so that the maximum temperature rise of any part will not exceed 65°C in an ambient temperature of 40°C.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Buses shall be joined together with a minimum of two bolted connections. Bus joint hardware shall be non-corroding.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	A continuous copper ground bus shall be run near the bottom, the full length of the switchboard. The metal frames of all components shall be connected to the ground bus. Provide a lug for connecting to the external ground conductors at each end of the bus.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	The momentary rating of the ground bus shall be equal to or greater than that of the apparatus in the assembly. The minimum size shall be 7 mm x 50 mm.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Provide bus transition sections where required, with bolted access panels.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16426.4 **Circuit Breakers**

.1	Air circuit breakers shall be 3 pole, single-throw, 60 Hz, quick make, quick break, trip free, electrically-operated, spring-closed, stored energy type, complete with three adjustable solid state series overcurrent tripping devices, arc chutes, position indicator and mechanical trip button.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Breakers shall be equipped with a grounding device to solidly ground the framework before the main disconnecting contacts are engaged and to maintain the grounding until after the contacts have separated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Breakers shall be capable of withdrawal from the "connected" to the "test" and "disconnected" positions with the cubicle door closed. Each breaker shall be equipped with a position indicator, mechanically connected to the circuit breaker mechanism. Interlocks shall be provided to prevent moving a closed breaker into or out of the "connected" position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Circuit interrupting devices shall have high interrupting efficiency and shall minimize the formation of arc flame and gases.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Breakers shall have ground fault interrupting devices.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Circuit breakers shall give visual indication of the reason for tripping. Trip indicators shall be maintained type which remain in position until manually reset and which operate without an external power supply.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	The air circuit breakers shall have silver-tungsten, butt type contacts which operate under high pressure. The arcing contacts shall be of arc-resisting silver-tungsten. The breaker shall be equipped with arc chutes which effectively enclose the arcing contacts and confine the arc to reduce the disturbance caused by short circuit interruption.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.8	The removable element shall consist of an air circuit breaker equipped with the necessary disconnecting contacts, wheels and interlocks for drawout application.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	The closing springs shall be capable of being charged manually by means of an emergency handle. The release of the energy to close the breaker manually shall be by means of a mechanical pushbutton which ensures positive control of the closing operation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Breakers shall have a solid state overcurrent tripping system, consisting of one current sensor per pole, one solid state trip unit and one trip actuator operating on the flux transfer principle. The trip unit shall have continuously adjustable long delay current pick-up, long delay time, short delay current pick-up, short delay time and instantaneous pick-up. Breakers shall be equipped with a ground current pick-up, set at the factory, at a level determined by the coordination study.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	Main breakers shall have ground fault protective equipment, including ground fault sensors, current monitors, relays and devices for a complete ground fault protection system. Main incoming circuit breakers and tie circuit breaker shall be equipped with shunt trip to allow for remote connection to a remote trip contact.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	All necessary tripping energy shall be derived from the load current and no separate power supply shall be required. All tripping functions on each breaker must be performed by one secondary control circuitry, with no mechanical or direct magnetic action between the primary current and the mechanical tripping parts of the breaker. Mechanical tripping of the breaker shall be made by an actuator which will operate the mechanical tripping mechanism of the breaker when a tripping pulse is emitted by the trip unit. When the trip unit does not have an instantaneous element, it shall include a discriminator feature to permit instantaneous tripping only when the breaker is being closed. Breaker trips shall be completely self-powered with no external control power source required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	Each trip unit shall have a terminal block equipped with test plug terminals accessible at the front to permit convenient field checking and calibrations. The tripping current range shall be established by the sensor rating rather than by the trip unit. Necessary tripping energy shall be produced by current sensors installed on each phase which shall produce an output proportional to the load current, so the breaker continuous current rating for any frame size can be changed simply by changing the sensors. Sensors shall be installed on the load side of the breakers and must remain with the breaker when it is withdrawn.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.14	All breakers of the same frame size shall be interchangeable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



		<u>C</u>	<u>NC</u>	<u>N/A</u>
16426.5	<b>CDP Panel Sections</b>			
.1	The ends of the low voltage switchboard shall be provided with a distribution panel section. The voltage, current rating and short circuit rating shall be discussed with the U of T Project Manager.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Provide circuit breakers with current limiting fuses if necessary to meet the short circuit rating.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	The panel shall be double row, with maximum number of spaces that height permits, based on the section being the same height as the switchboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	The panel sections shall have hinged lockable doors and hinged front cover plates to permit inspection by thermal scanning. A directory card holder shall be welded to the back of the door and be complete with card and clear plastic cover with typed directory.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Lamacoid nameplates shall be installed next to each circuit breaker, minimum 6mm high white letters on black background secured with stainless steel screws, identifying the load supplied.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16426.6 **Metering**

.1	Provide sub metering for areas such as food services, tenants, chillers or lab's with high usage equipment where it would be desirable to separate from the rest of the building. Discuss the requirements with U of T Project Manager.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Provide all necessary current and potential transformers for the Owner's metering and alarms requirements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Potential transformers shall be primary fused and fuses shall be HRC type, readily accessible. P.T. secondary shall be 120 V.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Current transformers shall have revenue grade (0.3%) metering accuracy and shall be provided with dead front shorting type test blocks. Current transformer secondary shall be 5 Amp. CTs shall be bar type or solid core donut type, split core is not acceptable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Provide switchboard digital metering of the integrated microprocessor based type, true RMS measurement for the display of the following: Energy – kWh, kVARh, kVAh; Demand – kW, kVAR, kVA; Voltage – Phase voltage, Line voltage; Current – Phase current, Line current; Frequency; Power factor; Harmonics – THD for voltages and current.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

For demand (kW, kVAR, kVA), voltage, current, frequency, power factor, and harmonics contents, provide instantaneous, maximum and minimum values for each phase and totals for all phases. Show imbalance for voltages and currents. Readings for

		<u>C</u>	<u>NC</u>	<u>N/A</u>
	each of these parameters shall be separately resettable. For energy contents (kWH, kVARH, kVAH) provide accumulated totals for all phases. The readings for energy parameters shall be non-resettable.			
.6	Digital metering shall continuously monitor and store the readings in a non-volatile memory. Should a power interruption to the switchboard occur, the last readings shall be available for display once power is restored.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Digital meters should be backlit LCD type or LED type, suitable for displaying the maximum number of characters required including floating decimal point. Character sizes should be minimum 3/8 inch high with proportional width to provide easy readability.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Reading refresh rate for the digital meter shall be once per second (or faster).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	Digital metering accuracy shall be $\pm 0.5\%$ of full range or better, preferably Measurements Canada Revenue approved type.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Digital meters and associated switches shall be flush mounted on the front of the switchboard or in a metering cabinet mounted on the wall with proper identification.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Where the switchboard is divided into Bus "A" and Bus "B" sections separated by a normally open tie circuit breaker, provide a separate digital meter for each bus.			
.11	Digital meters shall be capable of remote communication, interface via Modbus TCP/IP protocols, through serial or Ethernet communications.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	Digital meters shall be powered from a separate power supply or control power transformer and shall not be powered from the metering PTs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16426.7 **External Connections**

.1	Provide bus extensions and bus duct flanges as required, completely coordinated to the incoming bus duct feeders. Provide bus transition section where required with bolted access panels.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Bus ducts shall be copper, of current rating and voltage as required and in sprinkler-proof enclosure, complete with all required elbows, terminations, fittings and accessories.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	The switchgear manufacturer shall be responsible for proper coordination of the bus duct at the switchgear and transformer ends.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Bus terminations shall be accessible for inspection.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Provide clamp type terminal blocks complete with marking strips for all interconnecting and outgoing small wiring. Terminal blocks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
	shall be accessible for inspection and testing.			
.6	Identify terminals and conductor ends by means of suitable markers, to agree with the wiring diagrams.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Control wiring shall be type TEW thermoplastic equipment wire.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Control wiring shall be run not closer than 150 mm from the bottom of the switchboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16426.8 Accessories</b>				
.1	Nameplates shall be engraved lamacoid, with white letters on a black background, fastened with stainless steel screws.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Nameplates for main and tie breakers, section and cell identification and for the entire switchboard shall have letters not smaller than 13 mm high. Nameplates for branch breakers, switches, pushbuttons, control devices, pilot lights and metering shall have letters 6mm high.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Warning signs on doors and access panels shall be engraved lamacoid with white letters on a red background, fastened with stainless steel screws.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Pen size for all lettering shall be 1mm (minimum).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Control contacts, auxiliary contacts, relays and small or light mechanisms shall be enclosed and protected, and shall be accessible for repair or adjustment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Furnish the following accessories: <ul style="list-style-type: none"> <li>- set of extension rails;</li> <li>- hoisting device for removing breakers;</li> <li>- breaker lifting yokes;</li> <li>- 1 test plug for each test block;</li> <li>- levering out device, if required;</li> <li>- 2 sets of special tools and hardware, for maintenance, removal and handling.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**16461 Dry Type Transformers**

**16461.1 4.16 kV and 13.8 kV Dry Type Power Transformers (Indoor use only)**

.1	Transformers shall be power type ANN/ANF indoor, air cooled, dry type with continuous ANN capacity as specified. Transformers shall comply with the latest requirements of ANSI-C57.12.01 and CSA C9.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Transformer enclosures shall be NEMA 2-S, sprinkler proof construction.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Transformer windings shall be copper.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.4	Transformers shall be three phase with Delta primary and Wye secondary, with the wye solidly grounded.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	The insulation shall be Class H, 220 °C, with maximum temperature rise 150°C over 40°C ambient at ANN rating.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	The transformers shall have four 2.5 % full capacity primary taps, two above and two below normal voltage. Provide off load tap changing capability.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	The transformers shall be high efficiency, low impedance type.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	The maximum sound level at ANN rating shall be 68 db for transformers rated up to 3,000 kVA.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	The transformers shall have B.I.L. rating as required for the voltage class, minimum 60 kV for 4.16 kV and minimum 95kV for 13.8 kV.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	The transformers shall be equipped with fans to increase the ANN rating by 33%.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	A sprinkler proof control panel for the transformer forced air cooling supply and control, transformer local audible and visual alarms and auxiliary relays for local and remote trip and alarms, shall be mounted on the exterior of the transformer enclosure. Control panel shall have a hinged access door. Visual alarms shall be LED type annunciation lamps, one per individual alarm, and shall be located on the front door of the control panel. Audible alarm shall be minimum 4" horn mounted on the front of the control panel door, with provision for remote audible alarm.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	The control panel power supply shall be wired from the secondary of the power transformer and shall include necessary transformation to 120 Vac. The control panel shall incorporate main fusing and wiring sized for fan supply requirements, fused control transformer and fans contactor and associated on-off- auto control switch, local and remote alarm horn, and auxiliary relays as required for local and remote alarm requirements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	The control panel shall include all wiring to the transformer winding temperature thermometer which shall have 3 sets of contacts: 1) fan cooling; 2) high temp alarm; 3) high temp trip. Fan cooling contacts shall initiate fan start-up, high temperature alarm shall initiate local and remote audible alarm and auxiliary relay in control panel for remote alarm, with form 'c' set of contacts terminated on a terminal block. High temp trip contact wiring shall terminate on terminal strip in control panel. All alarm relays in the control panel shall be seal-in and an alarm horn silencing switch with ring back feature together with an alarm manual reset switch located in the control panel shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.14	A dial type winding temperature 3 stage thermometer having 3 sets of contacts (fan cooling, high temp alarm, high temp trip) shall be	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
	mounted on exterior of transformer enclosure. Dial thermometer shall have maximum temperature indicator with manual reset.			
.15	All wiring shall be provided between the transformer control panel and transformer cooling fans.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.16	Primary terminations shall match type and arrangement of incoming power connections. Potheads, where required, shall be part of transformer. Provide grounding stirrup with sufficient clearance at primary terminations.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.17	Secondary terminations shall match type and arrangement of outgoing bus ducts or cables.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.18	Adequately size junction or throat to accommodate phase connections.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.19	The neutral bushing shall be brought out into junction box and grounded.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.20	Transformers having hinged access doors to the HV compartment shall have Kirk key interlock to prevent access unless the respective load break switch in the high voltage switchgear is in the open position. Co-ordinate keying with the switchgear manufacturer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.21	The transformer enclosure shall be factory finished ANSI 61 grey.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.22	Certified test report on the transformer, including temperature, sound level, impulse, impedance regulation, winding loss, core loss, excitation, turns-ratio and polarity, shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.23	Prior to energizing or commissioning the transformer, it shall be fully inspected, tested, checked and adjusted and the following verified: – Grounding; – Ratio; – Polarity; – Insulation Resistance.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.24	Transformer name plates shall be installed in accessible locations.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16461.2 **Dry Type Transformers – Low Voltage**

.1	Transformers shall comply with the latest requirements of ANSI-C57.12.01 and CSA C9.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Transformers shall be of the indoor, air cooled, dry type of the size, rating and capacities to suit.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Transformers shall have sprinkler proof enclosures.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	All windings and terminations shall be copper.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Transformers shall be of the 1.2 kV Class, standard B.I.L. Insulation shall be Class H, 220°C, with maximum temperature	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
	rise 150°C over 40°C ambient.			
.6	Transformers shall have 4 primary 2.5% full capacity taps, 2 above and 2 below normal, with wires brought out to tap board. Provide tap changing board with links.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Ample ventilation openings at top, bottom, front and sides shall be provided, but these shall be shielded to prevent access to the live parts.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Transformers shall be equipped as required with eye bolts, braces, etc. to enable them to be wall mounted, floor mounted or suspended. Transformers rated larger than 75 kVA shall be floor mounted.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	External, anti-vibration isolation mountings shall be supplied and installed for all transformers, on minimum 4" high housekeeping pads.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Transformers shall be factory finished ANSI 61 grey.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	Transformers shall be Harmonic Cancellation type.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	Transformer losses and high efficiency shall comply with ASHRAE/IES 90.1-1989.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.13	All K13 transformers should be replaced with the harmonic cancellation transformers as follows: <ul style="list-style-type: none"> <li>- Harmonic cancellation transformers (kVA as indicated, Phase shift to be determined with the manufacturer, Voltage as indicated, 60Hz, 45dB, 200% rated neutral);</li> <li>- Performance Validation – Independent performance validation by us Department of Energy Test Lab for harmonic performance and energy efficiency is mandatory;</li> <li>- Energy Savings – Transformer must bear the Energy Star and Environmental Choice logos. Minimum efficiency shall be 98%;</li> <li>- Load Compatibility- K-20 load profile, crest factor of 5, without derating;</li> <li>- Insulation Class – Class ‘R’ (Class ‘H’ is not acceptable);</li> <li>- Operation Temperature Rise: 130°C;</li> <li>- Electrostatic Shield – Each winding is independently single shielded with full-width copper electrostatic shield;</li> <li>- Construction Standards – NEMA St-20 and TP-1, appropriate UL, CSA, and ANSI/IEEE standards;</li> <li>- Windings and Terminals – Copper;</li> <li>- Taps – four 2.5% taps, 2 above and 2 below nominal;</li> <li>- Zero sequence data – 95% ZS impedance, 0.3% ZS</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

reactance;

- Secondary Windings – Wound to cancel zero sequence current flux. These currents shall not be coupled into the primary windings of the transformer;
- Enclosure – E3R (Sprinkler proof enclosure) complete with anti-vibration pads. Floor mounted enclosure to be completed with 4” high housekeeping pads.

.14 Transformer name plates shall be installed in accessible locations.           

16470 **Panelboards**

16470.1 **Lighting and Receptacle Panelboards**

- |    |   |                          |                          |                          |
|----|---|--------------------------|--------------------------|--------------------------|
| .1 | Panelboards shall conform to CSA requirements.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .2 | Panelboards shall be factory assembled sprinkler proof type if in sprinkler area, dead front type, enclosed in Code gauge steel equipped with door having concealed hinges, lock and panelboard directory, and shall be suitable for surface or flush mounting as required. Panelboards shall be keyed alike and each panelboard shall be provided with two keys.   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .3 | Panelboard bus shall be copper and shall extend the full length of the panel. Neutral bus shall be rated 200% of main bus rating  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .4 | Circuit breakers shall be ambient compensated type, calibrated at 40°C and be of the bolt-on type, without any plug-in connections. Multi-pole breakers shall have common trip. Circuit breakers for 120/208 Volt application shall have a minimum symmetrical interrupting rating of 10,000 Amps. For 600 Volt applications, the rating shall be minimum 35,000 Amps. All interrupting ratings shall exceed available fault level as determined by coordination studies. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .5 | Tandem double density circuit breakers are not acceptable.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .6 | Panelboards, including tubs, shall be factory finished ANSI 61 grey. Emergency power panelboards shall be green.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .7 | Panelboards shall be of the same manufacturer as the switchboard.   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| .8 | Panelboards are to be mounted so that the top of the panels are 6'-6" (2m) above finished floor.  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.9	Panelboards shall be identified as LP (lighting) or RP (receptacle) or E (emergency) followed by the designation letter, voltage and current rating, and the designation of the source of power supplying the panelboard. Example: "LP3A1 120/208V 225A 3PH 4W Fed from Main Switchboard". Panelboard identification shall be on engraved lamacoid plate, white letters ½" high on black background for normal power panels, white letters on green background for emergency supply panelboards. Lamacoid plates shall be fastened to the outside of the panelboard with stainless steel screws. Pen size for lettering shall be 1 mm minimum.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Panelboard directories shall be typewritten. Directories shall indicate the final room numbers as designated by Office of Space Management (OSM).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	Provide two 1" empty conduits from each flush mounted panelboard to the ceiling spaces above and below for future installation of wiring. The conduits shall terminate in junction boxes with fish wires.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.12	Provide filler plates on all blank breaker space.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16470.2 **Power Panelboards**

.1	Panel boards shall conform to CSA requirements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Panel boards shall be factory assembled sprinkler proof type if in sprinkler area, dead front type, enclosed in Code gauge steel equipped with door having concealed hinges, lock and panel board directory, and shall be suitable for surface or flush mounting as required. Panel boards shall be keyed alike and each panel board shall be provided with two keys.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Panel boards shall be of the "CDP" type with the sizes and type of breakers as specified.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Circuit breakers shall be ambient compensated type, calibrated at 40°C and be of the bolt-on type, without any plug-in connections. Multi-pole breakers shall have common trip. Circuit breakers for 120/208 Volt application shall have a minimum symmetrical interrupting rating of 10,000 Amps. For 600 Volt applications, the rating shall be minimum 35,000 Amps. All interrupting ratings shall exceed available fault level as determined by coordination studies.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Splitter troughs incorporated in the panelboard shall be complete with copper bus bars the length of the trough.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Panelboard bus shall be copper and shall extend the full length of the panelboard. Neutral bus shall be rated 200% of main bus rating.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Panelboards shall be provided with non-ferrous plates for single conductor entry as required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



		<u>C</u>	<u>NC</u>	<u>N/A</u>
.8	Panelboards shall be of the same manufacturer as the main switchboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	No plug-in connections of any type are acceptable within a panelboard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Panelboards, including tubs, shall be factory finished ANSI 61 grey. Emergency power panelboards shall be green.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.11	Panelboard directories shall be typewritten. Directories shall indicate the final room numbers as designated by Office of Space Management (OSM).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16482 **Motor Starters and Motor Control Centres**

- Refer to Division 15 – Mechanical Services.

16510 **Lights**

16510.1 **Lighting Levels**

.1	Rooms where reading and writing is the major activity, such as tutorial rooms, offices, lecture halls, libraries and laboratories, the illumination level shall be 50 to 75 foot candles luminance at the performed task. Some rooms, such as laser rooms and computer terminal rooms, may require less illumination level than an office. The designer shall propose the illumination level to the U of T Project Manager for approval.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Common areas, corridors, stairways, washrooms, elevators, lobbies, lecture rooms, the illumination level shall be 10 to 20 foot candles as a general lighting standard throughout the space.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Bulletin boards mounted in corridors could be “spot lighted” for improved visibility.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Sports facilities need to be specifically designed and provided for according to their use, and will not fall under this general lighting standard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Residences are a very subjective issue. They should also be specifically designed and provided for according to room function and tenant comfort. Their corridors, washrooms and stairways, though, should comply with the general lighting guidelines above.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16510.2 **Lighting Controls**

.1	All lighting systems, except those required for emergency or exit lighting, shall be provided with manual, automatic, and/or programmable controls. (E.g. motion sensors in large area).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	The washrooms shall not have switches at the door where people may switch the lights off and create an unsafe condition for others.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
	These areas must be controlled by keyed switches. Key switches shall be provided to control lighting fixtures in isolated exit door areas. The light shall be located both in the interior area and also on the exterior of the exit.			
.3	Electronic classrooms shall be controlled by manual switches only, DO NOT USE touch screen switches.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Programmable lighting control system may be used as part of a Building Automation System or an independent control system for the purpose of energy savings. The system shall be simple and user friendly, and have manual override or bypass feature. Submit proposal to the U of T Project Manager for approval. Provide all necessary equipment, accessories, manual, as-built documents, settings and passwords as required for the normal operation and adjustment of the system.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 16510.3 Lighting Fixtures

.1	<u>Lamps:</u> Fluorescent lamps: 4 ft., 32 watt, "T8" 3500 °K, or as otherwise specified. T5 lamps are acceptable.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	H.I.D. lamps: Induction lamp or LED, 4100 °K.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	<u>Ballasts:</u> Indoor installations: Energy efficient electronic ballast for fluorescent lamp. Induction or LED lamps in high bay areas. Ballasts shall be instant start.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<u>Outdoor installations:</u> Energy efficient lamps suitable for -30°C cold weather fluorescent lamp, induction lamps, or LED.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<u>H.I.D. lamp's ballast:</u> Energy efficient ballasts shall be located in accessible position.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Exit Lights: LED type, long life, 120V, 4W HPF surge protected. Photoluminescent EXIT signs may be accepted in well illuminated areas. Submit proposal to U of T Project Manager for approval.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Emergency Lighting = 12V; maintenance free, sealed lead battery; having a design life of 10 years and remote test feature. Emergency light fixtures that are fed from building emergency supply shall be identified with permanent markings with red dot or "E" on the end of the fixture.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	PL pot light fixtures shall be complete with <u>vertical</u> lamp.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Light bulbs shall be specified to have a "natural" colour (metal halides, fluorescent etc).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Pot lights with specular clear or gold reflectors shall not be used in	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
	classrooms as they reflect the light and are very distracting especially in front of a classroom. Pot lights with black coilex baffles shall be used.			
.8	Chalkboards lighting shall be provided in classrooms.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.9	A task light shall be provided at podiums. The type of task light used must be standardized so that it will be easier to stock and replace parts and bulbs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.10	Lights along the stairs in lecture theatres shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16510.4 **Lamp Standards**

.1	<u>Lamp fixtures:</u>			
.1	Lamps shall be energy efficient induction or LED, 4100°K white suitable for -30°C cold weather outdoor installation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Ballasts shall be energy efficient and high power factor (0.9 or higher) electronic ballasts, located in accessible positions with easy disconnect plugs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Shape of light fixtures shall be such that no bird can stand on it nor build a nest around it.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Globes shall be made of one-piece seamless injected-molded satin clear and UV resistant material.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Provide easy access mechanism, such as hinges on hood with stoppers and captive screws, for access to the lamp, ballast and reflector. Provide good quality gasket to ensure weatherproofing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	<u>Poles:</u>			
.1	Height of lamp poles shall be 12 feet (3.658 metres) above ground level.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Pole shafts shall be minimum 4 inches (100mm) in outside diameter.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Pole shafts shall be made from round extruded aluminium tubing, welded to the pole base.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Colour of poles shall be black mat.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Pole finishes shall be highly durable UV and salt spray resistant, humidity proof and with anti-graffiti non-stick coating.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Provide a minimum 2 inches X 4.5 inches (51mm X 114mm) maintenance opening centred 20 inches (508mm) from ground level, complete with weatherproof aluminium cover and a copper ground lug on each pole.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.7	Provide identification tag with 2 inches high reflective white numbering on black background mounted on each pole at 10 feet (3 metres) above ground level.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	<u>Bases:</u>			
.1	Pole bases shall be hinged on one side.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Provide 2-piece base cover made from cast aluminium, mechanically fastened with stainless steel screws.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	All exposed screws shall be stainless steel.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16613 **Diesel Generator Set**

16613.1 **General**

.1	Diesel generator set shall be rated as specified at 0.8 power factor for continuous prime power duty with 10% continuous overload capacity at 0.8 power factor.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	New and retrofit installations of diesel generator set shall comply with Ministry of Environment requirements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Diesel engine shall be full compression ignition type, four stroke single acting, for No. 2 diesel oil fuel injection with all accessories as required to comply with the specified functions and performances.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Engine speed at normal full load operation shall not exceed 1800 RPM.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Engine Governor capable of maintaining the engine speed within 3% of the rated frequency from no load to full load generator output. The frequency at any constant load, including no load, shall remain within a steady state band width of 0.25% of rated frequency.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Fusible fire shutoff valve to be installed in fuel supply line to the main tank and day tank.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Drip pan to be installed under the diesel engine.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Natural gas fired generators to be considered for non-life safety equipment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16613.2 **Diesel Engine Starting System**

.1	The engine shall be provided with a 24 Volt electric starting system of sufficient capacity to crank the engine at a speed which will allow full diesel starting of the engine.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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		<u>C</u>	<u>NC</u>	<u>N/A</u>
.2	Maintenance-free sealed type lead acid battery shall be furnished, having sufficient capacity for cranking the engine for at least 60 seconds at firing speed in the ambient temperature of 10°C, consisting of at least six 10 second cranking attempts, with battery and voltage not less than 80% rated voltage.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Engine coolant heater: 120°F to 140°F (50° to 60°C), with auto cut-out on engine start.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16613.3 Engine Instruments</b>				
.1	An engine or generator-mounted instrument panel shall contain the following gauges for proper engine surveillance and maintenance: <ul style="list-style-type: none"> <li>- Engine water temperature;</li> <li>- Engine lube oil pressure;</li> <li>- Engine lube oil temperature;</li> <li>- Engine running hour meter;</li> <li>- Battery charging indicator;</li> <li>- Engine fault indicators for oil pressure, water temperature, and engine speed.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16613.4 Exhaust System</b>				
.1	A suitable silencer, of the hospital grade, shall be furnished with the engine.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	A flexible, continuous, bellows type, stainless steel interlocking joints exhaust pipe, at least 24 inches long, shall be furnished for each engine exhaust outlet. The pipe outlet connections shall be compatible with standard ASA-125 lb. Pipe flange.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	The exhaust pipe shall be terminated at the highest point of and above and away from supply/exhaust systems. Provide rain guard on exhaust pipe. Muffler shall be insulated and shall have drain line extended to the floor drain of the diesel generator room.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16613.5 Safety Controls</b>				
.1	The engine shall be equipped with automatic safety controls which will shut down the engine in the event of low lubricating oil pressure, high jacket water temperature, engine over speed, engine over-crank, and electrical contacts for alarm lights on the alarm panel. In addition, pre-alarm signals for high water temperature, over speed and low oil pressure shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
<b>16613.6 Generator Set Performance</b>				
.1	The voltage regulation from no load to rated load shall be within a band of 1% of rated voltage. The steady state voltage stability shall remain within a 0.5% band of rated voltage. Steady state voltage modulation shall not exceed one cycle per second.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	The voltage dip shall not exceed 20% of the rated voltage for any addition of load up to and including 90% of the rated load.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16613.7 Engine Panel</b>				
.1	Provide a wall-mounted or free standing panelboard having a hinged door and lockable door handle.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	The following equipment shall be mounted on the upper portion of door at eye level: <ul style="list-style-type: none"> <li>- 3 thermal demand and indicating ammeters, flush mounted on door;</li> <li>- 1 voltmeter and voltmeter switch;</li> <li>- 1 frequency meter;</li> <li>- Engine alarms, including a common horn and indicating light for each of the following functions: <ul style="list-style-type: none"> <li>- Engine water temperature;</li> <li>- Engine lube oil pressure;</li> <li>- Engine overspend;</li> <li>- Engine over crank;</li> <li>- Fuel supply;</li> <li>- Battery charger;</li> <li>- Alarm lamp test feature.</li> </ul> </li> <li>- Synchronization to be discussed with U of T Project Manager and shall be provided or have provision for adding in the future.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Provide all control logic, sequence of events, settings and passwords.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>16613.8 Testing of Diesel Generator(s) (Factory Testing)</b>				
.1	Before shipment, the complete generating plant(s) shall be tested at the factory under actual load conditions for performance and proper functioning of component parts. The Owner's representative shall have the right to witness such tests. Provide 14 days notice of test date. The consultant will ensure that the contractor carries out the following: <ul style="list-style-type: none"> <li>.1 Provide an artificial load as required to test engine(s) at 100% and 110% of full kilowatt resistive load.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
.2	Perform the following tests to include the diesel engine, generator and subsystems:			
.1	Verification that all set components are correctly installed and interconnected.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Verification that all subsystems are complete and operate according to design criteria.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Verification of voltage drop on assumption of load under the specified (simulated) conditions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Individual testing of each protective device and verification of the accuracy of control set points.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.5	Operate the diesel engine(s) from 0 to 100% simulated load, starting at no load and increasing in increments of 25%. Check at each load point stable operation, fuel consumption and engine performance.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.6	Operate diesel generating set(s) at 110% load for one hour or longer as required until engine temperature stabilizes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.7	Provide a photograph of an oscilloscope trace of the generator output 60 cycle sine wave.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.8	Submit factory test results in writing for review by U of T prior to shipping of equipment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Before final acceptance of the installation, carry out testing at the site in the presence of the U of T representative.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Provide an artificial load as required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	Pay all costs for the services of a technician, provided by the supplier, to perform initial start up and testing for as long as necessary to verify the system performance and operation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16613.9 **Diesel fuel system**

– Refer to Division 15.

.1	Provide TSSA inspection and certification as required.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Provide manual bypass valve on solenoid valve.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Indicating lamps shall be LED.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.4	All vent pipes from the main diesel tank or day tank shall be directed to the outside of the building.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		<u>C</u>	<u>NC</u>	<u>N/A</u>
16613.10	<b>Automatic Transfer Switch</b>			
.1	Automatic transfer switch shall be 4 pole, double throw, (complete with a manual transfer feature incorporating a spring handle), of current and voltage ratings as indicated, and all accessories as indicated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.2	Automatic transfer switch shall be completed with the following features: <ul style="list-style-type: none"> <li>- Time delay normal to emergency (TDNE) adjustable from 1 to 60 seconds.</li> <li>- Time delay emergency to normal (TDEN) adjustable from 1 to 60 seconds.</li> <li>- Test selector switch (TSS).</li> <li>- LED pilot lights: Normal supply (Green) and emergency supply (Red) in cover of enclosure.</li> <li>- Normal source complete protection.</li> <li>- Automatic operation.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.3	Provide all control logic, sequence of events, settings and passwords.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**13860 Fire Alarm**

- Refer to separate Division.

**END OF SECTION**

**Recommended Manufacturers**

The list of recommended manufacturers of electrical equipment is updated frequently. Check with the U of T Project Manager for the most up-to-date list.