26 00 00 Electrical

26 05 00 Electrical Common Work

Symbols

.1 All drawings submissions, regardless of the phase of the project, shall have a legend of all symbols used in the drawing.

Floor Plans and Riser Diagrams

.1 Building floor plans shall accurately represent the architectural as-built conditions.

.2 Electrical systems and equipment shall be illustrated showing major conduit/wireway locations, equipment, receptacles, lighting, communications systems, security systems, fire alarm, emergency lighting and power on appropriate layers as defined in the General Section of Queen's Building Design Standards.

.3 Riser diagrams shall be provided for all major systems and shall conform to Queen's standard arrangements, showing equipment by floor levels.

Record Drawings and Maintenance Manual

This section should be read in conjunction with section 01 70 00 Close-Out Requirements.

.1 Records drawing shall include, are not limited to:

- Campus digital map will indicate all underground services (if applicable)
- 5kV power distribution operating diagrams (if applicable)
- Building floor plans illustrating major conduit runs, locations of equipment, proper equipment identification, circuit numbers
- Fire, security, and normal/emergency power system riser diagrams

.2 Manufacturer's catalogue data, equipment schedules, panel schedules, panel summaries, warranties, certificates, verification and test reports, spare parts, short circuit, coordination, and arc flash study, operating and maintenance instructions shall be provided at the end of the project.

Identification of Equipment

.1 Paint in yellow "KEEP CLEAR AT ALL TIMES" for working space around electrical equipment as required by the latest revision of the Ontario Electrical Safety Code. In locations where this is not practical, high visibility labels shall be affixed to the equipment.

.2 All equipment including panels, transformers, network switches, disconnect devices, safety switches, control equipment etc., shall be labelled with white lamacoid nameplates using black engraved lettering for normal-powered equipment, and red lamacoid nameplates using white engraved lettering for emergency-powered equipment.

.3 Nameplates shall be permanently secured in place with screws and/or Facilities approved adhesive.

.4 Nameplates shall include all pertinent information such as equipment designation, voltage of panel, no. of phases/wires, and where panel is fed from and location of feeder panel. See Appendix D at the end of the section for examples of lamacoid design.

.5 The following abbreviations and numbering schemes shall be used:

Abbreviation	Equipment Description
NS	(5kV) Medium Voltage Network Switch
IS	(5kV) Isolation Switch (Fused or Non-Fused)
TR	Transformer
HPP	600V (High Voltage) Power Panel in Vault
LPP	208V (Low Voltage) Power Panel in Vault
HDP	600V (High Voltage) Distribution Panel
LDP	208V (Low Voltage) Distribution Panel
HP	600V (High Voltage) Panelboard
LP	208V (Low Voltage) Panelboard
MCC	Motor Control Centre
HSP	600V (High Voltage) Splitter (Panel or Trough)
LSP	208V (Low Voltage) Splitter (Panel of Trough)

.6 Prefix "E" shall be added to any of the abbreviations to designate "Non-Life Safety Emergency" power when fed from a standby generator or central inverter system, i.e. EHP = Emergency High Voltage (600V) Panel; and prefix "ES" shall be added to any of the abbreviations to designate "Life Safety Emergency" power fed from a standby generator i.e. ESLPP = Life Safety Emergency Low Voltage Power Panel.

.7 Suffixes shall be provided for each abbreviation used as follows:

- Main Switchboards, Power Panels, Distribution Panels and Splitters shall be assigned double letters in sequence i.e., HPP-AA, LDP-BB, LSP-CC.
- Branch circuit panel boards shall be assigned alphanumeric suffixes with floor level and single letter in sequence i.e., LP-1A, HP-1B, ELP-1C, LP-2A, EHP-2B.

.8 Receptacles on emergency power shall be red in colour.

.9 A sticker indicating the source panel and circuit number shall be placed on all receptacles.

Electrical Interference

.1 The use of electronic, low voltage devices in research and teaching is increasing. To avoid interference, electrical fixtures and equipment should be electrically "quiet" and non-arcing.

.2 Harmonics generated by equipment shall have no deleterious effect on the distribution system or other building equipment.

Equipment Housekeeping Pads

.1 Install base mounted equipment on chamfered edge housekeeping pad: minimum 4" high, minimum 2" larger than equipment dimensions all around.

Wiring Methods

.1 Wiring shall be installed in conduit to facilitate changes, i.e. increasing wire gauge, adding circuits, repairing damaged wiring etc. Where practical, conduit shall be oversized to accommodate such change.

.2 Connection to equipment subject to vibration/movement (such as motors) shall be flexible conduit.

.3 Lighting circuits shall be wired in conduit except final drops may be made with type AC90 cable. No runs of type AC90 cable shall exceed 3 meters in length.

.4 Provide a separate (minimum #12 AWG) green insulated ground wire in all conduits and raceways.

.5 The use of isolated grounding systems is strongly discouraged.

.6 Main electrical distribution shall be solidly grounded.

.7 All branch circuits are to be stranded type.

.8 Label all wires in junction boxes as well as at terminations.

.9 Where 347V and 120V lighting is in the same space, they shall be clearly marked as such, and easily identifiable.

Conduit

.1 Conduit shall be adequately sized with room for fifteen percent more wire in general areas and fifty percent in lab and research areas.

.2 No more than three ¼ bends (or equivalent) shall be allowed in any conduit run between pull points.

.3 Conduit shall be Electrical Metallic Tubing (EMT) electro-plate steel where code permits; Electrical non-metallic Tubing (ENT) embedded in concrete is acceptable in most applications.

.4 Aluminum conduit may be used provided that the alloy used conforms to Canadian Standard Association (CSA) standards and provided that it is not embedded in concrete.

High Voltage Power Cables and Terminations – 15kV

.1 The main campus power grid comprises a 4,160V distribution system utilizing 15,000V (minimum) insulated phase conductors with insulated bonding conductor.

.2 New services will require evaluation of the network to establish interconnection requirements. New power cables may be 500 MCM AWG single conductor concentric neutral, XLPE-TR insulated or 500 MCM AWG single conductor, tape shield, XLPE-TR insulated. If tape shield is to be used, a separate 4/0 AWG bonding conductor shall be installed. All cables are to be copper conductor and have 133% insulation level.

.3 15kV Termination shall be 3M Cold Shrink QT-III or approved equivalent and 15kV splices shall be 3M Cold Shrink QS-III or approved equivalent. Splices will be kept to a minimum and shall be installed in accessible, preferably dry locations.

Wire and Cables (0-1000V)

.1 All branch wiring shall be copper conductor, #12AWG minimum. Feeder cables shall XLPE rated at 90◦C. Building wiring may be XLPE or TWH. A separate insulated ground conductor shall be installed in all conduit systems.

The following colour code shall be used:
Ground: Green
Neutral: White
Phase A: Red
Phase B: Black
Phase C: Blue
Low voltage wiring: Brown

Wiring Devices

.1 Preferred manufacturers are Hubbell, Bryant, Arrow Hart, Pass & Seymour and Leviton. Stainless steel cover plates are preferred.

.2 Occupancy sensors and vacancy sensors may be proposed.

.3 Manufacturer's catalogue cuts including specifications are required for wiring devices provided.

Short Circuit Rating

.1 Devices added to existing equipment (ie. panelboard, switchboard, MCC) shall have a minimum short circuit rating of the existing equipment.

.2 Devices shall be specification grade "heavy duty".

Connection and Terminations

.1 Wiring connectors that enable the connection to be inspected, before the insulation is applied, are preferred such as MARR connectors with socket-type screws or compression type connectors such as the Buchanan connectors.

.2 All power cable terminations shall be of the compression fitting type such as Thomas & Betts 54100 series, Burndy Hylugs, or Burndy UNITAP Multiple Tap Connector (clear/insulated).

System Short Circuit, Co-ordination, and Arc Flash Studies

.1 A short circuit, co-ordination, and arc flash study shall be provided for all protective devices and equipment in the electrical distribution system in co-operation with suppliers of all pertinent equipment. Any short circuit, co-ordination, and arc flash problems shall be resolved or brought to the attention of Facilities Engineering for resolution. Arc flash labels will be provided by the company performing the study.

.2 A copy of the short circuit, co-ordination, and arc flash study shall be included in the Maintenance Manual.

Bus Duct and Other Flexible Systems

.1 Special permission must be given by Facilities for bus duct or other flexible system.

Padlocks for Electrical Switchgear

.1 Switchgear that is energized, that requires a lock, shall be padlocked with the standard electrical Master Padlock with key number X2286.

.2 Network switches shall have each Test Position Access normally locked open using the standard Master padlock with key number X2286.

.3 Switchgear that, in the open position, defines an open point in the distribution system shall be locked open using the standard Master lock padlock with key number 2233.

.4 Switchgear access doors requiring restricted access shall be locked using the 2233 padlock.

.5 Padlocks shall be manufactured by Master Lock Company. They shall have a 44mm wide (1 ¾") laminated brass body and hardened steel shackle 8mm (5/16") diameter; 19mm (¾") horizontal clearance; 38mm (1 ½ ") vertical clearance. Padlock shall be complete with protective bumper, precision 4 pin tumbler locking mechanism and number stamped into padlock base.

.6 Acceptable products: Master Padlock catalogue numbers – 2KALF to key X2286 and 2KALF to key 2233.

Electrical Equipment Rooms

.1 Access to electrical equipment rooms shall be limited to authorized personnel. Entrance doors shall be marked according to latest revision of Ontario Electrical Safety Code.

.2 Door locks shall be keyed to Medeco J1 for electrical rooms containing >750V and Medeco JB for electrical rooms containing <750V. In some cases a padlock hasp shall be provided, padlock to be supplied by Facilities.

.3 Provide copper ground bus around entire main electrical room and connect to all electrical switchgear (if required by Ontario Electrical Safety Code).

.4 Main electrical equipment rooms shall be sized to provide room and cable entrance space for (up to) a six-pole network switch and include room to expand the number of SKV load break switches as well as the secondary distribution panel.

.5 The layout of electrical equipment rooms shall be reviewed and approved by Facilities.

.6 The main electrical room of a building shall be above grade and easily accessible to replace equipment in future.

.7 No water services will be run through the main electrical room(s) within any building unless it directly serves the main electrical room(s) such as room sprinkler piping, room chilled/condenser piping, etc.

.8 Design Checklist for electrical equipment rooms:

Location
- Facilitate major electrical equipment replacement/repair (electrical room at grade and double door access)
- Avoid proximity of water (pipes, sumps)
- Minimize noise transmission to adjacent spaces
- Level of electrical room floor must be above all sewage/sump pits

Ventilation
- Isolated
- Adequate to control temperature
- Supply and exhaust
- Minimum noise
- Mechanical cooling when required (in addition to supply and exhaust fan system)

Access
- Key specified by Operations Department

Protection
- Fire Detection (Photo Electric Smoke Detector preferred)
- Fire Suppression may be considered but electrical equipment must be sprinkler-proof

Lighting
- Lighting to be switched
- Emergency - battery operated (only if no standby power or if standby power equipment in room i.e. ATS, generator, etc.) or on standby power
- Adequate lighting on standby power (if possible) so that equipment maintenance can be performed when no utility power.

Emergency
- Provide Emergency Receptacle(s) if standby power is available

Signage
- In accordance with latest revision of Ontario Electrical Safety Code and Queen's Signage Policy
- Single Line Distribution Diagram to be framed, posted

Grounding
- In accordance with code requirements

Records
- Accurate As-Built Drawings

Electric Vehicle Chargers

.1 Install minimum four (4) electric vehicle chargers as part of the construction of a new building or an entire building renovation if parking nearby. In all cases, make certain electrical service size accommodates a minimum of four (4) electric vehicle chargers.

Motors

.1 All motors shall be of energy efficient design.

.2 All motors shall have life seal lubricant ball bearings.

.3 Motors up to but not including 3/4HP may be single phase 120V. However, fractional horsepower motors that are required to start and stop frequently shall be three phase.

.4 Division 22/23 (Mechanical) often provides motors for pumps, fans, air conditioners etc. The specifications for these motors and controls must be coordinated with Division 26 and meet all requirements of Division 26.

.5 Motors to be controlled by variable frequency drives shall be inverter-duty rated. (i.e. Class F insulation (min.))

.6 All motorized equipment shall be designated with maintenance identification supplied by Facilities Operations/Engineering.

.7 Documentation shall include motor nameplate data, catalogue cuts and specification sheets.

Infrared Scanning

1. After installation of new electrical distribution equipment (i.e. switchboards, transformers, circuit breakers) and after 24 hours of energization, confirm tight connections using infrared scanning and provide a report of the results. Perform similar scanning 1 year after energization to reconfirm tightness of connections.

Appendix D – Labelling

<u>Network Switches</u>

Plate Size	Lettering Required	Letter Size
125mm x 35mm	NS-64	25mm

NS #	Plate Size	Letter Size		Lettering Required	Letter Size
NS-64	160mm x 35mm	25mm	A	SUPPLY FROM KGH SUBSTATION FEEDER 18	5 mm 10mm 5mm
NS-64	160mm x 35mm	25mm	B	SUPPLY TO MEDICAL BUILDING IS-243 and IS-244	5mm 10mm 5mm
NS-64	160mm x 35mm	25mm	C	THEOLOGICAL HALL NS-20 POSITION C	10mm 5mm
NS-64	160mm x 35mm	25mm	D	BOTTERELL HALL NS-46 POSITION D	10mm 5mm
NS-64	160mm x 35mm	25mm	E	BIOSCIENCES NS-40 POSITION D	10mm 5mm

Medium Voltage Load Break Switches

Plate Size	Lettering Required	Letter Size
To Suit	IS-243	25mm
	FUSED FEED TO	5mm
	TR-1	10mm
	FED FROM	5mm
	NS-64 POSITION B	5mm

Power Panels or Distribution Panels

Plate Size	Lettering Required	Letter Size
To Suit	**HPP-BB**	25mm
	600/347V	10mm
	FED FROM	5mm
	TR-2	7.5mm
	ADJACENT	5mm

Plate Size	Lettering Required	Letter Size
150mm x 75mm	**EHDP-DD**	15mm
	600V 3PH, 3W	10mm
	FED FROM	5mm
	EHPP-EE	7.5mm
	IN RM. 077	5mm

Transformers

Plate Size	Lettering Required	Letter Size
150mm W x 100mm H	FED FROM	5mm
	IS-243	7.5mm
	TR-1	15mm
	1000 kVA 600/347V	10mm
	SUPPLY TO	5mm
	HPP-AA	7.5mm
	ADJACENT	5mm

Automatic Transfer Switches

Plate Size	Lettering Required	Letter Size
To Suit	**ATS-1**	10mm
	600V 3PH, 3W	7.5mm
	NORMAL FEED FROM	5mm
	HPP-BB	7.5mm
	ADJACENT	5mm
	EMERGENCY FEED FROM	5mm
	EHPP-CC	7.5mm
	ADJACENT	5mm

Panelboards

Plate Size	Lettering Required	Letter Size
To Suit	**ELP-BJ**	10mm
	208/120V 3PH, 4W	7.5mm
	FED FROM	5mm
	ELDP-1BB	7.5mm
	IN RM. 174	5mm
To Suit	**LP-BA**	10mm
	208/120V 3PH, 4W	7.5mm
	FED FROM	5mm
	LDP-BAA	7.5mm
	IN RM. 074	5mm

Feeder Breakers within Power Panels/Distribution Panels

Location	Lettering Required	Letter Size
HPP-BB	1 MCC-PH-N1 IN PENTHOUSE	7.5mm 10mm 5mm
HPP-BB	2 ATS-1 ADJACENT	7.5mm 10mm 5mm
HPP-BB	3 CHILLER 1 IN PENTHOUSE	7.5mm 10mm 5mm
HPP-BB	4 SPARE	7.5mm 10mm 5mm
HPP-BB	5 LDP-4AA via TR-11 IN RM. 474	7.5mm 10mm 5mm
HPP-BB	6 LDP-3AA via TR-9 IN RM. 374	7.5mm 10mm 5mm
HPP-BB	7 LDP-BAA via TR-4 IN RM. 074	7.5mm 10mm 5mm

26 06 00 Schedules

Schedules

.1 Motor and apparatus schedules, lighting fixture schedules and panel board schedules are required. Suggested forms which can be included in specifications are illustrated in the appendices. Digital versions of new panel schedules shall be provided for every project.

.2 For renovations and equipment replacements, existing schedules are to be updated.

.3 As-built schedules shall be produced and submitted following 26 05 00 Common Work, Section 3.

26 09 00 Instrumentation and Control for Electrical Systems

Secondary Metering

.1 All substations shall be provided with secondary metering, which provides:

Amps for each phase (A)	Kilovolt-amps (kVA)
Volts phase to phase (all phases) (V)	Kilovolt-ampere hours (kVAH)
Volts phase to neutral (all phases) (V)	Power factor
Kilowatts (kW)	Digital Output
Kilowatt demand (kWd)	Frequency (Hz)
Kilowatt-hours (total) (kWh)	% Harmonic distortion
KiloVARS (kVAR)	

.2 In order to facilitate reading of the meter the display shall be installed at eye level (1.7m AFF)

.3 Current Transformers (CT's) shall be sized to maximum rated current of transformer (not larger) with 5 amp secondary. Potential Transformers (PT's) are required on services over 250 volts.

.4 A colour coded test switch is required to facilitate testing and removal of each meter. ABB Flexitest switches are normally used.

.5 Queen's central metering system uses Schneider PME metering software. To be compatible, new meters shall be Schneider PM5560 or Eaton PXM 3000 with Ethernet communications. Where power quality monitoring is also required, the new meters shall be Schneider PM8000 or Eaton PXM4000 with Ethernet communications. The requirement for a power quality meter instead of a standard meter shall be determined by Facilities Engineering.

.6 The Electrical Contractor shall provide the Ethernet jacks for any electrical metering. Conduit to be supplied and installed by the contractor. Supply and installation of the Ethernet cable to be sub-contracted to an approved IT Sub-Contractor. The conduit and wire/cable will normally terminate at the main incoming communications node. Termination location at the field end shall be coordinated with Facilities.

.7 Documentation shall include catalogue cuts for meter, CT's and test switch, as well as operating and maintenance manual for meter.

.8 Unless approved by Facilities, do not use batteries as a power source. Power source shall come from the electrical distribution available through wired connections.

26 10 00 Medium and High Voltage Electrical Distribution

Source of Power and Substation

.1 All new buildings will require a unit substation fed at 4160V from the existing campus grid. This substation shall be indoors unless special permission given by Facilities Engineering.

.2 All new building 4160V feeds shall be designed in loops within the existing campus grid for power reliability. No radial feeds on the 4160V system allowed. As a result, all new buildings will require at least two 4160V feeders (1 primary, 1 backup). Connection points of these feeders within the existing campus grid will be provided in association with Facilities Engineering.

.3 Only in exceptional cases will the power be supplied at secondary voltage from an adjacent building. Special permission must be given by Facilities Engineering.

.4 Flexibility shall be maintained through the use of network switches, multiple 4160V feeds to each building and cross connections of the feed-through network switches.

.5 Phasing is marked from left to right or top to bottom Red-Yellow-Blue, Red-White-Blue, or A-B-C.

Buried Services and Duct Banks

.1 Location of all 4160V cables in duct shall be marked with brass markers either supplied by Queen's or to Queen's Standard Design. A sufficient number of these markers is to be arranged to allow the cable route to be easily determined.

.2 All 4160V cables will be installed within concrete-encased duct banks. All concrete-encased buried electrical power duct banks shall contain 5" ducts and shall be installed according to the latest Ontario Electrical Safety Code and Ontario Provincial Standard Drawings (whichever is more severe). Direct buried cables are not acceptable.

.3 New or changed underground services shall be recorded on the digital campus map and on the 5kV operating diagram as well as on the design drawings associated with the project (if applicable).

.4 New duct banks shall be constructed with spare ducts to allow for future campus expansion and to enable cable replacement. In other words, duct banks serving one building will have capacity for the maximum number of feeders to that building plus minimum one spare. (i.e. A building containing a 4-position 4160V network switch has the capacity for 3 feeders from other locations. As a result, the number of ducts to that building will be 4 ducts (minimum).) For duct banks serving more than one building, multiple spare ducts shall be required for future expansion. In this case, the total number of ducts shall be determined in association with Facilities Engineering.

.5 Building incoming and outgoing loop feeds are to be located in separate duct banks whenever possible. Feeders which form backup pairs are to be in separate duct banks whenever possible.

Transformers – Dry Type 5kV

.1 Transformers shall be three phase, indoor, dry type with copper windings and have 220 insulation class and 115◦C temperature rise. Transformers may be liquid-filled if to be located outside and will require approval by Queen's Facilities Engineering.

.2 The primary shall be delta-connected, rated 4,160V and a Basic Impulse Level (BIL) of 60kV minimum. Four taps shall be provided: 2 at 2 ½ % full current above nominal (FCAN), 2 at 2 ½% full current below nominal (FCBN). Normally the primary taps will be set at 97 ½%.

.3 For a newly constructed/renovated building the secondary voltage shall be wye-connected at 600/347V, three phase, four wire, and grounded neutral. The transformer shall have 10 kV BIL on the secondary. 208/120V distribution shall be provided by a single main 600-208/120V transformer or distributed via smaller transformers as required throughout the building. This will depend on the type/layout of the building. For partial renovations, the secondary voltage of the 5KV transformer can also be 208/120 V. System design shall be reviewed and approved by Facilities Engineering.

.4 The transformer capacities shall be double the designed operating load (not connected load) and shall include for the installation for at least four vehicle chargers.

.5 Transformers shall be provided with Qualitrol winding temperature indicators complete with remote terminals and shall be connected to a remote monitoring system (in most cases, the building automation system).

.6 Infrared window (minimum 4" diameter) shall be provided and adequately positioned on transformer enclosure to allow thermal inspection on transformer key components and cable terminations.

.7 Facilities Engineering shall be provided with appropriate data for updating the 5kV operating diagram and the 5kV computer model.

.8 Facilities Engineering shall be provided with complete nameplate data to be entered in the 5kV transformer (TR) database and the Facilities maintenance database.

.9 The transformer shall be identified according to Queen's naming convention and shall be identified with a nameplate manufactured to Section 26 05 00.

.10 A disconnecting device for the transformer shall be located within the same room unless approved by Queen's Facilities Engineering.

.11 Approved manufacturers: Hammond and Delta.

.12 Documentation for transformers shall include manufacturer's catalogue cuts, recommended operating and maintenance instructions and warranty information, and shop drawings.

Network Switches – 15kV

.1 15kV network switches are used on campus to interconnect the 4160V grid. New switches are to be indoor, SF6 insulated and are manufactured by G&W Electric Limited. Outdoor network switches, when required, shall be of S&C Vista type. The requirement and configuration for a switch shall be determined by Facilities Engineering. (15kV switches are used because 5kV switches are no longer manufactured.)

.2 Network switches shall include test positions to facilitate grounding of connected cables. Each indoor network switch shall be supplied complete with three (3) Cooper Power System LPC-215 deep-well bushing insert kits and three (3) Cooper Power System LPC-215 protective caps. The inserts and caps shall be installed prior to network switch commissioning.

.3 SF6 network switch shall have a valve before the SF6 pressure gauge which would allow the isolation of the gauge from rest of the SF6 chamber.

.4 New added SF6 network switches shall have analog SF6 pressure sensor connected to the building automation system.

.5 Network switches are assigned Facilities identification numbers (NS numbers). Nameplates shall be manufactured to Queen's standard and fastened to the front of the network switch.

.6 Complete nameplate data must be provided to Facilities Engineering to enter in Queen's NS database.

.7 Documentation shall include manufacturer's operating and maintenance instructions, specifications, data sheets and shop drawings.

Primary Switchgear Assembly – 5kV/15kV

.1 Primary gear shall not include metering, breakers or special control equipment unless approved by Facilities Engineering.

.2 Switchgear shall be rated to withstand the available fault energy estimated by Utilities Kingston to be 150 MVA.

.3 The insulation rating of all 5kV class primary supply equipment shall have a Basic Impulse Level (BIL) rating of 60kV minimum.

.4 Each building substation transformer shall be provided with a fused, load break switch rated at 600A, 5kV minimum. Clearly visible potential indicators shall be provided on each phase of the line and load side of the switch and shall be viewable via factory-installed windows.

.5 Isolation switches (IS) shall be manufactured and supplied by S&C Electric. Neither used nor reconditioned nor old stock equipment may be used without the express permission of Facilities Engineering. Power fuses shall be refill type SM-5 as manufactured by S&C. The refill current, voltage and time current rating shall be specified in conjunction with Facilities Engineering.

.6 Isolation switches are assigned Facilities identification numbers. Associated data must be provided to Facilities Engineering to enter in Queen's IS database.

.7 Enclosure shall be equipped with adequately positioned infrared window to allow thermal inspection on cable terminations.

.8 Documentation shall include manufacturer's operating and maintenance instruction, specifications, data sheets and shop drawings.

Motor Starters

.1 Motor starters shall be NEMA rated.

.2 5kV motor starters shall be equipped with digital electrical metering as specified in section 26 09 00.

.3 All three phase motor starters must be equipped with protective devices that will disconnect the motor completely from the supply in the event of an overcurrent or sustained overload condition and prevent single phasing.

.4 Solid state motor starters shall have proper temperature, overcurrent and overvoltage protection included in the design. The starters shall be shipped with proper fuses installed. The fuses selected shall be based on actual tests of fuses in series with the semiconductors. Overvoltage protection shall be voltage breakover clamping inherent in the starter design.

.5 Motor status shall be acquired using current switches, not by using auxiliary contacts on the contactor.

.6 Documentation shall include manufacturer's catalogue data, shop drawings, manufacturer's replacement parts list, operation and maintenance data.

26 20 00 Low Voltage Electrical Distribution

Buried Services and Duct Banks

.1 All buried services shall be installed within concrete-encased duct banks except for power feeds to devices such as light poles, etc. In those cases, underground services can be direct buried. Buried services shall be installed according to the latest Ontario Electrical Safety Code and Ontario Provincial Standard Drawings (whichever is stricter).

.2 New or changed underground services shall be recorded on the digital campus map as well as on the design drawings associated with the project (if applicable).

Secondary Switchgear

.1 The transformer main secondary switchgear shall contain draw-out type air circuit breakers. All equipment shall be of Canadian manufacture or with parts readily available to Facilities.

.2 An appropriately sized spare air circuit breaker shall be provided to allow for maintenance servicing and testing with minimal interruption of service.

.3 Secondary switchgear shall have copper bus and surge protection. As well, switchgear shall contain arc fault reduction technology.

.4 Infrared windows (minimum 4" diameter) shall be provided and adequately positioned on the enclosure to allow thermal inspection on key components and cable terminations.

.5 Lockable hasps are to provided on all molded-case circuit breakers.

.6 Approved manufacturers are Schneider (Square D), Siemens, and Eaton (Cutler-Hammer).

.7 Documentation shall include manufacturer's shop drawings, catalogue cuts, data sheets, operation instructions and maintenance instructions.

.8 Circuit identification shall conform to Queen's standards. Nameplates shall be reviewed with Facilities prior to manufacture.

Fused Disconnects

.1 Heavy duty safety switches shall be specified.

.2 Disconnects shall accommodate CSA certified HRC1-J (Class J) fuses.

.3 Preferred manufacturers are Schneider (Square D), Siemens, and Eaton (Cutler-Hammer).

.4 Documentation shall include catalogue cuts clearly indicating specified products and options.

Transformers – Dry Type 600V

.1 Primary windings shall normally be copper conductor, delta connected, 1.2 kV class insulation, standard BIL complete with four 2½% taps, 2FCAN and 2FCBN.

.2 Secondary windings shall normally be copper conductor, wye connected.

.3 80°C temperature rise above 40°C ambient shall be specified.

.4 Approved manufacturers: Hammond and Delta.

26 24 00 Switchboards, Panelboards, Breakers, Surge Suppression

Panelboard Summary

.1 The assignment of panel names is managed using a table recording information related to all panels used throughout a building.

.2 The table is normally created when a building is built and updated when changes occur. The provision of this data is the responsibility of the contractor executing the work.

.3 The completed table shall be included in the operation and maintenance manual.

Panelboards – Power Distribution Type

.1 Power distribution panels shall be type CDP utilizing molded case circuit breakers. All panels shall be three phase, four wire, solid neutral, copper bus, 600/347V or 208/120V as required. Interrupting capacity shall be calculated and specified for each case.

.2 Lockable hasps are to provided on all molded-case circuit breakers.

.3 Fused panels are only to be used if it can be shown that coordination cannot be achieved or if the interrupting capacity of the available breakers is insufficient for the available fault current.

.4 Distribution panels and breakers must be of Canadian manufacture or with parts readily available in Kingston.

.5 Approved manufacturers are: Schneider (Square D), Siemens, Eaton (Cutler-Hammer).

.6 Coordinate with Facilities Engineering to install infrared window on major distribution panel enclosure to allow thermal inspection on bus/cable connections.

Panel boards - Breaker Type

.1 Branch circuit panel boards shall use bolt-on breakers and have lockable panel doors.

.2 All panels shall be three phase, four wire, solid neutral, copper bus, 600/347V or 208/120V as required.

.3 Equipment panels for student laboratories shall be provided with a main disconnect.

.4 Panels in general areas shall be sized to accommodate at least 15% additional circuits. Those in lab areas shall be sized to take at least 50% more than the original number of circuits.

.5 Panel boards and breakers must be of Canadian manufacture or with parts readily available in Kingston.

.6 Approved manufacturers are: Schneider (Square D), Siemens, Eaton (Cutler-Hammer).

Molded-Case Circuit Breakers

.1 Molded-case breakers shall be bolt-on type.

.2 Include 10% spare breakers, normally 1P-15A.

Fuses

.1 Fuses shall be CSA certified HRC1-J (Class J) time delay type.

Branch Circuit Loading

.1 Normally the maximum number of receptacles per 15-amp circuit shall be four.

.2 Service receptacles shall be fed separate from other receptacles (i.e. corridor receptacles intended for floor polishers will not be on the same circuit as office receptacles).

26 29 00 Low Voltage Controllers

Variable Frequency Drives

.1 All VFD's shall have a bypass option unless the application does not allow bypass operation.

.2 All VFD's shall be BACnet compatible. However, start/stop, status (i.e. running), and speed signals to/from the VFD shall be hardwired.

.3 ABB is the preferred manufacturer of VFD's. ABB ACH (HVAC) series drives shall be the standard.

Motor Starters

.1 Motor starters shall be NEMA rated.

.2 All three phase motor starters must be equipped with protective devices that will disconnect the motor completely from the supply in the event of an overcurrent or sustained overload condition and prevent single phasing.

.3 Solid state motor starters shall have proper temperature, overcurrent and overvoltage protection included in the design. The starters shall be shipped with proper fuses installed.

.4 Combination motor starters shall have, at a minimum, a status LED (i.e. running), an auto/off/manual selector switch, and a 120-volt (secondary) control transformer.

.5 Motor status shall be acquired through current switches, not auxiliary contacts on the contactor.

.6 Documentation shall include manufacturer's catalogue data, shop drawings, manufacturer's replacement parts list, operation and maintenance data.

Motor Control Centres

.1 Motor control centres (MCC's) shall be complete with nameplates as per Queen's standard.

.2 Motor status shall be acquired using current switches and not by using auxiliary contacts.

.3 Preferred manufacturers are: Schneider (Square D), Siemens, Eaton (Cutler-Hammer), and Allen-Bradley.

.4 If VFD is used in lieu of motor starter, the VFD shall be installed outside the MCC. No VFD shall be installed inside of any MCC wrappers.

.5 Documentation shall include manufacturer's catalogue data, shop drawings showing dimensions, equipment parts and catalogue numbers, complete manufacturer's wiring diagrams, engineering consultant's single line diagrams provided by the designer showing the interconnection with all control elements.

26 30 00 Emergency Power

Emergency Power – General

.1 Standby emergency power is required for most University buildings to supply emergency lighting and other emergency services such as fire pumps, sump pumps and similar critical loads. Since maintenance on standby equipment is regulated, it is important to minimize the quantity of generators. Groups of buildings shall be fed from a single generator servicing a designated area whenever possible.

.2 Generators shall be diesel or natural gas powered with three phase, four wire 600/347-volt output complete with automatic transfer switch and battery charger. The engine and generator shall be installed in a room separate from the main transformer and associated switchgear, shall be installed above grade, and shall allow easy access for a resistive load bank for required annual testing.

.3 Disconnects with cam-lock connectors shall be installed at grade to allow for easy connection of a resistive load bank to the generator as well as connection of a temporary generator if the building generator cannot operate (i.e. failure). Consult with Facilities Engineering as to when latter provision is required.

.4 In scientific buildings, consideration shall be given to providing each floor with a panel fed at 60 amps (minimum) located adjacent to the main power panels on each floor. These panels should be fed separately from electrical feeds to specific equipment.

.5 Approved generator manufacturers are Cummins, Onan, Kohler, and Caterpillar.

.6 Automatic transfer switches (ATS) will be four pole (switched neutral) and shall come with ability to bypass in order to maintain and repair switches without affecting the connected

loads. A supervisory on the fire alarm panel will be provided to indicate if "ATS is in bypass" and/or "ATS not in auto".

.7 Approved ATS manufacturer is ASCO Power Technologies.

.8 Documentation for the standby equipment shall include all operations and maintenance documentation recommended by the manufacturer, factory load test data, a single line diagram illustrating the complete, as-built distribution of the standby power, a table or panel schedule indicating the precise connected load, the measured load under test conditions and a completed Queen's data sheet for standby generators.

26 40 00 Electrical Protection

Lightning and Surge Protection

.1 Intermediate class metal oxide arresters rated at 2.55V maximum continuous operating voltage (MCOV) shall be provided at the incoming service to a building (sized to protect transformers from surges). Arresters shall be housed within the primary switchgear assembly.

.2 Exterior lightning rods or grounding mats may be required to protect sensitive electronic equipment. All grounding means must conform to the Ontario Electrical Safety Code. Isolated ground rods are not permitted.

.3 Surge protection shall be provided at distribution panels throughout the building when warranted.

.4 Documentation shall include manufacturer's catalogue cut sheets for the arresters and surge protectors plus any operating or maintenance data.

Transient Voltage Surge Suppression

.1 Transient voltage surge suppression devices shall be used to protect Fire Alarm control panels.

.2 Suppression devices should be considered for any critical loads utilizing computer or solid-state technology (such as life safety and security equipment).

26 50 00 Lighting

General

.1 Lighting designs shall reference the latest revisions of the following documents:

- Ontario Building Code
- IESNA Lighting Handbook
- Queen's University Facility Accessibility Design Standards
- ASHRAE 90.1

.2 As part of 66% design submissions, reflected ceiling plans as well as photometric design shall be submitted for all projects as part of new or replacement lighting. For clarity this includes all interior and exterior lighting designs.

.3 LED Luminaires and drivers must have a minimum 5-year warranty. The warranty should include the replacement of all fixtures if more than 15% of the fixtures fail within the first 5 years.

.4 For all projects installing new light fixtures.....the Lighting Warranty Form (Appendix A) must be completed and submitted to the Project Manager during close out procedures.

Interior Lighting

.1 Indoor Colour Temperature: 3500 K unless otherwise stated.

.2 Ultraviolet filters are required in art galleries, rare book collections and throughout the space occupied by the art department where fluorescent lamps are present.

.3 Task lighting must be considered for the following spaces:

- Classroom chalkboard
- Office Desk
- Lab Benches

.4 Unless information is given by the architect to the contrary, lighting design shall be based on the following reflection coefficients:

a)	Ceilings	80%
b)	Walls	50-60%
c)	Desktops	35-40%
d)	Floor coverings	30% or higher

.5 Spaces shall be designed to optimize reflection coefficients for high reflectivity without visual impairment.

Luminaires

.1 Installation for major renovations or new builds shall use new LED type fixtures. Where appropriate, dimmable LED fixtures shall be installed. See section 4.9 for a list of spaces where dimming is required.

.2 A sample fixture shall be purchased for all new lighting designs.

.3 Custom-made fixtures should be avoided whenever possible.

.4 For new builds and major renovations, the supplier & manufacturer shall demonstrate experience in manufacturing and implementing LED lighting equipment by providing:

- Information on a minimum of at least 3 other projects of similar scope

- Contact information for at least one other customer who has used the proposed fixtures

.5 Acceptable Manufacturers for LED fixtures are as follows:

- Cree
- Signify/Philips
- Leviton
- Eaton/Cooper
- Visioneering
- Sylvania
- Acuity brands
- GE Current/Hubbell

.6 Fixtures shall be chosen from the Facilities Approved Fixture List and part numbers must be chosen from the Design Lights Consortium Qualified Products List.

.7 Specifications requirements for LED Drivers:

- Total Harmonic Distortion < 10%
- Drivers must limit inrush current
- Must be rated for > 50,000 hours
- Power supplies must be capable of operation at 60 Hz with PF of 90% or better

.8 LED Fixtures must have a replaceable driver.

.9 Installation of lighting upgrade within existing buildings may use a combination of T8 LED tube retrofits and replacement LED fixtures. The decision-making guideline for selecting options is as follows:

- Option 1: When fixtures are in good condition, dimming is not required, and the existing layout is still appropriate for the space use, the recommended approach is to replace the existing fluorescent tubes with LED ("Type A" retrofit)
- Option 2: When lighting is distributed well throughout the room, but fixtures may be of an older style or have visible damage, remove the fixture and replace with a new integrated LED fixture or type C LED tube.
- Option 3: Where upgrading the existing layout to LED would unacceptably alter the even distribution of light, or when control systems such as occupancy sensors are missing from an area that should have them, a lighting redesign is recommended.

Lighting Controls

.1 Lighting controls systems shall favor maintainability and longevity over complex functionality.

.2 Building-level lighting control systems can be installed when deemed appropriate (i.e. according to building type/occupancy); however, they shall only be used to control lighting in common spaces such as hallways, atriums, and entrances. Where building- level lighting controls are utilized, a computer (with the lighting software installed), used to interface with the lighting control system, must be provided and connected to the Queen's network via Ethernet to ensure remote accessibility.

.3 Building/floor-level lighting control systems shall be centralized such that lighting relays and dimming modules are centralized in panels within electrical rooms/closets (or other similar non-public spaces). Switched power and/or 0-10VDC dimming signals shall come from these centralized panels to the individual light fixtures. Each centralized panel will power/control light fixtures for multiple areas within a floor, an entire floor or multiple floors depending on the building. Light switches, occupancy sensors, etc. are to be hard-wired to the lighting control system (i.e. not wireless communication nor battery-powered) and are not to use specialized cabling, tools, or knowledge to maintain or replace the devices within the system. Approved manufacturers: Leviton, Lutron, or other approved by Facilities Engineering.

.4 Addressable fixtures, ballasts, and drivers shall not be used.

.5 Where dimming is required, LED fixtures shall be controlled by a 0-10 VDC dimming control system.

.6 Wireless controls shall not be used.

.7 Room lighting will be controlled by wall switches, with dimming and occupancy sensing as appropriate.

.8 In spaces that require an in-room audio visual presentation system or areas that require specialized lighting control, the Lutron GRAFIK Eye shall be used. Other systems shall not be used unless explicitly approved by Facilities Engineering. See item 4.3 for system architecture.

.9 All new builds or major renovations shall have a dimming range of at least 20-100% in the following spaces:

- Lecture Theatres
- Performance Halls
- Classrooms
- Study Spaces
- Conference Rooms

.10 In areas with multiple lighting circuits, each circuit shall power alternating fixtures rather than each circuit powering a large grouping of fixtures. This is done to provide a way to dim room lighting by turning off different circuits.

.11 In spaces requiring dimmable fixtures and occupancy sensing, a wall switch, power pack and wall or ceiling occupancy sensor shall be used. The acceptable manufacturers are outlined below

- Lutron
- Leviton
- Or other approved by Facilities Engineering

.12 When common areas and corridor lighting are programmed or turned "off" after-hours, certain light fixtures shall remain on, conforming to the minimum lighting requirements as per the Ontario Building Code. Where feasible, these fixtures should also form the emergency lighting system. In those spaces where emergency light fixtures are installed but are switched off or dimmed due to audio/visual presentations, etc., then the lighting control system will immediately turn these emergency light fixtures on to full brightness. The lighting controls system must be approved for this function. ULC-approved relays can also be used to automatically power on fixtures to full illumination in case of power failure.

.13 No lighting components shall contain batteries except for emergency lighting unit equipment or central inverters unless explicitly approved by Facilities Engineering.

.14 Occupancy based dimming must use either ultrasonic or dual tech (ultrasonic and infrared) sensors.

.15 Occupancy sensors shall be applied in the following spaces and the time delay shall be set to the following values below:

a) Classroom	30 minutes
b) Office	30 minutes
c) Storage room	20 minutes
d) Study Rooms	30 minutes
e) Washrooms	30 minutes
f) Gymnasium	30 minutes
g) Parking Garages	20 minutes
h) Hallways and Corridors	20 minutes
i) Stairwells	20 minutes
j) Or other approved by Facilities Engineering	

.16 Daylight sensing shall be used in appropriate areas only when the total light usage can be offset by more than 1000 hours in a year.

.17 Service rooms (I.e., electrical room, mechanical room, elevator machine room, etc.) shall have locally switched lights. (i.e., no occupancy or vacancy sensor or remote-controlled light from lighting control system, etc.)

Emergency/Exit Lighting

.1 Emergency/exit lighting shall be powered from the building or area standby generator. When there is no building or area standby generator, emergency/exit lighting shall be fed from a central, battery-backed inverter. Where there is no inverter, or installing an inverter is not feasible, emergency/exit lighting fixtures shall have battery packs. Consultants MUST confirm with Facilities Engineering whether the building has access to emergency power or whether the emergency/exit light fixtures must be battery-powered.

.2 Unit equipment for emergency/exit lighting shall be selected for optimum life cost, maintenance being of utmost consideration. Automatic controls shall be provided for charging at both high and low rates. Meters/monitors shall be provided to indicate charge rate and condition. Lamp heads shall be of LED type.

.3 Unit equipment output voltage shall normally be rated 24 VDC.

.4 Commissioning of emergency lighting shall include recording the illumination levels achieved for all areas where provided.

.5 Fixtures (other than battery unit type) used for emergency lighting shall be marked with a visible label indicating that it is an emergency lighting fixture.

.6 Exit lights shall be LED-type, shall be robust for any student-intensive areas (i.e. Student Residences, etc.) and must be solidly mounted to the building structure.

.7 Documentation shall include manufacturer's operation instructions, maintenance instructions, catalogue cut sheets, data sheets, as-built floor plans, unique identification and listing of all emergency fixtures.

Exterior Lighting

.1 Exterior lighting shall conform to the principles outlined in the Campus Master Plan (2014). The Campus Master Plan is available here: https://www.queensu.ca/strategicplanning/cmp

.2 Exterior fixtures shall be assigned unique numbers referred to as grid numbers.

.3 Outdoor color temperature for lighting fixtures shall be between 2500 and 3000 K

.4 Illuminance values for applications not included in the plan shall be based on the latest edition of the IES Lighting Handbook.

.5 Documentation shall include manufacturer's catalogue cut indicating specific fixture and options, fixture designation and quantity specified.

.6 Pedestrian walkway fixtures, poles and lamps shall be heritage poles. Acceptable product numbers that meet the heritage pole specifications are outlined below (Please see Appendix B&C):

- Holophane Luminaire Top GVD3 P10 30K MVOLT MS GL5 BRUSHED GREY ST AO 360 HSS PERF
- Holophane Luminaire Pole NY – A – 10 – F4C – 17 – P07- ABG – BRUSHED GREY
- HCI Luminaire Top F111-S-Q-EGL-55-120V-IES type III-FA- BRUSHED GREY
- HCI Luminaire Pole P452 –BRUSHED GREY– PF280 – G5

.7 All heritage pole products must also meet the following specifications. Alternative heritage pole products will be considered if they can adhere to these requirements:

a) Lumen output of 3600 Lumens. Heritage poles with a lumen output greater than 3600 lumens must be capable of dimming to reduce glare and light intensity.

b) Color temperature must be 3000K to meet dark sky compliance regulations

c) Lifespan must be > 50,000 hours

d) Mesh shielding and downwards reflectors are required on the light source

e) For sidewalk lighting, Type 3 distribution is required. For general area lighting, Type 5 distribution is required

f) A minimum efficacy of 66 Lumens/Watt is required for induction bulbs (55 W or better). A minimum efficacy of 109 Lumens/Watt is required for LEDs.
g) Pole must be similar in appearance to those existing on campus
h) Pole base must be 17-21 inches x 25-31 inches.
i) Pole base must have a 4-bolt anchoring pattern
j) Pole height must be 10 ft, fluted to a 3-inch Tenon
k) Fixture necking must be compatible with Tenon on pole.
l) Pole must have 10-12 flutes.
m) Pole base and collar must be cast aluminum
n) Pole shaft must be cast or extruded aluminum
o) Pole must have a uniform thickness of 0.125 inches or better
p) Pole, collar and base must be colour matched to existing poles.
q) Paint on pole, top lens and collar must be electrostatically applied thermoset polyester powder coat with smooth semi-gloss finish.
r) Glass lens must have finial similar in size and shape to existing.
s) Collar must fit 3" Tenon.

Lighting for Assistance Phones

.8 The acceptable product manufacturer for all assistance phones related products is Code Blue. Refer to the Facilities Approved Fixture List for product information.