

**26 01 00 OPERATION AND MAINTENANCE OF ELECTRICAL SYSTEMS**

**26 01 01 POWER CABLES AND OVERHEAD CONDUCTORS**

General

1. This section applies to underground primary conductors fed from the University of Victoria 15kV primary voltage infrastructure.
1. Main electric services to new buildings typically requires dual radial primary voltage feeders from the main distribution loop to each building in order to achieve a dual bump-less power transfer system.
2. The following provides technical requirements for primary voltage systems cabling, manholes, terminations and support hardware.

Rubber Insulated Cables 5001 – 15000 V

1. 15 kV cables shall be #250 MCM single-core copper, Class B stranding, with semi-conducting shield cover core conductor, 90° C rated retardant insulation of cross-linked thermosetting polyethylene material, 15 kV rated for 100% voltage level, semi-conducting insulation shield overlaid with metallic wire or tape shield as described below, separator tape over shield, and extruded PVC jacketed rates - 40°C.
2. In general, all 15kV cables to be connected to the existing underground distribution system shall have concentrically served copper wire shield made up of 14 #18 strands (or equal) to match the established University standard installation and to withstand 3000 A of ground fault current for 0.2 seconds.
3. For projects requiring total cable quantities less than 1000m, the following alternative shield construction, cable installation and grounding arrangement may be acceptable by obtaining prior written permission from the University:
  - i. Cable construction utilizing overlapping copper tape shield providing 100% coverage over the semi-conducting layer, and:
  - ii. Cable installation which provides an additional #4/0 green insulated copper conductor installed in the same duct as the 3-phase conductors, and:
  - iii. Grounding arrangement which provides for the direct and effective bonding of the additional #4/0 grounding conductor to the cable shield ground leads at each end of the phase cables.
  - iv. The use of alternative shielding shall require each trefoil of feeder to have an accompanying #4/0 grounding cable in the same duct in addition to the standard duct bank grounding conductor which shall be separately installed in a 50mm duct as shown on the drawings.
4. The construction and testing of HV cables shall be in general accordance with ICEA Publication S-66-524 and AEIC Specification No. 5-71.
5. Cables shall be as manufactured by Canada Wire and Cable, CGE, Phillips, Pirelli, or Northern Electric Ltd.
6. HV cable grips for single cable or trefoil bundle: high-grade, non-magnetic tin-coated bronze strand construction. Kellems Type 022-01 (closed mesh), 022-02 (split mesh, lace closing).

7. HV cable identification tag ties: Thomas & Betts Nylon Ty-Rap #TY529M.

#### Concentric Neutral Power Cables 5001 – 15000 V

1. Concentric neutral power cable: to NEMA WC7-1992/ICEAS-66-524.
2. Single copper conductor, size as indicated.
3. Semi-conducting strand shield.
4. Compact round.
5. Insulation: cross-linked thermosetting polyethylene material rated 90EC and 15kV for 133% full capacity.
6. Semi-conducting insulation shield layer.
7. Copper neutral wires applied helically over insulation shield equivalent to 133% full capacity.
8. Separator tape over neutral wires.
9. Extruded PVC jacket rated minus 40EC.

#### Connectors and Terminations Rubber Insulated Cables

1. Copper crimp-on compression connectors as required sized for conductors.
2. All terminations 5kV and above shall meet IEEE 48.
3. Indoor 15 kV high voltage switchgear cable termination: complete with stress cones, shield grounding devices, and lugs. 3M Quick-Term II, 5620K series, Raychem HVT-152 series, or equal.
4. kV rated submersible, 600 A, elbow-type, non-load break power distribution connector: Elastimold 650 LR series complete with all necessary components, adapters, spade terminals, plugs, caps, connectors, and shield grounding devices suitable for the type and size of cable specified and compatible for connection to existing standard connectors in use at the University. The connector is to be equipped with voltage test points and all necessary bolts and hex nuts for assembling and dismantling without the use of hot-stick tools.

#### Manhole Cable Support Hardware

1. Hot-dipped galvanized continuous concrete pre-set inserts for mounting of steel channel supports: Cantruss RH2C or equal.
2. 41mm x 41mm hot-dip galvanized continuous concrete pre-set inserts for mounting of steel channel supports: Cantruss RH2C or equal.
3. Steel channels for mounting of cable brackets: as specified.
4. Porcelain "slip on" insulators, suitable for use with cable brackets specified: Pursley "Power-Strut" PS-1500 (for single cables) and PS-1501 (for trefoil cable bundle) or equal.
5. Heat shrink boots for cable bracket ends: T&B HSC, Raychem ESC, 3M ICEC, or equal.

#### Duct Allocation Signs in Manholes

1. 216mm x 216mm drawings on standard bond paper, sealed with thermally applied clear plastic laminate on both sides, sandwiched between two clear Plexiglas plates.
2. Install duct allocation signs at each duct entry location in each new and existing re-used manhole.

### **26 01 02 WIRE AND BOX CONNECTORS**

#### Materials

1. Pressure type wire connectors to: CSA C22.2 No.65, with current carrying parts of copper alloy sized to fit copper conductors as required.
2. Fixture type splicing connectors to: CSA C22.2 No.65, with current carrying parts of copper alloy sized to fit copper conductors 10 AWG or less.
3. Bushing stud connectors to: EEMAC 1Y-2 to consist of:
  - i. Connector body and stud clamp for stranded copper conductors.
  - ii. Clamp for stranded copper conductors.
  - iii. Stud clamp bolts.
  - iv. Bolts for copper conductors.
  - v. Sized for conductor as indicated.
4. Clamps or connectors for armoured cable and flexible conduit as required to: CAN/CSA-C22.2 No. 18.

### **26 01 03 WIRES AND CABLES**

#### General Requirements

1. In general, wiring to be used at the University of Victoria shall be:
  - i. Typically use insulated 98% conductivity copper conductor wiring enclosed in EMT (steel) conduit for the general wiring systems unless otherwise indicated.
  - ii. Aluminum conductors are not desirable. Upon special permission from FMEL they may only be permitted for feeder conductors larger than 3/0 AWG.
  - iii. Obtain approval of FMEL for the usage of any TECK wiring. Where permitted, TECK wiring up to 750 system volts to be PVC jacketed armoured cable, multi-copper conductor type Teck90 1000 volt having a PVC jacket with FT-4 flame spread rating.
  - iv. Flexible armoured AC90 cabling (BX) shall not be used for the general wiring system other than final drops to recessed light fixtures in concealed locations. Drops to receptacle outlets are not permitted. AC90 is permitted in tight spaces such as millwork and lab benches.
  - v. All control wiring except HVAC controls as specified in Mechanical Division is to be provided by the Electrical Contractor. This includes low voltage control wiring for motorized blinds and shades, to owner supplied equipment, to door access and security, to assistive hearing system, to audio-visual (AV) equipment.

#### Wire and Cable General

1. Conductors: stranded for 10 AWG and larger. Minimum size #12 AWG, copper.
2. Insulation to be 600 volt RW90XLPE (X link) for the general building wiring in conduit.

3. Use RWU90XLPE for underground installations.
4. Site service sub-circuits, including site lighting, to be minimum #10 AWG for power and #12 for controls. Increase wiring size for lengthy and/or loaded circuits so that system will not exceed the maximum voltage drop as recommended by the Canadian Electrical Code CSA 22.1.
5. Main feeders to be conduit and copper insulated wiring unless otherwise noted on drawings. Provide ground wiring for all conduits below slabs. Increase conduit size as required.
6. Armoured AC90 cable may only be utilized for recessed tee bar luminaire drops from ceiling mounted outlet boxes. "Tite Bite" connectors and their counterparts of other manufacturers shall not be used. Use anti-short connectors. Cable from luminaire to luminaire is not permitted. Allow nominally 900mm (3') extra cable looped and supported in the ceiling space to permit fixture relocations of one tile space.
7. TBS90 #14 AWG stranded shall be used in all switchgear assemblies. Current transformer secondary wiring shall be #12 AWG stranded. Current transformer leads shall incorporate ring type tongues for termination purposes.
8. Conductors are to be colour-coded. Conductors No. 10 gauge and smaller shall have colour impregnated into insulation at time of manufacture. Conductors size No. 8 gauge and larger may be colour-coded with adhesive colour coding tape, but only black insulated conductors shall be employed in this case, except for neutrals which shall be white wherever possible. Where colour-coding tape is utilized, it shall be applied for a minimum of 50mm at terminations, junctions, and pull-boxes and conduit fittings. Conductors are not to be painted.

#### TECK Cable

1. TECK cable may be used in special situations such as feeds to motors and equipment. For all other uses, obtain permission from the University. Cables shall be chemically cross-linked thermosetting polyethylene rated type RW90, 600V with inner jacket of polyvinyl chloride material. The armour shall be interlocking aluminum. The outer jacket shall be low-acid gas-emitting, fire-retardant PVC rated for low temperature, black. Connectors shall be watertight approved for TECK cable.

#### Armoured Cables

1. The use of insulated copper AC90 cable with interlocking aluminum sheathing is permitted for drops to luminaires, not exceeding 3m in length and in difficult confined spaces and millwork.

#### Armoured Fire Alarm Cable

1. The use of flexible armoured fire alarm cable from junction box to ceiling mounted fire alarm device is permitted. Use SECUREX® II cable, fire rated to CSA FT4 requirements. Cable shall be armoured with interlocked aluminum tape armour. Cable armour shall be colour coded "red". This type of cable may also be used for renovations projects where conduit installation is difficult.

#### Wire Installation

1. Install wiring as follows:
  - i. All wires are to be pulled in together in a common raceway, using liberal amounts of approved lubricant.
  - ii. All power circuits connected to isolated ground type receptacles are to have individual separate neutral c/w insulated bonding conductor.

- iii. No combining of circuits onto common neutral will be permitted. Use 2 pole or 3 pole breakers for combined circuits, no connector clips will be allowed.
- iv. All dimmer circuits are to have individual neutral conductors for each circuit.
- v. Group all circuit conductors with their respective neutral conductor and provide identification of circuit number on conductors at all junction boxes.
- vi. Group all cables wherever possible on channels.
- vii. For all control cabling, ground control cable shield.
- viii. Installation of conduit in concrete slabs is NOT permitted unless specifically approved in writing by addendum during tender stage. All conduits shall be surface mounted under floor slabs.

## 26 05 00 COMMON WORK RESULTS FOR ELECTRICAL

### 26 05 01 GENERAL CONSIDERATIONS

#### Mounting Heights

1. Mounting heights for electrical devices shall be as follows where possible. Where these heights cannot be achieved, obtain written instructions from the University for alternate mounting heights.
2. In offices and laboratories, mounting heights for receptacles and communications outlets are generally 150mm above counter height, unless not physically possible.
3. Install electric equipment at following heights unless indicated otherwise:
  - i. Local switches: 1400mm.
  - ii. Wall receptacles:
  - iii. General: 300mm.
  - iv. Above top of continuous baseboard heater: 200mm.
  - v. Above top of counters or counter splash backs: 150mm.
  - vi. In mechanical rooms: 1400mm.
  - vii. Panel boards: as required by Code or as indicated.
  - viii. Communications outlets: 300mm.
  - ix. Wall mounted telephone and intercom outlets: 1500mm.
  - x. Fire alarm stations: 1200mm.
  - xi. Fire alarm bells: 2100mm (or if in conflict with ceiling, 300mm below ceiling).
  - xii. Television outlets: 300mm.
  - xiii. Wall mounted speakers: 2100mm.
  - xiv. Clocks: 2100mm.
  - xv. Thermostats: 1525mm
  - xvi. Doorbell pushbuttons: 1500mm.
  - xvii. Where possible, wall mounted devices such as lighting switches and thermostats shall be aligned vertically.

#### Operating and Maintenance Manuals

1. Submit a copy of operating and maintenance manuals for review, two weeks prior to substantial completion. This will be reviewed and returned within one week.
2. Submit two hard copy sets and one digital copy set on CD of final operating and maintenance manuals for equipment or as requested by the general section of the contract 2 weeks prior to substantial completion of the project. Include descriptive and technical data, all shop drawings, operating procedures, routine and preventative maintenance, wiring diagrams, spare parts lists, warranties, service companies, suppliers for replacement parts, test results, fire alarm certification of verification, electrical inspection authority certificate and contract guarantee.
3. Hard copy manuals shall be inserted in "RED" coloured heavy duty three ring binders, with lettering on the spine identified as "OPERATING AND MAINTENANCE MANUAL", project title and system names.
4. Obtain and include a copy of all variable frequency drive shop drawings provided by the mechanical contractor on the project in manuals.
5. Include in maintenance data:

- i. Details of design elements, construction features, component function and maintenance requirements, to permit effective start-up, operation, maintenance, repair, modification, extension and expansion of any portion or feature of installation.
- ii. Technical data, product data, supplemented by bulletins, component illustrations, exploded views, technical descriptions of items, and parts list. Advertising, sales or generic literature is not acceptable. All operations and maintenance data must pertain to the specific products used.
- iii. Wiring and schematic diagrams and performance curves.
- iv. Names and addresses of local suppliers for items included in maintenance manuals.
- v. Copy of reviewed shop drawings.
- vi. Guarantees and warranties information.
- vii. Test reports and systems demonstration: Include copies of all applicable test reports and manufacturer's letters verifying test completion.
- viii. Certificates: Include a copy of final certificates from electrical inspection authority, fire chief, and other authorities having jurisdiction over the work.
- ix. Schedules: All schedules included in the technical specification (motor schedules, lighting fixture schedules, panel schedules, security zone schedules, fire alarm schedules, low voltage relay schedules, dimmer schedules, etc.), shall be updated to reflect all changes made during tender and construction period.

#### **26 05 02 UNDERGROUND CIVIL WORK (ELECTRICAL) – GENERAL**

1. Site services to buildings require underground services installed in trenches, manholes, reinforced concrete encasement of ducts, etc.
2. This section covers the supply and installation of underground civil work required for electrical installations. The civil work shall include but not be limited to:
  - i. Trenching and excavation.
  - ii. Concrete encasement re-barring, etc. of underground raceways.
  - iii. Manholes and pull boxes.
  - iv. Concrete luminaire bases.
  - v. Sand bedding and back filling.
  - vi. Repairing existing grade finish.
  - vii. Pull pits beneath main switchgear, secondary distribution of centres, and in communications rooms.

#### Protection of Existing Features

1. Contractors are to be made aware of existing features, trees, sidewalks, walkways, roadways, and other items which must be protected from damage.

#### Backfill

1. Sand shall mean screened pit material, free of all organic material. Screen shall eliminate all stones over 5mm in diameter and any sharp debris.
2. Selective granular material shall mean material found in excavation or obtained from a gravel pit, that excludes rubble, hard packed clays, sharp objects or rock that could cut duct or cable, and be free of all stones over 50mm in diameter.
3. Native material, shall mean material found on site, excluding material that would deteriorate over time, for example wood scraps or rubble, and stones over 300mm in diameter.
4. Crushed rock and drain rock shall be as obtained from reputable gravel pit, clean of rubble and fines.

#### Concrete Mix

1. Type 10 Portland cement, min. compressive strength 20 Mpa at 28 days, slump 50-75mm at point of discharge, nominal coarse aggregate.

#### Drainage

1. Floor drain in each manhole to consist of floor drain, backwater valve trap and pipe connection to provide positive drainage to storm drain system.
2. Sump pit 300 x 300 x 125mm with rock drainage only allowed if specifically noted for each location.
3. Provide power connections to sump pumps indicated on mechanical or civil drawings.

#### Manhole

1. Concrete manhole neck to bring cover flush with finished grade or 40mm above grade in unpaved areas.
2. Build up neck with brick and mortar to achieve above.
3. Precast concrete manholes, for primary power and communications services where indicated on plans.
4. Concrete manhole neck to bring cover flush with finished grade or 40mm above grade in unpaved areas.
5. Build up neck with brick and mortar to achieve above.
6. Size 4.3 metres long x 2.5 metres wide x 1.8 metres inside depth. AE Precast Products Ltd. #C-23-“C” Series Manhole Type.
7. Manhole to be complete with knockout windows, steel reinforcement, unistrut channel supports (all sides), pulling irons, circular sump complete with metal cover, grounding sleeve, and #C-23/23A cast iron frame and traffic rated cover marked “Electrical” for power services, and “Communications” for communications service manholes.
8. Manholes to be complete with minimum 610mm deep concrete sump complete with concrete base, cast iron grate, and suitable for 100mm mechanical drainage service entry.
9. Seal all penetrations.

#### Manhole Frames

1. Cast iron manhole frames and covers road rated.
2. Hinged checker plate standard covers for pre-cast manholes or pull boxes.

#### Ground Rods

1. Ground rods – 3 metre copperweld. Provide ground rod to each manhole.

#### Cable Racks



1. Cantruss pre-set inserts for rack mounting, hot dip galvanized cable racks and supports on all faces of manholes and pull boxes – two if side exceeds 1.2 metres long.

#### Luminaire Bases

1. Supply and install luminaire bases consisting of round concrete reinforced bases. In landscape areas, bases are to be 100mm above finish grade and flush with grade at concrete surfaces.

#### Cable Pulling Equipment

1. Pulling irons of galvanized steel rods, size, shape and location as indicated. Standard polypropylene pull rope with tensile strength 5kN continuous in each duct run.

### **26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

#### Grounding – Primary – General

1. This section covers work required for grounding of primary switchgear and for connections to the campus grounding system.

#### Materials

1. Use only ground rod electrodes, copper clad steel 19mm dia by 3m long. A minimum of four ground rods shall be provided and connected to the main grounding bus in the main electrical room.
2. Conductors for installation of campus ground in duct system and manholes shall be PVC-insulated, coloured green, stranded, untinned, soft annealed copper wire size # 4/0 AWG, unless noted otherwise.
3. Conductors: bare, stranded, untinned, soft annealed copper wire, size # 3/0 AWG, for ground bus, electrode interconnections, metal structures, transformers, switchgear, ground connections.
4. Bonding Conductor: # 2/0 AWG stranded soft annealed copper.
5. Conductors for grounding cable sheaths, raceways, pipe work, screen guards, switchboards, potential transformers: PVC-insulated, coloured green, stranded, untinned, soft annealed copper wire, size # 4 AWG.
6. Conductors: No. 3/0 AWG extra flexible (425 strands) copper conductor for connection of switch mechanism operating rod to gradient control mat, fence gates, and vault doors.
7. Cable Sheath Isolating Sleeves: Elastimold or equal, to match 15 kV cable connector kits on campus.
8. Wall-mounted ground bus shall be copper ground bus mounted on insulated supports on wall of electrical room. Bus to be 75mm wide and 6mm thick. Length of bus to suit connection requirements.

#### Grounding Installation

1. Install continuous grounding system including electrodes, conductors, connectors, accessories, as indicated and to requirements of local authority having jurisdiction.
2. Install connectors to manufacturer's instructions.

3. Protect exposed grounding conductors from mechanical injury.
4. Make buried connections, and connections to electrodes, structural steel work, using copper welding by thermit process or approved crimp-on type compressive connectors.

#### Neutral Grounding

1. Connect transformer neutral and distribution neutral together using 1000 V insulated conductor to one side of ground test link, the other side of the test link being connected directly to main station ground. Ensure distribution neutral and neutrals of potential transformers and service banks are bonded directly to transformer neutral and not to main station ground.
2. Interconnect electrodes and neutrals at each ground installation.
3. Connect neutral of station service transformer to main neutral bus with tap of same size as secondary neutral.
4. Ground transformer tank with continuous conductor from tank ground lug through connector on ground bus to primary neutral. Connect neutral bushing at transformer to primary neutral in same manner.

#### Grounding in Manholes

1. Install conveniently located grounding stud, electrode, size 2/0 AWG stranded copper conductor in each manhole.
2. Install ground rod with lug for grounding connection in each manhole so that top projects through bottom of manhole.

#### Cable Sheath Grounding

1. Bond single conductor, metallic sheathed cables together at one end only. Break sheath continuity by inserting insulating sleeves in cables.
2. Use No. 6 AWG flexible copper wire soldered, not clamped, to cable sheath.
3. Connect bonded cables to ground with No. 2/0 AWG copper conductor.
4. Use mechanical connectors for grounding connections to equipment provided with lugs.
5. Use # 4/0 AWG bare copper cable for main ground bus of substation.
6. Use tinned copper conductors for aluminum structures.

#### Campus Ground

1. Extend from existing manhole infrastructure a # 4/0 insulated ground to substation wall-mounted ground bus in main electrical room. Run through 50mm duct.
2. Ground Fault Circuit Interrupters – Class A

#### General Information

1. This section is for equipment and installation for ground fault circuit interrupters (GFCI).
2. The use of GFCI receptacles is also required for use within 1.5m of sinks in laboratories and washrooms.

#### Materials

1. Equipment and components for GFCI: to CAN/CSA-C22.2 No. 144.
2. Components comprising ground fault protective system to be of same manufacturer.

#### Breaker Type Ground Fault Interrupter

1. Single or two pole ground fault circuit interrupter for 15-20 A, 120 V, 1 phase circuit c/w test and reset facilities

#### Ground Fault Life Protector

1. 100 A, 2 pole circuit breaker to supply power to mains of 100 A, 208 V, 3 phase panel and complete with, automatic shunt trip breaker, zero sequence current sensor, facilities for testing and reset, CSA Enclosure 1, surface mounted, and ground fault trip indicator light.

#### Ground Fault Protector Unit

1. Self-contained with 15 A, 120 V circuit interrupter and duplex or single receptacle complete with solid state ground sensing device, facility for testing and reset, and CSA Enclosure 1, flush mounted with stainless steel face plate.

#### System Ground Fault Protection Panel

1. Self-contained panel suitable for 120/208 V, 3 phase, 4 wire, grounded supply with automatic 100 or 225 A breaker with shunt trip, ground fault relay factory set at 10 mA with inverse time delay characteristics from pick-up 1 s to 0.025 s, zero sequence current sensor, provision for testing and reset, and CSA Enclosure 1, surface mounted.

#### Pump Protection Panel

1. Ground fault personnel protection shall be provided for pump control panel circuits rated for 20 hp at 208 V 50 hp at 600 V, 3 phase grounded supply with test button, ground indicator light, reset button, line and load terminal blocks and control terminal block for wiring to starter control, unit sensitivity: 10 mA, and CSA Enclosure 1, surface mounted, contact rating: 5 A, 120 V, 60 Hz.

### 26 05 33 CLEARANCES AND DEPTH OF RACEWAYS

1. Unless specifically stated on plans, the following clearances are to be maintained for all underground raceways, to be used for power cables and communications.
  - i. Between communication and power raceways:
    - a. In concrete encasement – 75mm.
    - b. Direct buried raceway – 300mm.
  - ii. From all gas, water (except landscape sprinkler lines) and sewer utilities:
    - a. 1000mm running parallel.
    - b. 500mm at crossings.

- c. 150mm at crossings is allowed if electrical raceway is concrete encased for length of crossing, plus 1000mm to either side of crossing.
    - iii. From landscape sprinkler lines:
      - a. 1000mm running parallel.
      - b. 150mm at crossings if sprinkler lines are run over electrical lines.
- 2. Unless specifically stated on plans, the following clearances are to be maintained for all underground direct buried cables for power and communications:
  - i. Between communications and power – 600mm.
  - ii. From all gas, water (except landscape sprinkler lines) and sewer utilities:
    - c. 1500mm running parallel.
    - d. 1000mm at crossings.
    - e. 150mm at crossings is allowed if cable is sleeved with duct and concrete encased for 1000mm to either side of crossing.
- 3. Unless specifically stated on the plans, the following depth of raceways shall be a minimum from top of duct:
  - i. Roadways and private property except rock excavation:
    - f. Communications – 600mm.
    - g. Secondary power to 750 volts – 600mm.
    - h. Power above 750 volts – 900mm.
  - ii. Rock excavation:
    - i. All systems – 150mm from the top of concrete encasement. All raceways to be concrete encased with a minimum of 50mm concrete all round.
- 4. Unless specifically stated on the plans all cables shall be buried to a minimum of 1000mm.

### **26 05 33 CONDUIT FOR ELECTRICAL SYSTEMS**

#### Conduit, Conduit Fastenings and Fittings – General

1. The use of AC90 (BX) cabling inside buildings is generally permitted only for luminaire drops and in tight spaces such as millwork and lab benches. Special permission must be obtained in writing from the Consultant and FMEL for uses elsewhere.
2. This section describes the accepted types of conduit and underground ducts for the campus.
3. The use of electric non-metallic tubing (ENT) is NOT permitted on campus.
4. To provide flexibility, conduit home run fill should be limited to 20% in order to accommodate pulling of future conductors.
5. Conduit is not permitted inside concrete slabs for educational buildings. All conduits shall be surface mounted under suspended slabs. Underground conduit shall be “under” the slab.

#### Basic Wiring Method

1. Underground or in concrete exterior to building:
  - i. All wiring shall be in PVC DB2 conduit, complete with bonding conductor sized to suit.
2. Concrete walls and slabs interior to building:
  - i. All wiring shall be in rigid PVC conduit, complete with bonding conductor sized to suit (minimum 3/4”).

- ii. Conduit shall run under slabs-on-grade and NOT in concrete, sized to suit.
  - iii. All wiring in areas of suspended slabs shall be EMT surface mounted to the underside of slab.
3. Partition walls and ceilings:
  - i. All wiring to be run in EMT conduit for branch circuits. EMT for fire alarm and low voltage raceways, and EMT and wire for all feeders and surface wiring in electrical and mechanical rooms.
4. T-bar ceilings:
  - i. EMT and wire to junction box with flexible armoured cable drops for individual luminaires (no feed through wiring to luminaires allowed, except for luminaires butted together). Allow adequate cable to relocate luminaire one T-bar space in any direction.
5. Motors and transformer connections (and all equipment that vibrates):
  - i. Short (600 to 1200mm) PVC jacketed flexible conduit with liquid tight connectors shall be used. Wire shall be stranded for all sizes. Allow sufficient slack to avoid strain on connectors at extreme extension of equipment movement.
6. Surface raceways – interior:
  - i. All surface raceways shall be EMT, except if located without protection in areas susceptible to damage, which shall be rigid steel conduit.
7. Surface raceways – exterior:
  - i. All surface raceways shall be rigid PVC conduit, protected from damage and excessive heating to the Consultant's satisfaction.
8. Gutters/wire-ways:
  - i. Gutters/wire-ways for branch circuits above and below electrical panels shall be a minimum of 250mm high. Depth and width shall be as required by Electrical Code.

#### Location

1. Locate electrical devices on walls with main regard for convenience of operation and conserving wall space, in conjunction with the electrical drawings. Switches, receptacles, fire alarm pull stations, etc. generally to be vertically lined up where items are in the same general location. Adjacent common devices to be installed in common outlet box.
2. Do not install outlets back-to-back in party wall; allow minimum one stud space horizontal clearance between boxes. Install behind all outlets in party walls a Lowry Acoustic backing pad.
3. Locate light switches on latch side of doors. Locate disconnect devices in mechanical rooms on latch side of door.
4. All outlets located on exterior walls to be complete with moulded plastic vapour barriers to maintain integrity of wall vapour barrier system.
5. All raceways and wiring shall be installed concealed in building fabric, except for mechanical and electrical rooms where they shall be installed on the surface.
6. All outlet boxes, junction boxes, and cabinets to hold electrical devices shall be mounted so the equipment can be flush mounted.

7. All junction boxes and other raceway access devices shall be mounted avoid being visible from public areas. Obtain approval for any and all junction boxes that (due to the building design) cannot be concealed.
8. All junction boxes mounted, out of necessity, on surface of solid walls shall be painted to match adjacent surface, with junction boxes painted to match designated system.

#### Installation

1. Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
2. Conceal conduits except in mechanical and electrical service rooms and in unfinished areas.
3. Use electrical metallic tubing (EMT) except above 2.4m not subject to mechanical injury.
4. Use rigid PVC conduit underground, in corrosive areas, and surface mounted in wet areas not subject to damage.
5. Use flexible metal conduit for connection to motors in dry areas, connection to recessed incandescent fixtures without a prewired outlet box, connection to surface or recessed fluorescent fixtures and work in movable metal partitions.
6. Use liquid tight flexible metal conduit for connection to motors or vibrating equipment in damp, wet or corrosive locations.
7. Use explosion proof flexible connections for connection to explosion proof motors. Install conduit sealing fittings in hazardous areas. Fill with compound.
8. Minimum conduit sizes for lighting and power circuits: 21mm.
9. Minimum sizes for conduit home runs shall be 21mm.
10. Provide minimum 50% spare capacity in conduit for all branch circuits.
11. Install fish cord in empty conduits.
12. Run 2-27mm spare conduits up to ceiling space and 2-27mm spare conduits down to ceiling space from each flush panel. Terminate these conduits in junction boxes in ceiling space or in case of an exposed concrete slab, terminate each conduit in surface type box.
13. All conduits shall be fastened to structure with steep straps (no cast type straps allowed).
14. All EMT fittings to be steel (no cast type fittings).

#### Rigid PVC Ducts and Raceway

1. Install PVC conduit and fittings using new PVC cement, approved by the conduit manufacturer. PVC cement to be low VOC type.
2. Clean terminations with solvent and bevel inside edge of field cut conduit.
3. Protect conduit and fittings from water and keep dry while making connections.

4. Secure PVC raceway using PVC clamp on surface runs, and use tie wire in concrete slab when connecting to rebar.

#### EMT Raceway

1. Insure that fittings are installed on raceway to provide effective continuity of raceway ground.
2. Fire Stopping
3. Apply ULC approved fire stopping assembly to all conduit penetrations passing through fire rated walls and floors.
4. Provide shop drawings showing details for each type of application on the project. Shop drawings shall include catalogue data and installation details.
5. For all communication sleeves accessible via ceilings or in stacked closets/rooms passing through floors, provide 2 hour rated STI EZ-PATH assembly. Provide minimum 4 – 100mm square sleeves between each floor and each communication closet/room.

### **26 05 36 CABLE TRAYS FOR ELECTRICAL SYSTEMS**

#### General Information

1. In general, the use of cable tray along corridors is preferred for communications cable installation and management. Where space permits, cable tray shall be minimum 300mm wide and 150mm deep. Ladder type tray with rungs at minimum every 150mm is required. Where there is insufficient space, use basket tray as specified.
2. Cable trays shall also be provided inside communications rooms running along the perimeter of the room.
3. Where cable tray is installed in server rooms, tray will be exposed and will require multiple receptacle outlets of various CSA configurations. This will require confirmation with the FMGT Project Officer prior to design.

#### Cable Tray – Centre Hung Type

1. Centre hung supported tubular member steel tray system, complete with minimum C-1 load rating and triangular 100mm deep rungs spaced at 150mm centres.
2. Tray sections joined by two bolt splice connector complete with 12mm diameter threaded steel rod support assembly.
3. Cable trays to be bottom rung supported nominal 305mm wide.
4. Rungs to be complete with protective end caps.

#### Cable Tray – Basket Type

1. Ceiling steel rod Cantruss rack supported 150mm wide wire basket type tray system, 50mm high, and 50mm x 100mm mesh pattern.
2. Heavy gauge zinc plated carbon steel wire.

3. Provide radiused drop outs at each cable tray termination (5 positions) and 8 positions above optical table.
4. Provide 10mm threaded rods for support of cable tray.
5. Provide plastic protector caps for protection from irregular cuts.
6. Provide 90 degree horizontal elbows (radiused corners) at all turns.

#### Installation

1. Support cable-trough on one or both side(s) depending on if the cable-trough is centre hung or basket tray style.
2. Cable tray system is not to pass through walls. Penetration at all wall locations to consist of minimum 4 – 50mm conduit sleeves, complete with bushings at each end, and sealed around conduits to maintain integrity of wall separation system. Where penetrations pass through fire rated assemblies, use 4 – 100mm square STI EZ-Path fire stopping sleeves.
3. Provide bonding of cable tray system using #6 copper bonding conductors connected to building ground system in accordance with Canadian Electrical Code.

#### Cables in Cable-Trough

1. Lay cables into cable-trough individually using rollers when necessary to pull cables.
2. Secure cables in cable-trough at 6m centres, with nylon ties.
3. Identify cables every 30m width size 2 nameplates.

### **26 05 43 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS**

#### Installation of Cables in Trenches and Ducts

1. The University's power distribution and communications campus backbone consists of underground ducts and manholes which provide durability and flexibility during maintenance operations and when new facilities are being constructed.
2. Consideration shall be given to design new duct-banks that have spare capacity and that provide flexibility for providing services to potential future campus development sites.
3. Typical duct-banks for the campus will include concrete encased ducts that carry power, telephone cabling, copper data communications cabling, fibre optic cabling, security cabling and fire alarm cabling.

#### Cable Protection

1. Provide plastic marker tape with metallic backing strip above all duct-banks in order to facilitate future locating of ducts.

#### Direct Burial of Cables



1. Direct buried cables are to be avoided as much as possible. When needed, they shall be enveloped in sand bedding and separated as required by code.
2. Underground cable splices are not acceptable.
3. Minimum permitted radius at cable bends for rubber, plastic or lead covered cables, 8 times diameter of cable; for metallic armoured cables, 12 times diameter of cables or in accordance with manufacturer's instructions.
4. Cable separation shall be as prescribed by the Canadian Electrical Code.

#### Cable Installation in Ducts

1. Installation of cables in ducts is the preferred underground installation. Cabling shall be installed without splices inside ducts.
2. Use CSA approved lubricants of type compatible with cable jacket to reduce pulling tension.
3. To facilitate matching of colour coded multi-conductor control cables reel off in same direction during installation.
4. Before pulling cable into ducts and until cables are properly terminated, seal ends of lead covered cables with wiping solder; seal ends of non-leaded cables with moisture seal tape.
5. After installation of cables, seal duct ends with duct sealing compound.

#### Markers

1. Mark cable every 150m along duct runs and changes in direction.
2. Mark underground splices.
3. Where markers are removed to permit installation of additional cables, reinstall existing markers.
4. Install cedar post type markers.
5. Lay concrete markers flat and centred over cable with top flush with finish grade.

#### Field Quality Control

1. All cables and wires shall be checked for phase rotation, for continuity, short circuits and grounds. Ensure resistance to ground of circuits is not less than 50 megohms.
2. After installing cable but before splicing and terminating, contractors are to perform insulation resistance test with 1000 V megger on each phase conductor.
3. Provide Consultant with list of test results showing location at which each test was made, circuit tested and result of each test.
4. Remove and replace entire length of cable if cable fails to meet any of test criteria.

#### **26 05 53 IDENTIFICATION FOR ELECTRICAL SYSTEMS**

### Wiring Identification

1. Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.
2. Maintain phase sequence and colour coding throughout.
3. Colour code: to CSA C22.1.
4. Use colour coded wires in communication cables, matched throughout system.
5. Group neutral with associated conductors in junction boxes.

### Conduit, Junction Box and Cable Identification

1. Junction box covers are to be colour coded as follows:
  - i. Fire Alarm – Red
  - ii. Communications – Green
  - iii. Mechanical Controls – Blue
  - iv. Emergency Power – Yellow
  - v. Audio-Visual and Intercom – Orange
  - vi. Security system – White
2. Colour coding for cables/wire shall be as follows: 25mm wide prime colour and 20mm wide auxiliary colour.

	Prime	Auxiliary
up to 250 V	Yellow	
up to 600 V	Yellow	Green
up to 5 kV	Yellow	Blue
up to 15 kV	Yellow	Red
Communications Category 5E	Yellow	
Communications Category 6 or 6A	White	
Other Communication Systems	Green	Blue
Emergency Voice	Red	Blue
Other Security Systems	Red	Yellow

**26 09 00 INSTRUMENTATION AND CONTROL FOR ELECTRICAL SYSTEMS**

**26 09 19 ENCLOSED CONTACTORS**

General

1. Materials and installation for contactors for system voltages up to 600 V.
2. Contactors: to CSA C22.2 No. 14.
3. Mechanically held controlled by pilot devices as indicated and rated for type of load controlled. Half size contactors not accepted.
4. Fused switch combination contactor as indicated.
5. Complete with 2 normally open and 2 normally closed auxiliary contacts unless indicated otherwise.
6. Mount in CSA Enclosure 1 unless otherwise indicated.
7. Include following options in cover:
  - i. Red indicating lamp.
  - ii. Stop-Start pushbutton.
  - iii. Hand-Off-Auto or On-Off selector switch, as indicated.
8. Control transformer as required.

**26 09 23 LIGHTING CONTROL DEVICES**

Low Voltage – System Description

1. The use of central low voltage lighting controls provides the University with energy management capabilities, which enhance its sustainability and reduce greenhouse gas emissions. The central control systems are programmable and tied to the overall campus energy management system.
2. Central low-voltage controls systems are to be provided with low-voltage relays, switches, photoelectric daylighting sensors, programmable scanners, time clocks, occupancy sensors, and vacancy sensors. The preferred vendor for this system is Douglas Controls.
3. In video conferencing spaces and spaces which are provided with dimming fluorescent and/or incandescent lighting, central relay controls with low-voltage switching shall be provided in addition to local incandescent or fluorescent dimmer controls.
4. In classrooms, provide sufficient relays and control switches to accommodate full lighting level, 50% lighting levels, whiteboard illumination, front and back of classroom illumination. The use of luminaires with T5HO fluorescent lamps and stepped ballasts may be appropriate in these spaces.
5. For LEED® projects, special attention to controllability of lighting must be considered in the control system design.

Occupancy Sensor Lighting Control

1. Wall mounted wall switch style PIR occupancy sensors shall have adjustable delayed-off time setting 30 seconds to 30 minutes, and a 180° field of view. Product shall be Wattstopper or Sensor Switch equal.
2. Ceiling mounted PIR occupancy sensors with 120V controls shall have adjustable delayed-off time setting 20 seconds to 15 minutes, 360° field of view, and built-in isolated relay. Product shall be Leviton #ODC0S-I1W or Sensor Switch equal.
3. Ceiling mounted PIR occupancy sensors with 24V controls shall have adjustable delayed-off time setting 15 seconds to 30 minutes, 360° field of view, 24VDC supply, and built-in isolated relay. Product shall be Wattstopper "CI" Series with range suitable for coverage area and complete with Wattstopper power pack or Sensor Switch equal.

#### Photosensitive Daylighting Control

1. Light Level Switch shall be accomplished with indoor ceiling or wall mounted photo conductive cell that switches a circuit for stepped ballasts off when sufficient daylight is sensed, resulting in a 50% lighting output for the luminaires being controlled. Acceptable product: Wattstopper #LS-100 with range suitable for sensing area and complete with Wattstopper power pack.

#### Exterior Lighting Electronic Time Clock/Photocell Control

1. Electronic controls for exterior lighting shall consist of a microprocessor controlled low voltage lighting control panel with adjustments and indications built into face of controller. Douglas #WPC-5577 photometric controller. The system shall comprise of two output groups, each with three Douglas Relay outputs (max two 20A relays per output) and 2 on/off momentary outputs, a master override button built into the control panel, memory backup (7 days), an astronomical clock and a remote photo sensor complete with weatherproofing mounting package. Douglas #WPS-5527. Manufacturer: Douglas or Leviton equivalent.

#### Exterior Lighting Combination Time Clock and Photocell Control

1. Combination time clock and photocell controls shall comprise of:
  - i. Recessed mounted adjustable photocell capable of switching 1500 watt load.
  - ii. A 365 day electronic timing control centre complete with photo control feature.
  - iii. Time clock controls 3 circuits independently, complete with manual bypass switch for each circuit.
  - iv. Shall be complete with 24 hour reserve power timing mechanisms. Manufacturer: Intermatic #ET70415CR or equivalent.
2. Contactor to switch exterior lights to 40 Amp rated poles as required, electrically held controlled by 120 volts from photocell / time clock. Acceptable manufacturers: Square D, Cutler-Hammer.

#### Network Lighting Controls – General Information

1. Lecture theatres and teaching spaces that require dimming controls or controls using Creston audio-visual interface shall be provided with a networked lighting control system with DMX communication interface.

#### Acceptable Manufacturers

1. Lutron Electronics Co. Inc. or approved equal.

2. All lighting control equipment – dimming panels, switching panels, dimming ballasts, control panel and controls – shall be manufactured by a single manufacturer.

#### Panels

1. The networked lighting control system shall be installed in a panel which is completely pre-wired by the manufacturer. These panels and components are to be U.L.C. or CSA marked as appropriate.
2. Panels are dedicated feed through type and are not required to contain branch circuit protection. Branch circuit power is obtained from the associated power panel. Refer to the Dimmer/Switch System details.
3. Panels shall be cooled via free-convection, unaided by fans, and capable of continuous operation to all of these section specifications within an ambient temperature range of 0°C (32°F) to 40°C (104°F).
4. Control panels shall be able to control a “scene” or “pre-set” as a specified look or mood created by different lighting zones set at different intensities.
5. In the event that any of the communication lines to any of the dimmer and/or relay panels is interrupted for any reason, the lights controlled by those panels shall remain at their current levels until the interruption is cleared. In the event of a control station failure or interruption of a communication line to any of the controls, the lights controlled by those stations shall remain at their current levels. The control system shall have non-volatile memory backup that can store all system data for one year minimum. It shall not be necessary to reboot the system manually nor use any tape or floppy disk/hard drive to restore the system once power has been restored – system shall automatically return to its previous state. The main processor shall be protected by an integral isolation transformer and shall meet the ANSI/IEEE specification for transient protection.
6. Control Panel: Lutron Cat. #GRAFIK EYE 3000 System.
7. Dimmer panels shall be constructed of dimmer modules with four circuit dimmer modules rated 20A (16A continuous) at 120V per circuit. Module shall be capable of controlling incandescent, tungsten, magnetic low voltage and neon/cold cathode sources directly. Module shall be capable of controlling fluorescent (using dimming ballasts) and electronic low voltage sources (using electronic transformers) directly. All dimmers shall be voltage regulated so that a  $\pm 10\%$  variation in line voltage shall cause no more than a  $\pm 5\%$  variation in load voltage when dimmer is operating at 40V (5% light output). Filtering shall be provided in each dimmer so that the current rise time shall be at least 350 $\mu$ sec at 50% rated dimmer capacity as measured from 10-90% of the load current waveform at a 90% conduction angle, and at no point rise faster than 30 $\mu$ A/msec. Manufacturers shall note that additional filters may be required to meet this specification. These filters need not be integral to the dimming module, but must be integral to the dimming cabinet.

#### Controls

1. The control panel shall have a built-in dry contact A/V interface for monitoring emergency stand-by power status and activating full brightness scene. Lutron Cat. #GRXAV.
2. Wallstation Controls shall be 2-button remote wall station: For activation of pre-programmed scenes at control panel. Lutron Cat. #SJ2BSL C-Touch remote activator. White finish complete with lockable cover. Wall stations are to be provided on the wall at the front of all lecture theatres and teaching spaces as well as in the lecture booth. Stations shall also be provided at the entrance of lecture and teaching space to provide a pre-set scene for entering and accessing the space safely.

3. In large lecture theatres, lighting shall be controlled in banks running front to back and side-to-side. Control of lamps individually in each luminaire is preferred over dimming.
4. All digital control stations shall be provided with a lockable front hinged cover.
5. Provide 5-50mm conduits from instructor's console to control booth.
6. Provide 25mm conduit from instructor's console to motorised shade operators for low-voltage control wiring.

#### Programming

1. Pre-programming is to be completed by Lutron prior to delivery.
2. Final programming of dimmer system is to be done by Lutron once system is substantially complete.

#### Field Quality Control

1. Testing and Inspection: Complete system is to be tested and inspected in accordance with manufacturer's recommendations.
2. On completion of installation, manufacturer representative shall be notified to carry out site inspection and report any inconsistencies to the Department Representative and Consultant.
3. One copy of the test results is to be provided to Electrical Design Consultant and one copy is to be included in each Maintenance Manual.

#### Spare Parts

1. 2 dimmer modules.

### **26 09 36 MODULAR DIMMING CONTROLS**

#### Dimming Switches

1. Incandescent dimmers shall be full range dimmer designed to produce 0% to 100% brightness control by means of single slider. Dimmers shall be advanced solid-state circuitry with silicon symmetrical switch, LED push button switch separate from slide to turn dimmer on/off, rated 1000 watts at 120V.
2. Electronic low voltage dimmers shall be full range dimmers designed to produce 0% to 100% brightness control by means of single slider. They shall be provided with advanced solid-state circuitry with silicon symmetrical switches, LED push button switch separate from slide to turn dimmer on/off. Rated at 425 watts.
3. Fluorescent line voltage dimmers shall be full range dimmer designed to produce 0% to 100% brightness control by means of single slider. These shall be provided with advanced solid-state circuitry with silicon symmetrical switch and line voltage control interfaces to work with Advance Mark X or Lutron Hi-Lume/Eco-10 T5 and T8 electronic ballasts. Units are to have LED push button switch separate from slide to turn dimmer on/off, rated at 1000 watts at 120V.
4. Fluorescent low voltage dimmers shall be full range dimmer designed to produce 0% to 100% brightness control by means of single slider. These dimmers shall be advanced solid-state circuitry with silicon symmetrical switch with low voltage (0-10VDC) control signal to interface to Advance Mark VII or Motorola Helios T5 and T8 dimming ballasts.

5. All dimmers shall have LED push button switch separate from slide to turn dimmer on/off and be complete with 120V power supply where required, have multi-location capability, be equipped with radio/TV interference filter. Accepted manufacturers: Lightolier Sunrise ZP425QE or Lutron equivalent.

## **26 10 00 MEDIUM-VOLTAGE ELECTRICAL DISTRIBUTION**

### **26 11 01 SUBSTATIONS**

#### Unit Substation to 15kV – General

1. New buildings are to be provided with an indoor unit substation designed to accept 15kV and 25kV primary voltages, however the primary voltage connected will be 15kV.
2. Indoor unit substations are to be provided with:
  - i. Primary switchgear including two incoming 25kV and one 25kV outgoing SF6 gas filled switches.
  - ii. Dual bumpless transfer primary switching controls including uninterrupted power supply, programmable logic controller, HMI control interface and outlet jack.
  - iii. Primary switch contact lights with manual momentary switch located on the primary switch enclosure.
  - iv. Power transformer.
  - v. Secondary switchgear.
  - vi. Digital information metering.
3. The unit substation is suitable for use on a 12.47kV/25kV, 3-phase, 3-wire, 60 Hz grounded system with a 3-phase fault level of 5,000 A.
4. The high voltage unit substation consists of an assembly of high voltage switchgear transformer, bus bar, and all equipment and connections necessary to make a complete installation.
5. Provide DANGER – HIGH VOLTAGE signs for all high voltage switchgear cubicle doors and transformer enclosures.
6. Provide adequate lifting lugs for transformer as well as all cubicle sections.
7. Install all unit substation components and auxiliary equipment in sheet steel cubicles.
8. Cubicles shall be of formed code-gauge sheet steel construction with all panel edges turned into the framework. All panels (including side panels) not installed against walls or adjacent cubicles shall be hinged with “hold-down” bolts. All other panels shall be welded in place. Enclosure panels shall be well braced and reinforced to prevent vibration.
9. Provide keyless porcelain lamps in HV fused disconnect switch and transformer cubicles complete with a labelled flush-mounted switch on the cubicle door of the main switch.
10. All panels on which relays, meters, meter switches, metering test blocks, controls, and other similar apparatus are mounted shall be hinged to give ready access to equipment wiring when the door is opened. These panels shall be completely barricaded from high voltage cubicles.
11. The unit substation shall be assembled by a single manufacturer regularly engaged in the fabrication of such equipment and shall be completely shop assembled and tested prior to delivery to the site.
12. Interlocks shall be provided as shown on the drawings.

13. Provide continuous lamicooid or neatly painted mimic single line diagram fastened to the front of switchgear and extending from cubicle to cubicle.
14. A, B, and C phase designation shall be made obvious in the back of each cell.

#### Quality Assurance

1. Submit 10 copies of production test results to FMGT Representative/Consultant. Do not ship equipment until test results have been accepted by FMGT Representative/Consultant.

#### Extra Materials

1. Include 3 fuse refills for primary switched.

#### Indoor Unit Substation

1. Primary switchgear: Indoor, 25kV, 600 A, 3-phase, 4-wire, interrupting capacity 250 MVA, symmetrical, BIL 95kV.
2. Interior mounted metal-enclosed unit substation.
3. Provide a 15kV class interior mounted metal-enclosed unit substation, c/w provision for dual radial feeders.
4. All sections, high voltage and low voltage, when bolted together shall present a unified aesthetic appearance.
5. The unit substation shall be adequately and naturally ventilated (louvers on the substation roof are not permitted). Louver sizes for the core and coil assembly shall be as recommended by the transformer manufacturer.

#### High Voltage Switchgear Cubicles

1. The high voltage switchgear cubicles shall include a fixed disconnect switch and accessory components, all completely factory assembled and type tested.
2. The cubicles shall be complete with appropriately sized, CSA-approved, split support for high voltage cables and shall be suitable for the installation of stress cone cable terminations specified elsewhere. Details of the terminations shall be provided on submission of shop drawings. Terminals shall be pre-drilled holes to accept one-hole crimp-on type compression lugs.
3. Service entrance cubicles shall have provision for padlocking by Owner.
4. The minimum rating of the integrated assembly shall be as follows:
  - i. Voltage class: 12.47/25kV.
  - ii. BIL: 95kV.
  - iii. Minimum short circuit capacity: 250 MVA at 25kV (symmetrical for all current carrying components).
  - iv. 60 Hz withstand 55kV for circuit breakers.
  - v. Main bus, continuous current: 600 A.
5. Bus bar supports shall be NEMA BIL rated epoxy or porcelain insulators. All bus bars shall be designed to withstand thermal and electromagnetic stresses at the specified ratings and shall be tin-plated copper construction.



6. Nameplates shall be permanently fixed to the exterior of each enclosure indicating:
  - i. Manufacturer's name.
  - ii. Switchgear kV.
  - iii. Switchgear BIL.
  - iv. Switchgear maximum short circuit MVA.
  - v. Switchgear momentary amperes.
  - vi. Switchgear fault closing amperes.
  - vii. Switchgear continuous bus amperes.
  - viii. Switchgear year of manufacture.
  - ix. Switchgear drawing numbers.
  - x. Circuit breaker catalogue number.
7. The high voltage switchgear shall be designed, manufactured and tested in accordance with CSA 22.2 No. 31 and shall bear CSA approval label and meet the requirements of the local inspection authority.

#### Bus Bars

1. Three phase and full capacity neutral bare bus bars, continuous current rating 600 A extending full width of multi-cubicle switchboard suitably supported on insulators.
2. Main connections between bus bars, major switching components of continuous current rating to match major switching components.
3. High conductivity copper for bus bars and main connections.
4. Brace bus bar system to withstand stresses resulting from short circuit currents specified.
5. Tin surfaced joints, secured with non-corrosive bolts and washers, tightened with torque wrench in accordance with manufacturer's recommendations.
6. Identify phases of bus bars by suitable markings.
7. Bus bar connectors when switchgear shipped in more than one section.

#### Grounding

1. Copper ground bus not smaller than 60mm x 6mm extending full width of multi-cubicle switchboard and situated at bottom.
2. Lugs at each end for size 4/0 AWG grounding cable.
3. Bond non-current carrying parts, including switchgear framework, enclosure and bases to ground bus.

#### Dual Primary Load Interrupter Switches

1. 15k/25V, 600A continuous, 3-pole, gang-operated, SF6 gas filled, non-automatic type. All arcing accompanying interruption shall be contained within completely enclosed interrupting units. The units shall be mechanically operated by and interlocked with the interrupter blades so as not to open until the blades have cleared the main contacts by a distance greater than the external flash over distance across the interrupting unit. Manual remote operating HMI interface permitting operation of switches from a safe distance is required.
2. Interrupting rating to match that of switchgear.

3. Inspection windows shall be of wired safety glass or laminated heat-tempered safety-plate glass, gasket mounted at the front. Windows shall be so located that the open and closed position of the switches can be readily seen from the exterior of the enclosure.
4. Live-line neon-type indicating lights shall be connected on each phase of the incoming cubicles. Indicating lights shall be connected to the line side of the disconnect switch and shall be visible through the inspection window.
5. Operating handles shall be externally mounted and non-removable and shall provide for latching and padlocking in open positions. They shall swing in a vertical plane normal to the front face of the switchgear.
6. Provide two Form C contacts on each load break switch. Wire from one contact on each switch to 2 status inputs on the digital metering system (2 separate status points for each contact). The contacts will be wired to indicate which feeder is currently energized and in conjunction with primary parallel transfer system.
7. Provide Kirk key type interlocking as shown on the drawings with 2 keys and 3 locks as shown. Provide full operating instructions as indicated on drawings inscribed on lamicoid labels and installed at the operating handle location of each load break switch.
8. Provide inspection luminaires to observe the open/closed status of load break switch contacts. Luminaires shall have keyless porcelain lamp holders, complete with 100W rough service lamp and a labelled flush-mounted switch on the cubicle door of the load break switch.

#### Dual Primary Parallel Transfer System

1. Provide a complete dual primary parallel transfer switch system as indicated on drawings and specified herein.
2. Key Interlock Synchronization Control Station.
3. Provide control station as shown on the drawings and completely manufactured, pre-wired, and tested at the factory. Submit factory test reports to the Consultant.
4. The synchronizing check relay shall be verified by the independent testing agency for phase angle allowance, and voltage difference. This testing will be required to meet IEEE/ANSI/NETA standards. The standard of acceptance shall be the power system simulator microprocessor based relay test set known as the Doble System. Sync-check relays shall be Basler BE1-25 M1E-A6P-N4S3F.
5. The programmable relay shall be proven for all required functions and tested, commissioned, and witness verified, to the satisfaction of the Consultant and electrical maintenance staff. Programmable relay shall be Moeller "Easy" 618-AC-RC.
6. Provide solenoid operated key release designated as "K1" on the drawings, complete with 1 N.O. and 1 N.C. auxiliary contacts.
7. Provide test switches as shown on the drawings. Test switches shall be ABB/Westinghouse Flexi-test type FT-1 or equivalent.
8. Provide adjustable volume, selectable tone alarm horn, Edwards 5540B or equal.
9. Provide a locking handle for the control station front door. Key for the front door handle shall be identical to substation.

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10. The manufacturing and pre-wiring of control station to be of matching quality and appearance to unit substation equipment.
  11. Potential Transformers:
    - i. Potential Transformers (PTs) shall comply with the latest edition of CAN3-C13 and IEEE C57.13.
    - ii. Provide PTs of the number shown on drawings complete with heavy gauge steel draw-out assembly, disconnecting and grounding means, and primary and secondary fuses. The PTs shall have the following characteristics:
      - a. Insulation: 15kV, 95kV BIL.
      - b. Ratio: as shown on drawings.
      - c. Continuous thermal rating (30°C rise above 55°C ambient): minimum 500VA.
      - d. CSA accuracy class: 0.3 WXYZ, 0.6 ZZ.
    - iii. The steel draw-out assembly shall typically include all the standard features of the switchboard manufacturer's 15kV class PT drawer, complete with pre-drilled mounting provision for a second PT core. The drawer shall be a compact assembly designed to fit into the switchboard cubicle.
    - iv. PT drawers shall be completely manufactured, pre-wired, and tested at the factory. Submit factory test reports to the Consultant.
    - v. Provide warning signs on PT drawer-out assemblies.
    - vi. Provide solid bus bar taps complete with bus bracing and support insulators from the switchgear main bus to the PT-1 and PT-2 high voltage stab connectors. Cable taps are not acceptable unless factory test results are submitted for Consultant's approval, showing compliance with BIL rating of 95kV crest.
  12. Switchboard and Control Station Wiring:
    - i. Provide the monitoring and control devices complete with all necessary wiring, fuses, fuse blocks, and terminal blocks for external and internal connections. Identify all terminals clearly with the appropriate control circuit wire numbers.
    - ii. All control wiring shall be Type TBS or SIS and shall conform to CSA C22.2 No. 31. Provide wire numbering sleeves for all conductors.
  13. Relay Programming:
    - iii. Provide two non-volatile memory cards EASY-M-16K, for use with the Moeller programmable relay. One card will be used to load a standardized control program. The second card shall be a spare. Program the relay as follows:
      - a. Relay starts in RUN mode when the power is switched on (to ride through momentary power interruption when switching CS-1).
      - b. If control power to the relay is on, and I1 is not turned on with 1 minute of I2 being turned on, initiate alarm; otherwise, turn to Q1 to proceed with paralleling.
      - c. If control power to the relay is on, and I2 is on, and I4 and I5 are both off continuously for more than 5 minutes, initiate alarm.
      - d. If I1 is on and I2 is on, initiate alarm.
      - e. If I2 remains on for more than 5 minutes, initiate alarm.
      - f. Alarm: Flash Q2, turn on Q3, and turn on Q4 to sound the horn.
      - g. Horn silence: If I3 is turned on momentarily, turn off Q4 and check all "initiate alarm" conditions listed above. If any alarm condition remains, continue flashing Q2, even though the horn is turned off. If alarm conditions have all cleared, turn off Q2.
    - iv. Submit full program printout and ladder-type logic circuit diagram for Consultant's approval.
    - v. Upon receiving the Consultant's approval, store the circuit diagram, as well as all the parameter settings for the circuit diagram, and all the system settings in both memory cards.

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- vi. Provide a 4 hour training session for UVic personnel in the use and programming of the relays.
  - vii. Demonstrate, during the training session, how to program the circuit diagram and how to transfer the program to relays.
  - viii. Hand over both memory cards to UVic upon completion of working session.
14. Field Tests:
- ii. Perform tests in accordance with University requirements.
  - iii. Inspect and test load break switches as follows:
    - a. Inspect and check quick-make, quick-break operation.
    - b. Check contact resistance ("millivolt drop" test)
    - c. Check operation of all auxiliary contacts.
    - d. Test all interlocking procedures.
    - e. Fully test the correct and safe operation of the parallel transfer system.
15. The entire system and its operation shall be demonstrated with operational training of the procedures, calibrations, and safety interlocks to the electrical maintenance staff. Allow for minimum 2 training sessions for the staff.

## **26 12 16 DRY-TYPE, MEDIUM-VOLTAGE TRANSFORMERS**

### General

1. Dry type medium voltage transformers shall be designed and included in the primary unit substation. The transformer shall be rated for 115,000kV and 25,000kV primary but connected to and fused for 15,000kV.
2. The unit shall be kept heated and dry to prevent moisture and dampness from penetrating transformer.

### Shop Drawings

1. Shop drawings shall include:
  - i. Dimensioned drawing showing enclosure, mounting devices, terminals, taps, internal and external component layout.
  - ii. Technical data shall include kVA rating, primary and secondary voltages, frequency, 3-phase, polarity or angular displacement, full load efficiency, regulation at unity of pf, BIL, insulation type, and sound rating.

### Control Submittals

1. Submit to FMGT Representative/Consultant 6 copies of standard factory test certificates of each transformer and type test of each transformer in accordance with CSA C9.

### Transformer Characteristics

1. Transformers shall be as follows:
  - i. Type: 3-phase, dry type natural air ventilated, ANN (T type or Scott connection type not acceptable).
  - ii. Ratings: 300kVA.
  - iii. Voltages: Primary: 25000 V delta.
  - iv. Secondary: 120/208 V wye, solidly grounded.
  - v. Frequency: 60 Hz.
  - vi. Coil Winding Material: Copper.

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- vii. Insulation Class: Class H (Class 220 system) non-hygroscopic, VIP type.
  - viii. Impedance: Approximately 6.0% at 135°.
  - ix. Voltage Taps: 4 full capacity taps, 2 1/2% each, 2 above and 2 below rated voltage.
  - x. Sound Level: Maximum 68 dB when installed on vibration isolators within enclosure at ANN rating.
  - xi. Voltage Class: 15kV.
  - xii. BIL: 95kV.
  - xiii. Max. Full Load Temperature Rise: 115°C average temperature rise for the windings measured by resistance when operating continuously at full load in 40°C maximum ambient.
  - xiv. Max. Magnetizing Inrush Current: 12 times rated full load current.
2. Provide a ventilated formed sheet-steel enclosure with bolted removable sides compatible with enclosures of adjacent cubicles. Enclosure panels shall be well braced and reinforced to prevent vibration. Provide transformer with "coil-face taps" behind a hinged locked door key-interlocked with the transformer primary disconnecting device such that it is impossible to open the door with the switch closed. Identify the door as to function and affix thereto a nameplate with detailed connection diagram, key-interlocks, and instructions for tap-changing.
  3. Provide for transformer an enclosure-mounted thermometer and a thermostat having its temperature-sensing element affixed to the core and coil assembly in such a way as to best sense the winding temperature. Remote current actuated sensing devices are not acceptable. Set the thermostat to operate main fusible load interrupter shunt trip mechanism and a remote bell when the temperature reaches 100% of this rating. Wire via identified terminals in the control cubicle section of the low voltage switchboard for extension by others to remote Building Alarm Panel/Building Automation System.
  4. Insulation panels on the interior of transformer enclosures shall be provided if necessary to maintain electrical clearances.
  5. Provide flexible connections between transformer and high voltage and low voltage bus bars.
  6. Each transformer shall have vibration dampers, placed between core/coil and structural members.
  7. Provide terminal board, tap changing links, and suitable solderless connections.
  8. Mount transformer core and coil assemblies on vibration isolators and restrain with Mason Industries Type "Z41011" snubbers.
  9. Special additional features shall be as follows:
    - i. All terminations shall use a minimum of 2 bolts.
    - ii. All connections shall be made from flat bus bar for solid bolting (clamped round rod not allowed).
    - iii. Solid material shall be used for coil end blocks.
    - iv. All bus bars shall be fully insulated.
    - v. All bus bar mounting hardware shall include Belleville washers.
    - vi. All non-conductor mounting shall have 2 lock nuts.
  10. Transformers shall be supplied with a copper grounding pad at the base.
  11. Nameplate shall be installed on transformer clearly showing the following information.
    - i. Manufacturer's name.
    - ii. Transformer serial number and year of manufacture.
    - iii. Rated kVA.

- iv. Rated high and low voltage levels.
  - v. Rated frequency.
  - vi. Connection diagram and physical terminal markings.
  - vii. Percentage impedance at rated voltage.
  - viii. Temperature rise (or total temperature).
  - ix. Insulation class.
  - x. HV BIL.
  - xi. Voltage Tap data.
  - xii. Total weight of transformer.
12. Transformer shall be manufactured and tested (production tests) in accordance with CSA C9-M1981 incorporating modifications as specified herein. Submit production test reports.
  13. Transformer shall be manufactured by Square D, Hammond Manufacturing Co. Ltd., Canadian General Electric Co. Ltd., ABB Inc., Skyway, Magnetek-Polygon, Tracon Engineering, or approved equal subject to compliance with these specifications.
  14. Transformer manufacturers listed above as well as all manufacturers requesting approval during the tender period must submit the following information pertaining to total losses (iron, copper, and other miscellaneous losses) no later than 10 days prior to tender closing. The figures shall include transformer enclosure losses:
    - i. No load.
    - ii. 25% load.
    - iii. 50% load.
    - iv. 75% load.
    - v. 100% load.

#### Enclosure

1. Fabricated from sheet steel.
2. Bolted removable panels for access to tap connections, enclosed terminals (fan brackets, fans, other accessories).
3. Conductor entry:
  - i. Knockouts.
  - ii. Potheads.
  - iii. Junction boxes.
  - iv. Bushings.
  - v. Clamping rings.
  - vi. Entry for (bus bars, cable).

#### Accessories

1. Winding temperature detector relay and sensing elements 2 sets of SPDT contacts.
2. Wiring and terminal box for protective devices.
3. Digital type winding temperature indicator with alarm contacts.
4. Fans for forced air cooling, (\_\_\_\_) V, (\_\_\_\_) phase, 60Hz, with thermostat control.
5. Grounding terminal: inside of enclosure.

#### Field Quality Control

1. Energize transformers and apply incremental loads:
  - i. 0% for 4 hours.
  - ii. 10% for next 1 hour.
  - iii. 25% for next 2 hours.
  - iv. 50% for next 3 hours.
  - v. Full load.
  - vi. At each load change, check temperatures ambient, enclosure and winding.
  - vii. Adjust cooling fan controls if required.

#### **26 13 16 MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHGEAR**

##### Disconnected Switches – Fused and Non-Fused – General

1. Fusible or non-fusible, horsepower rated disconnect switch in CSA Enclosure 1, to CAN/CSA C22.2 No. 4 size as indicated.
2. Provision for padlocking in on-off switch position by three locks.
3. Mechanically interlocked door to prevent opening when handle in ON position.
4. Fuses: size as indicated, in accordance with standards.
5. Fuse Holders: to CSA C22.2 No. 39 relocatable and without adaptors, for type and size of fuse indicated.
6. Quick-make, quick-break action.
7. ON-OFF switch position indication on switch enclosure cover.

##### Fusible Load Interrupter Switch

1. 3-pole, gang-operated, 24kV, 600 A continual, non-automatic load interrupter switch. Operating handle externally mounted and non-removable, and provides for latching and padlocking in open position. It shall swing in a vertical plan normal to the front face of the switchgear. Provide Kirk key type interlocking as shown on the drawings. Include full operating instructions on a nameplate mounted above the opening handle of each unit.
2. Continuous full load rating: 600 A, interrupting rating: 20 kA symmetrical.
3. Voltage rating: 25kV.
4. Interphase barriers:
  - i. Inspection window mounted at the front. Window located so that the open and closed position of the switch can be readily seen from the exterior of the enclosure.
5. Interrupting rating that of switchgear.
6. Fixed operating handle.
7. Provide non-renewable current-limiting type fuses. Provide 3 spare fuses of the same type and rating, and install a separate metal cabinet in the electrical room.

#### Load Break Switch

1. Indoor load break switch with integral fuse holders.
2. Ratings:
  - i. Voltage: 7.2/12.5kV
  - ii. BIL: 95kV
  - iii. Continuous current rating: 600 Amps
  - iv. Interrupting capacity: 250 MVA
  - v. Fault closing (RMS): 20,000 Amps
  - vi. Momentary rating (RMS): 40,000 Amps
3. Switches:
  - i. Gang operated with manual actuator that can be locked in the "OFF" position and position indicator. Phase to phase and phase to ground insulating barriers. Energized components to be supported from the mounting frame on porcelain insulators. Provide current-limiting fuses equipped with striker pins to give blown fuse protection (failure of one fuse to open other phases). Provide 3 spare fuses mounted at the cubicle.
4. Trip Power: Provide adequate capacitor power supply for automatic tripping of the load break switch.
5. Trip Relays: Ground fault on secondary side of transformer. Thermal relay to trip on high transformer temperature.

#### Main Dry Type Transformer

1. Refer to Section regarding Dry Type, Medium Voltage Transformers.
2. Secondary Switchgear
3. Secondary switchgear: indoor, 120/208V, (\_\_\_) A, 3-phase, wye connected, maximum short circuit current (42) kA, manufactured to CSA C22.2 No. 31.
4. Matches primary switchgear enclosure construction and outline exactly.
5. Cubicles contain:
  - i. Digital metering system complete with current transformers.
  - ii. Distribution circuit breakers.
  - iii. Copper bus including double capacity neutral from transformer to distribution cubicles including vertical buses. Bus ratings as per drawings.
6. The switchboard has provision for all outgoing feeder cables as well as allowance for future cables.
7. Distribution circuit breakers:
  - i. Moulded-case, fixed-mount with bus extensions for rear connection. 942) kA 1.C. min. Adjustable thermal-magnetic trip elements or adjustable electronic trip units per drawings. Tripping characteristics shall be set per the coordination study requirements.
8. Digital metering system: refer to Section Metering and Switchboard Instruments.

#### Equipment Identification

1. Provide equipment identification in accordance with Section – Electrical General Requirements.



2. Nameplates: Switchgear designation: label – white plate, black letters, 30mm high lettering, engraved Main 12.5kV Switchgear, L.R.C.

#### Coordination Study

1. Provide a Computer Programmed System Coordination Study using ETAP software, prepared on time characteristic curves plotted on KE form #485258 log graph paper, showing the system selectively from the main substation down to the largest low voltage breaker on the main secondary switchboard for this project. The study will be completed and stamped by a Professional Engineer registered in B.C. The study shall include the following:
  - i. Supply authority's relays or fuses protecting the incoming service.
  - ii. Main and feeder protective devices necessary to insure coordination.
  - iii. Main feeder cable damage curve.
  - iv. Transformer single and 3-phase thermal damage curve.
  - v. Symmetrical and asymmetrical fault current calculations will be completed and recorded, verifying protection of various elements of the system.
  - vi. A summation chart showing all ratings and settings with reference to the appropriate curve.
  - vii. Recommendations and conclusions of the effectiveness of the coordination study.
  - viii. Protective devices associated with the largest motor.
  - ix. Protective devices associated with the standby emergency power plant.
  - x. The drawings will not be hand drawn but shall be of computer graphics quality.

#### Acceptable Manufacturers

1. Subject to full compliance with the requirements of these specifications, equipment supplied by the following distributors/manufacturers is acceptable:
  - i. Siemens Electric.
  - ii. Schneider Group.
  - iii. Cutler Hammer.

**26 20 00 LOW-VOLTAGE ELECTRICAL TRANSMISSION**

**26 21 00 LOW-VOLTAGE ELECTRICAL SERVICE ENTRANCE**

Service Equipment – General Information

1. This section applies to service entrance rated service equipment and buildings not equipped with a unit substation.

Service Entrance Board

1. Service entrance board shall have cubicles, free standing, dead front, size as required. Frame and structure of enclosure and all components to be secured to earthquake standards.
2. These boards shall have a barrier metering section from adjoining sections and be compliant with B.C. Hydro metering standards.
3. Bus bars and main connections shall be copper.

Moulded Case Circuit Breakers

1. Fully rated for available fault.
2. Common-trip breakers with single handle and trip mechanism for multipole applications.
3. Magnetic instantaneous trip elements in circuit breakers, 400A and above, to operate only when the value of current reaches setting. Trip settings on breakers with adjustable trips to range from 3-10 times current rating.

Moulded Case Circuit Breakers – Current Limiting

1. Fully rated for available fault.
2. Common-trip breakers with single handle and trip mechanism for multipole applications.
3. Breakers up to 225 Amp to limit fault (RMS Symmetrical Amps) to 10,000A at 51,600 Amp input.

Fusible Disconnects

1. Disconnect switches shall be heavy duty, lockable position, complete with HRC fuses, quick make/quick break mechanism, adapted for HRC fuses.

Fuses

1. All fuses shall be designed for special fault limiting.
2. Fuse sizes 30A – 350 Amp shall be bus low peak LPN-RK1 (or equivalent fuse providing equal or better fault limiting characteristics).
3. Fuse sizes 400 – 600 Amp shall be bus T-tron type JJN (or equivalent fuse providing equal or better fault limiting characteristics).

#### Grounding

1. Copper ground bus extending full width of cubicles and located at bottom.
2. Copper lugs at each end for size #4/0 grounding cable, connect to main ground bus.

#### Equipment Identification

1. Provide equipment identification nameplates with:
  - i. White plate, black letters, size 30mm lettering.
  - ii. Complete board labelled: "120/208 600V".
  - iii. Branch disconnects labelled: "Feeder Panel \_\_\_\_\_".

#### Manufacturers

1. Manufacturer: Square D, Cutler-Hammer, Seimens.

### **26 23 00 LOW-VOLTAGE SWITCHGEAR**

#### General

1. Materials and installation for low voltage switchgear for controlling relatively large loads – 2000 A or larger.
2. Provide and install a complete distribution centre as indicated on the plans.
3. The available space is restrictive, and the electrical equipment has been designed to accommodate this. All proposed manufacturers shall take particular note of this when pricing equipment, and include for any variations to their standard equipment in the tender sum.
4. This section of specification includes main distribution centres, and fused disconnects in main distribution centres.

#### Shop Drawings & Product Data

1. Submit shop drawings and product data that indicates:
  - i. Floor anchoring method and foundation template.
  - ii. Dimensioned cable entry and exit locations.
  - iii. Dimensioned position and size of bus.
  - iv. Overall length, height and depth of complete switchgear.
  - v. Dimensioned layout of internal and front panel mounted components.
2. Include time-current characteristic curves for circuit breakers and fuses rated 250A and higher.

#### Storage and Protection

1. Store switchgear on site in protected, dry location. Cover with plastic to keep off dust.
2. Provide energized strip heater in each cell to maintain dry condition during storage.

#### Extra Materials

1. Provide maintenance materials including:
  - i. 3 fuses for each type above 600 A.
  - ii. 6 fuses for each type up to and including 600 A.

#### Rating

1. Secondary switchgear: indoor, (347/600) (120/208) V, 3 phase, 4 wire, 60 Hz, minimum short circuit capacity (65) kA (RMS symmetrical), in amperage capacity sized to Canadian Electrical Code plus a 25% spare capacity.

#### Enclosure

1. Main incoming section to contain:
  - i. Moulded case circuit breaker sized as indicated.
  - ii. Digital metering.
2. Distribution sections to contain:
  - i. Moulded case circuit breakers sized as indicated.
  - ii. Copper bus, from main section to distribution sections including vertical bussing.
3. Metal enclosed, free standing, floor mounted, dead front, indoor, CSA Enclosure 1 (2) cubicle unit.
4. Access from front (and rear).
5. Steel channel sills for base mounting in single length common to multi-cubicle switchboard.
6. Interior lighting: 100 W lamp in porcelain lamp-holder in each cubicle with externally mounted switch and pilot light.
7. Receptacle: 120 V, single phase, 60 Hz, duplex, U-ground, in each cubicle.

#### Bus Bars

1. Three phase and full capacity neutral bare bus bars, continuous current rating, self-cooled, extending full width of cubicles in the switchboard, suitably supported on insulators.
2. Main connections between bus and major switching components to have continuous current rating to match major switching components.
3. Bus bars and main connections: 99.3% conductivity copper.
4. Provision for extension of bus on both sides of unit without need for further drilling or preparation in field.
5. Tin plated joints, secured with non-corrosive bolts and Belleville washers.
6. Identify phases of bus bars by suitable marking.
7. Bus bar connectors, when switchboard shipped in more than one section.

#### Grounding

1. Copper ground bus not smaller than 50mm x 6mm extending full width of cubicles inside the switchboard and situated at bottom.
2. Copper lugs at each end for size #4/0 grounding cable, connect to main ground bus.

#### Ground Fault Unit

1. For main breakers rated at 1000 amps, 347/600 volt or higher or 2000 amps at 120/208 volt or higher, provide ground fault breaker unit.

#### Moulded Case Circuit Breakers

1. Rated for fault as indicated on one line.
2. Common-trip breakers with single handle and trip mechanism for multipole applications.
3. Magnetic instantaneous trip elements in circuit breakers, 400A and above, to operate only when the value of current reaches setting. Trip settings on breakers with adjustable trips to range from 3-10 times current rating.
4. Manufacturer: Square D, Cutler-Hammer.

#### Moulded Case Circuit Breakers – Current Limiting

1. Rated for fault as indicated on one line.
2. Common-trip breakers with single handle and trip mechanism for multipole applications.
3. Breakers up to 225 Amp to limit fault (RMS Symmetrical Amps) to 10,000A at 51,600 Amp input.
4. Manufacturer: Square D, Cutler-Hammer.

#### Fusible Disconnects and Fuses

1. Disconnect switches shall be heavy duty, lockable position, complete with HRC fuses.
2. Disconnects shall have quick make/quick break mechanism.
3. Disconnects shall be adapted for HRC fuses.
4. Manufacturer: Square D, Cutler-Hammer.

#### Fuses

1. All fuses shall be designed for special fault limiting.
2. Fuse sizes 30A – 350 Amp shall be bus low peak LPN-RK1 9or equivalent fuse providing equal or better fault limiting characteristics).
3. Fuse sizes 400 – 600 Amp shall be bus T-tron type JJN (or equivalent fuse providing equal or better fault limiting characteristics).

#### Equipment Identification

1. Nameplates:
  - i. White plate, black letters, size 7.
  - ii. Complete switchgear labelled: "(120) (208) (600) V".
  - iii. Main cubicle labelled: "Main Breaker" or "Main Switch".
  - iv. Branch disconnects labelled: "Feeder Panel \_\_\_\_\_".

#### Low Voltage Lighting Switching System

1. Low voltage relays shall be mounted in lighting relay cabinet sized to hold relay groups complete with barriers for relays from different sources, sequencers/scanners/scheduler, nodes, modules, controls, and transformer. Each relay cabinet shall be provided with 4 spare relays minimum. Control relays for new cabinets to be 2 wire, latching, 20A, 1-pole HID type. Douglas #WR-6161 and control relays for KO type cabinets to be 2 wire, latching, 20A, 1-pole KO mount type. Douglas #WR-6221. Provide additional enclosures as required to house new relays.
2. Transformer shall be 120V primary/24V secondary, 40VA steady draw. Douglas #WR-4075-120. Source of power to transformer shall be from emergency power distribution.
3. Sequencers/scanners shall provide programmable Douglas sequencers/scanners #WRS-2224.
4. Systems shall have network nodes at each lighting control panel for communications between panels using LON Works protocol. Douglas #WNX-2624.
5. Low voltage switches shall be Douglas low voltage switches complete with mounting brackets and brushed stainless steel cove plates. Provide filler plates in unused button sections. Switches shall be:
  - i. 2 wire LED switches Élan Series capable of switching up to minimum 8 low voltage relays. Douglas #WR-8600 Series.
  - ii. 2 wire mullion type #WN-3851/WN-38012 capable of switching up to minimum 4 low voltage relays.
  - iii. 2 wire non-LED switches #WR-8001 capable of switching up to minimum 8 low voltage relays.
  - iv. Programmable data line switches to control groups of relays from anywhere in the W-2000 network (i.e. useful for master switching stations). Douglas #WNS-2300 Series.
  - v. Key switches to be Douglas #WRK-8611.
6. Provide LAN/web-based interface for remote monitoring by UVic Electrical Shop. Douglas Network Manager #WNP-2150. Provide data outlet at lighting controls location in electrical room and connect to network manager.
7. Provide 120V relay connected to local lighting circuit. Connect this relay to a delay timer (Douglas #WTS-4181) and connect the delay timer output to the programmable scanner input to indicate power failure. In the event of a power failure, all lighting relays for circuits from emergency power panel to be enabled.

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### 26 24 13 SWITCHBOARDS

#### Metering and Switchboard Instruments – General

1. The University requires that all main service power distribution to be provided with Owner's digital information metering. The metering equipment must also be provided with Ethernet port for connection to the campus central monitoring system.
2. The use of meters can be a valuable tool for monitoring energy consumption as well and monitoring abnormalities such as low/high power factor, harmonic distortion and phase imbalance.
3. The type of digital metering in this section is typically not suitable for achieving the LEED® measurement and verification credit due to cost. For LEED® measurement and verification, the use of DDC system CT's is acceptable.
4. Digital metering products shall be Power Measurements 7550 ION Digital Metering System for educational buildings and Power Measurements 7330 ION Digital Metering System for residential buildings. These meters shall measure the following as a minimum:
  - i. Meter to display true RMS value of: A – 3-phase current, V – L to L or L to N, 3-phase voltage, kW – kilowatts, kVA – kilovolt amperes, KVAR – kilovolt amperes reactive, Pf – power factor, F – frequency, kWd – kilowatt demand, Ad – amperes demand, kWh – kilowatt hours, programmable LED for energy (kWh) pulsing, Vuax - auxiliary input to 120 V AC/DC.
  - ii. Record and store the following information in meter memory: V – max/min at 1 second interval, A – max/min at 1 second interval, F – max/min at 1 second interval, kW – max/min at 1 second interval, Pf – max/min (or kVA max/min) at 1 second interval, kWd – at field programmable intervals of 1 minute to 30 minutes; set at 1 minute, Ad – per kWd.
5. Connection of Ethernet to campus monitoring system will be provided by University forces.

### 26 24 16 PANELBOARDS

#### Panelboards Breaker Type – General Information

1. Panels may be recessed in walls in corridors of buildings, however, it is preferable to have such equipment located in electrical rooms and closets.
2. All panels shall have hinged lockable front doors.

#### References

1. Canadian Standards Association (CSA International)
  - i. CSA C22.2 No. 29 latest edition, panelboards and enclosed panelboards.

#### Panelboards

1. Panelboards: to CSA C22.2 No. 29 and product of one manufacturer.
  - ii. Install circuit breakers into panelboards before shipment.
  - iii. In addition to CSA requirements manufacturer's nameplate must show fault current that panel including breakers has been built to withstand.
2. (250) (600) V panelboards: bus and breakers rated for A (symmetrical) interrupting capacity as required.

3. Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.
4. Panelboards shall be provided with minimum 50% spare capacity for future breaker additions.
5. Two keys for each panelboard and key panelboard alike.
6. Copper bus with neutral of same ampere rating as mains.
7. Mains: suitable for bolt-on breakers.
8. Trim with concealed front bolts and hinges.
9. Trim and door finish: baked gray enamel.

#### Breakers

1. Breakers with thermal and magnetic tripping in panelboards except as indicated otherwise.
2. Main breaker: separately mounted on top or bottom of panel to suit cable entry. When mounted vertically, down position should open breaker.
3. Lock-on devices for fire alarm, clock outlet, emergency lighting, door supervisory controls, intercom systems, stairway lighting, exit and night light circuits.

#### Equipment Identification

1. Provide equipment identification nameplate for each panelboard size 4 engraved.
2. Nameplate for each circuit in distribution panelboards size 2 engraved.
3. Complete circuit directory with typewritten legend showing location and load of each circuit.

#### Installation

1. Locate panelboards as indicated and mount securely, plumb, and true and square, to adjoining surfaces.
2. Install surface mounted panelboards on plywood backboards. Where practical, group panelboards on common backboard.
3. Mount panelboards to height to meet CSA-22.1 breaker mounting height requirements.
4. Connect loads to circuits.
5. Connect neutral conductors to common neutral bus with respective neutral identified.
6. Provide written directory cards indicating devices and equipment being fed, including the room number.



## 26 24 19 MOTOR-CONTROL CENTRES

### General Information

1. Group motor starters in mechanical or electrical rooms in a motor control centre. Obtain permission from FMGT if loose starters have been used.
2. Motor control centres are to be installed on a concrete housekeeping pad.

### Shop Drawings

1. Submit shop drawings that indicate:
  - i. Outline dimensions.
  - ii. Configuration of identified compartments.
  - iii. Floor anchoring method and dimensioned foundation template.
  - iv. Cable entry and exit locations.
  - v. Dimensioned position and size of bus bars and details of provision for future extension.
  - vi. Schematic and wiring diagrams.

### Supply Characteristics

1. (347/600) (120-/208) V, 60Hz, wye connected, 3-phase, 4-wire, grounded neutral.

### Vertical Section Construction

1. Independent vertical sections fabricated from rolled flat steel sheets bolted together to form rigid, completely enclosed assembly.
2. Each vertical section divided into compartment units, minimum 305mm high, or as indicated.
3. Each unit to have complete top and bottom steel plate for isolation between units.
4. Horizontal wire-ways, equipped with cable supports, across top and bottom, extending full width of motor control centre, isolated from bus bars by steel barriers.
5. Vertical wire-ways c/w doors for load and control conductors extending full height of vertical sections, and equipped with cable tie supports. Installation wiring to units accessible with doors open and units in place.
6. Openings, with removable cover-plates, in side of vertical sections for horizontal wiring between sections.
7. Incoming cables to enter at (top) (bottom) with terminals.
8. Provision for outgoing cables to exit via top or bottom with terminals.
9. Removable lifting means.
10. Provision for future extension of both ends of motor control centre including bus bars without need for further drilling, cutting or preparation in field.
11. Divide assembly for shipment to site, complete with hardware and instructions for re-assembly, as recommended by the manufacturer.

#### Sills

1. Continuous 75mm channel iron floor sills for mounting bases with 19mm diameter holes for bolts.

#### Bus Bars

1. Main horizontal and branch vertical, 3-phase and neutral high conductivity tin plated copper bus bars in separate compartment (bare) self-cooled, extending entire width and height of motor control centre, supported on insulators and rated as required using standard products.
2. Branch vertical bus bars for distribution of power to units in vertical sections.
3. No other cables, wires, equipment in main and branch bus bar compartments.
4. Brace bus work to withstand effects of symmetrical short-circuit current as required.
5. Bus supports: with high dielectric strength, low moisture absorption, high impact material and long creep age surface designed to discourage collection of dust.

#### Ground Bus

1. Copper ground bus extending entire width of motor control centre.
2. Vertical ground bus strap, full height of section, tied to horizontal ground bus, engaged by plug-in unit ground stab.

#### Motor Starters and Devices

1. Units EEMAC size 5 and smaller, circuit breaker units 225A and smaller, plug-in type with self-disconnect. Guide rail supports for units to ensure that stabs make positive contact with vertical bus. Provision for units to be installed or removed, off-load, while buses energized.
2. Unit mounting:
  - i. Engaged position – unit stabbed into vertical bus.
  - ii. Withdrawn position – unit isolated from vertical bus but supported by structure. (Terminal block accessible for electrical testing of starter).
  - iii. Provision for positive latching in either engaged or withdrawn position and padlocking in withdrawn position.
  - iv. Stab-on connectors free floating tin plated clips, self-aligning, backed up with steel springs.
3. External operating handle of circuit switch interlocked with door to prevent door opening with switch in “ON” position. Provision for 3 padlocks to lock operating handle in “OFF” position and lock door closed.
4. Hinge unit doors on same side.
5. Overload relays manually reset from front with door closed.
6. Pushbuttons and indicating lights mounted on door front.
7. Devices and components by one manufacturer to facilitate maintenance.

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8. Pull-apart terminal blocks for power and control to allow removal of starter units without removal of field wiring.

#### Equipment Identification

1. Motor control centre main nameplate:
  - i. Size No. 7, engraved "MCC ##" on the first line.
  - ii. "(347/600V) (120/208V) 3-phase, 4-wire" on the second line.
2. Individual compartment nameplates: Size No. (5), engraved as indicated.

### **26 26 00 POWER DISTRIBUTION UNITS**

#### Motor Starters to 600V – General

3. This section includes the requirements for starters MCC mounted or loose mounted.

#### Shop Drawings and Product Data

1. Submit shop drawings that indicate, mounting method and dimensions, starter size and type, layout of identified internal and front panel components, enclosure types, wiring diagram for each type of starter, and interconnection diagrams.

#### Extra Materials

1. Provide listed spare parts for each different size and type of starter:
  - i. 3 contacts, stationary.
  - ii. 3 contacts, movable.
  - iii. 1 contact, auxiliary.
  - iv. 1 control transformer(s).
  - v. 1 operating coil.
  - vi. 2 fuses.
  - vii. 10% indicating lamp bulbs used.

#### Starters

1. Starters: to IEC 947-4 with AC4 utilization category.

#### Manual Motor Starters

1. Single or 3-phase manual motor starters of size, type, rating, and enclosure type as indicated, with components as follows:
  - i. Switching mechanism, quick make and break.
  - ii. One or 3 overload heater(s), manual reset, Trip indicating handle.
2. Accessories:
  - i. Toggle switch, heavy duty labelled as indicated.
  - ii. Indicating light: heavy duty type and colour as indicated.
  - iii. Locking tab to permit padlocking in "ON" or "OFF" position.

#### Full Voltage Magnetic Starters

1. Magnetic and combination magnetic starters of size, type, rating and enclosure type as indicated with components as follows:

- i. Contactor solenoid-operated, rapid action type.
  - ii. Motor overload protective device in each phase, manually reset from outside enclosure.
  - iii. Wiring and schematic diagram inside starter enclosure in visible location.
  - iv. Identify each wire and terminal for external connections, within starter, with permanent number marking identical to diagram.
2. Combination type starters to include fused disconnect switch with operating lever on outside of enclosure to control disconnect, and provision for:
  - i. Locking in "OFF" position with up to 3 padlocks.
  - ii. Independent locking of enclosure door.
  - iii. Provision for preventing switching to "ON" position while enclosure door open.
3. Accessories:
  - i. Selector switches: heavy duty labelled as indicated.
  - ii. Indicating lights: heavy duty type and colour as indicated.
  - iii. 1-N/O and 1-N/C spare auxiliary contacts unless otherwise indicated.

#### Magnetic Starter, Reduced Voltage, Auto-Transformer

1. Auto-transformer starter closed circuit transition type, of size, type, rating and enclosure type as indicated and with the following components:
  - i. Three – 3 pole contactors.
  - ii. Auto-transformer with (50%, 65% and 80%) (65% and 85%) taps.
  - iii. One adjustable pneumatic timing relay.
  - iv. One – 3 pole manual reset overload device.
  - v. Thermal overload protection of auto-transformers.
2. Accessories:
  - i. Selector switches heavy duty labelled as indicated.
  - ii. Indicating lights: heavy duty type and colour as indicated.
  - iii. Auxiliary control devices as indicated.

#### Variable Frequency Drives

1. Variable frequency drives are specified by the Mechanical Consultant but require consultation with FMEL.
2. Obtain a copy of shop drawings from the Mechanical Contractor and insert a copy into each Operating and Maintenance Manual.

#### Control Transformer

1. Single phase, dry type, control transformer with primary voltage as indicated and 120 V secondary, complete with secondary fuse, installed in with starter as indicated.
2. Size control transformer for control circuit load plus 20% spare capacity.

#### Equipment Identification

1. Provide equipment identification in accordance with Section 26 05 00 Common Work Results – Electrical.
2. Manual starter designation label, white plate, black letters, size 1, engraved.

3. Magnetic starter designation label, white plate, black letters, size 1, engraved.

## **26 27 23 INDOOR SERVICE POLES**

### General Information

1. Indoor aluminum service poles are to be used to provide power and communications outlets to work stations and equipment in open spaces where floor boxes are not acceptable.

### Indoor Service Poles

1. Indoor service poles: extruded aluminum sections to ASTM B317, brushed finish.
2. Nominal length of poles: from floor to ceiling, with plus or minus 50mm adjustment. Total adjustment: 100mm. Refer to architectural drawings and elevations for ceiling heights.
3. Service poles approximately 100mm square with snap on covers to provide access to wiring without removing unit. Barrier to isolate power from communication systems.
4. Service poles with fastening accessories at top of pole to secure to an inverted T-Bar ceiling using set screws to permit relocation. Flange at ceiling to conceal wiring.
5. Metal sleeves at bottom of pole to conceal vertical adjustment. Removable and reversible grip-tight devices for carpet and tile floors to prevent movement of poles.
6. Service poles with prewired duplex receptacles as indicated, 4 knockout holes for communication. (Cord with moulded set extending 3 m from top of pole.) (3TW No. 12 AWG leads terminating in utility box with cover, mounted at top of pole.)

## **26 27 26 WIRING DEVICES**

### General Information

1. Switches, receptacles, wiring devices, cover plates and their installation is covered under this section.
2. In general, wiring devices are to be specification grade throughout with the exception of residential buildings where residential grade devices are acceptable.

### Switches

1. 15 A, 120 V, single pole, double pole, 3-way, 4-way switches, as indicated, to: CSA-C22.2 No. 55 and CSA-C22.2 No. 111.
2. Manually-operated general purpose ac switches with terminal holes approved for No. 10 AWG wire, silver alloy contacts, urea or melamine moulding for parts subject to carbon tracking, suitable for back and side wiring and white toggle.
3. Toggle operated fully rated for tungsten filament and fluorescent lamps, and up to 80% of rated capacity of motor loads.

### Receptacles

1. Provide a minimum of one general purpose maintenance receptacle outlet at 15 metre intervals in corridors and common spaces. Outlets are to be CSA 5-20RA type fed from 20A-1P branch circuit breakers. Feed no more than 8 general maintenance outlets from a single branch circuit.
2. Duplex receptacles, CSA type 5-15 R, 125 V, 15 A, U ground, to: CSA-C22.2 No. 42 with white urea moulded housing, suitable for No. 10 AWG for back and side wiring, break-off links for use as split receptacles, 8 back-wired entrances, 4 side-wiring screws, and triple wipe contacts and riveted grounding contacts.
3. Duplex receptacles in corridors and for general maintenance, CSA type 5-20 RA, 125 V, 15 A, U ground, t-slot, to: CSA-C22.2 No. 42 with white urea moulded housing, suitable for No. 10 AWG for back and side wiring, break-off links for use as split receptacles, 8 back-wired entrances, 4 side-wiring screws.
4. Triple wipe contacts and riveted ground contacts. Single receptacles CSA type 5-15 R, 125 V, 15 A, U ground with white urea moulded housing, suitable for No. 10 AWG for back and side wiring, and 4 back-wired entrances, 2 side-wiring screws.
5. Other receptacles with ampacity and voltage different from those above shall be compatible with equipment being served.
6. Clock hanger outlets, 15 A, 125 V, 3-wire, grounding type, suitable for no. 10 AWG for installation in flush outlet box.

### Cover Plates

1. Cover plates for wiring devices to: CSA-C22.2 No. 42.1.
2. Sheet steel utility box cover for wiring devices installed in surface-mounted utility boxes.
3. Stainless steel, vertically brushed, 1mm thick cover plates, thickness 2.5mm for wiring devices mounted in flush-mounted outlet box.
4. Sheet metal cover plates for wiring devices mounted in surface-mounted FS or FD type conduit boxes.
5. Weatherproof double lift spring-loaded cast aluminum cover plates complete with gaskets for duplex receptacles as indicated.
6. Weatherproof spring-loaded cast aluminum cover plates complete with gaskets for single receptacles or switches.

## **26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

### Moulded Case Circuit Breakers

1. Materials for moulded-case circuit breakers, circuit breakers, and ground-fault circuit-interrupters.

### Submittals

1. Include time-current characteristic curves for breakers with ampacity of 225 A, and over or with interrupting capacity of 22,000 A symmetrical (RMS) and over at system voltage.

### Breakers

1. Moulded-case circuit breakers, circuit breakers and ground-fault circuit-interrupters: to CSA C22.2 No. 5.
2. Bolt-on moulded case circuit breaker: quick-make/quick-break type, for manual and automatic operation (with temperature compensation for 40°C ambient).
3. Common-trip breakers: with single handle for multi-pole applications.
4. Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting.
  - i. Trip settings on breakers with adjustable Trips to range from 3-8 times current rating.
5. Circuit breakers with interchangeable Trips as indicated.
6. Circuit breakers to have minimum 10,000 symmetrical RMS interrupting capacity rating.
7. All circuit breakers used for emergency generator power distribution shall be fully rated. The use of series rated breakers is NOT acceptable.

### Thermal Magnetic Breakers

1. Moulded case circuit breaker to operate automatically by means of thermal and magnetic tripping devices to provide inverse time; current tripping and instantaneous tripping for short circuit protection.

### Magnetic Breakers

1. Moulded case circuit breaker to operate automatically by means of magnetic tripping devices to provide instantaneous tripping for short circuit protection.

### Current Limiting and Series Rated Thermal Magnetic Breakers

1. Thermal magnetic breakers with current limiters.
  - i. Time current limiting characteristics of fuses limiters coordinated with time current tripping characteristics of circuit breaker.
  - ii. Coordination to result in interruption by breaker of fault-level currents up to interrupting capacity of breaker.
2. Series rated breakers to be manufacturer tested and listed. Breakers to be applied following manufacturer's guidelines and accepted best practice.
  - i. Breakers applied following manufacturer's guidelines and accepted best practice.

### Solid State Trip Breakers

1. Moulded case circuit breaker to operate by means of solid-state trip unit with associated current monitors and self-powered shunt trip to provide inverse time current trip under overload condition, and tripping time for phase and/or ground fault short circuit protection, as required.

### Optional Features

1. Include:
  - i. Shunt trip.
  - ii. Auxiliary switch.



- iii. Motor-operated mechanism c/w time delay unit.
- iv. Under-voltage release.
- v. On-off locking device.
- vi. Handle mechanism.

### **26 29 33 CONTROLLERS FOR FIRE PUMP DRIVERS**

#### General

1. Connect emergency distribution to fire pump controller. Fire pump controller will be provided by the Mechanical Contractor.
2. Make all connections to the fire pump controller, as required by the Mechanical Contractor.
3. Provide fire pump alarm monitoring in accordance with NFPA20. This shall include the following:
  - i. Pump or motor running.
  - ii. Loss of phase.
  - iii. Phase reversal.
  - iv. Controller connected to alternate source.

**26 30 00 FACILITY ELECTRICAL POWER GENERATING AND STORAGE EQUIPMENT**

**26 32 13 ENGINE GENERATORS**

Diesel Electric Generating Units – Liquid – General

1. New buildings are to be provided with a new diesel fired emergency/standby power generator complete with sub-base fuel tank, sound attenuated weatherproof enclosure.
2. Generators shall generally be mounted outdoors on a reinforced concrete slab.
3. The fuel tank shall have a volume capable of 72 hours of run time at full load.
4. Where buildings require both emergency and standby power distribution, 2 auto-transfer switches will be required in order to separate the 2 distribution sets.
5. The generator enclosure is to be vandal and rodent proof.
6. All equipment shall be new and of current production by a national firm who manufactures the generator and control panel and who assembles the standby generator set as a matched unit having a service and parts organization within British Columbia.
7. Single supplier: The supplier shall be the manufacturer's authorized distributor, who shall provide initial start-up services, conduct field acceptance testing, and warranty service. The supplier shall have 24-hour service availability and factory-trained service technicians authorized to do warranty service on all warrantable products.

Operation and System

1. The standby power system is to be designed to energize the complete power service automatically on failure of normal power or when being tested.
2. The transfer switch shall include an automatic energizing mode that will cycle the emergency power system to run for an adjustable period on pre-selected days and time annually.
3. All signals shall be indicated remotely via annunciator in the electrical room. Annunciator shall be compliant with all requirements of CSA C282-(latest edition) and have all required indicators displayed on the annunciator.
4. The generator system shall be a liquid cooled diesel electric generating unit with control panel, with combined control, transfer and power isolating and by-pass panel.
5. All operating and maintenance data is to be provided in operating and maintenance manuals, at substantial completion stage of the project. The data must also include all testing and verification reports.

Warranty

1. Contractor shall hereby warrant the diesel generating unit, equipment and accessories against defects and malfunction for five years from the date of substantial completion commissioning stage.

Maintenance – Extra Materials

1. Provide spare materials for generator systems as noted in the following clauses.
2. For panels provide the following:
  - i. One spare control circuit breaker per rating.
  - ii. Twenty four spare indicating light bulbs per rating.
  - iii. One spare control relay and socket per rating and contact arrangement.
  - iv. One spare contactor operating coil.
  - v. One set of contacts (3) for transfer contactor.
3. Provide generator unit with standard set of engine manufacturer's spare parts for one year normal operation 1,000 operating hours. Spares to include:
  - i. Six fuel filter elements, for each type of fuel filter/water separator.
  - ii. Six lubricating oil filter elements.
  - iii. Three air cleaner elements.
4. Where metric size nuts and bolts are used, provide one set of sockets complete with ratchet handle and set of combination wrenches, to fit sizes used.
5. Provide conclusive evidence that Canadian distributor has been established and will stock in Canada spare parts likely to be required during normal life of engine.

#### Maintenance – Tools

1. Supply suitable engine barring device and battery manufacturer's standard set of tools for battery service.
  - i. Battery service tools to include hydrometer, 1 plastic bottle for topping up purposes, and 1 insulated battery terminal wrench.
2. Provide complete set of specialized tools required for proper care, adjustment and maintenance of equipment supplied.

#### Generator Plant

1. The generation plant shall consist of a fully automatic #2 diesel engine driven electrical generation plant completely equipped with the following:
  - i. Fuel system and sub-base fuel tank.
  - ii. Exhaust system.
  - iii. Cooling system.
  - iv. Battery starting system, including battery charger.
  - v. All automatic controls.
  - vi. Radio suppression to commercial standards.
  - vii. Block heater.
  - viii. Surge suppression.
  - ix. Fully rated breakers for emergency power, standby power, fire pump power and load bank power connection.
2. The unit shall be designed to provide a minimum of 25% spare capacity.

### 26 32 13 DIESEL-ENGINE-DRIVEN GENERATOR SETS

#### Diesel Engine – Generator Set

1. Diesel engine-generator set fueled with #2 diesels. Diesel engines requiring premium fuels shall not be considered.
2. Performance:
  - i. Voltage regulation shall be  $\pm 1.5\%$  for any constant load between no load and rated load.
  - ii. Maximum transient voltage dip shall not exceed 25% below rated voltage on application of the single largest surge load step at a 0.8 power factor.
  - iii. Maximum transient voltage rise shall not exceed 12% above rated voltage on removal of full load at 0.8 power factor.
  - iv. Transient recovery time is 1 second.
  - v. Stability plus or minus 0.25%.
  - vi. Frequency regulation shall be isochronous from steady state no load to steady state rated load.
  - vii. The diesel engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, with the engine-generator set at operating temperature.
  - viii. Motor starting capability shall be a minimum of 2 – 5 horsepower motors. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
  - ix. The unit shall be capable of delivering 10% overload for 1 hour every 12 hours of continuous operation, without exceeding maximum permissible temperature rise.
  - x. The unit shall be capable of providing stable voltage and pick up of essential loads within 10 seconds.
  - xi. The generator shall be equipped with surge suppression and the excitation system shall include an instantaneous overcurrent shutdown capability after 10 seconds.
  - xii. A wide range of load power factors can be expected on campus. Generator design and performance shall accommodate extreme power factors applicable to specified install locations. Consult with FMEL for generator selection.
3. AC Generator:
  - i. The AC generator shall be: synchronous, 4 pole, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc(s).
  - ii. All insulation system components shall meet NEMA MG1 temperature limits for Class H, 125°C insulation systems. Actual temperature rise measured by resistance method at full load shall not exceed 80°C ambient.
  - iii. A permanent magnet generator (PMG) shall provide excitation power for immunity from voltage distortion caused by non-linear loads. The PMG shall sustain excitation power for optimum motor starting and to sustain short circuit current at approximately 300% of rated current for not less than 10 seconds.
  - iv. The automatic voltage regulator shall be temperature-compensated, solid-state design. The voltage regulator shall be equipped with 3-phase RMS sensing the regulator shall control buildup of AC generator voltage to provide a linear rise and limit overshoot.
  - v. Voltage control is to be in accordance with applicable CSA Bulletins.
4. Engine-Generator Set Control:
  - i. Provide cycle cranking of 15 SEC (ON) / 15 SEC (OFF) for 3 attempts (75 SEC). If engine fails to start, indicate over-crank on the alarm status panel, but continue attempts to start.

- ii. The engine shall comply with all requirements of SCAQMD Rule 1470 and be Tier 3 approved in Canada. Provide all supporting documentation showing that these criteria are met.
  - iii. The control shall shut down and lock out upon: over-speed, low lubricating oil pressure, high engine temperature, or operation of a remote manual stop station. A panel mounted switch shall reset the engine monitor and test all the lamps.
  - iv. The CSA Type 3 weatherproof enclosed control panel shall be mounted on the generator set with vibration isolators. A front control panel illumination lamp with ON/OFF switch shall be provided.
  - v. Engine generator set control shall be of solid state design. Relays will be acceptable only for high current circuits. Circuitry shall be of plug-in design for quick replacement. Controller shall be equipped to accept a plug-in device capable of allowing maintenance personnel to test controller performance without operating the engine.
5. Base:
- i. The engine-generator set shall be mounted on a heavy duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
  - ii. The generator set shall be equipped with factory installed vibration isolators mounted between the set and fabricated steel base to prevent distortion of alignment between generator and engine when installed. Base channel and all parts to withstand this force without damage.
  - iii. The base is to have earthquake restraint as required by local codes.
  - iv. The exhaust flex-connector and all exposed exhaust components, including muffler shall be fully insulated by means of a thermos-fibre blanket-type heat resistant wrapping, 25mm thick, with SS mesh inner liner and silicone/aluminized outside cover secured by stainless steel lacing hooks and wire.
  - v. The engine shall be radiator cooled and equipped with a pusher fan. The cooling system shall be filled with a solution of 50% ethylene glycol. Provided shall be a translucent overflow coolant recovery reservoir.
  - vi. A 115 VAC engine jacket heater, sufficient to maintain coolant at 40°C, shall be provided complete with thermostat and electrical disconnect on engine start, if required to prevent element damage.
  - vii. Motorized (spring open/power close) air inlet and (gravity close) exhaust shutters shall be sealed to minimize air leakage and shall automatically open whenever the engine is started.
  - viii. Circuit Breaker:
    - i. Shall be mounted on the generator and shall be a non-automatic trip free thermal magnetic moulded case circuit breaker in CSA Type 3 (weatherproof) enclosure complete with neutral bar isolated from ground.
    - ii. Circuit breakers shall be 3-pole fully rated 3Ø, 4 wire operation.

#### Remote Annunciator

- 1. Supply a remote annunciator suitable for surface mounting, with audible alarm and status indicator. (Locate in main electrical room.)
- 2. Provide and install a 20-light LED type remote alarm annunciator with horn, located as shown on the drawings or in a location that can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called for by CSA 282 (latest edition) NFPA Standard 110 for Level 1 systems for the local generator control panel.

#### Generator Enclosure

1. The sound attenuated genset housing shall be a rigid, free-standing, vandal-resistant cabinet, fabricated to EEMAC 3 standards with sufficient bracing to form a structure capable of withstanding wind, snow and ice loading. The roof shall have a minimum 100mm overhang and provide rain gutters over all doors and openings. External hinges shall each feature a waterproof cap and lower grease fitting to permit pressure lubrication.
2. After fabrication the metal surfaces of the enclosure shall be prepared to SSPC-SP6 commercial blast. Immediately following surface preparation a 3 mil coating of zinc rich epoxy metal primer shall be applied. Primer coating material shall be Amercoat 68HS. After curing, two addition 2 mil coats of aliphatic polyurethane shall be applied, Amercoat 450HS approved, for a total 7 mil film thickness.
3. Alternately, galvanized metal surfaces shall be prepared with an etching primer, Metaprime 39103/39104 approved. Following this, 2 separate 2 mil coats of aliphatic polyurethane shall be applied, Amercoat 450HS coating material approved, for a total 4 mil film thickness.
4. Access to all regularly serviced items within the enclosure shall be provided by at least 2 hinged lockable doors on each side.
5. The enclosure must be vandal resistant. Externally accessible fasteners shall preferably be blind head (e.g. stove bolts) although Allen head will be permissible. Air inlet and outlet openings shall be designed such that objects of any size directed at the enclosure from vertically downward to horizontally flag cannot enter and shall be sized such that inlet air velocity is below the level at which water penetration will occur. No other enclosure openings will be allowed.

#### Generator Noise

1. The engine exhaust system shall incorporate a seamless, stainless steel flex-connector and critical silencing type muffler, all mounted within the genset enclosure. Discharge shall be into the air outlet hood, downstream of the radiator. Sound attenuated air inlet and discharge hoods with opening bird screens shall be rectangular in shape and match the profile of the enclosure.
2. Genset overall full load operating noise level shall be less than 65 dbA when measured at a distance of 7 meters from any side of the enclosure and 1 meter above ground. This shall be demonstrated during shop testing.
3. Ducting and sound attenuation components shall be designed and supplied by an approved manufacturer specializing in this type of work. Manufacturer shall be Excel Engineering, Alum-Tekko Industries or Sonic Engineering.

### **26 36 00 TRANSFER SWITCHES**

#### Transfer Switch Equipment

1. New automatic switches shall be Thomson Technology. Transfer switches shall be rated to carry 100% of rated current continuously in the enclosure. Transfer switches shall also be continuously rated in ambient temperatures of -10°C to +30°C, relative humidity up to 95% (non-condensing), with altitudes up to 3,048 meters. Transfer switch equipment shall have withstand and closing rating (WCR) in RMS symmetrical amperes greater than the available fault currents shown on the drawings.
2. Transfer switches are to be complete factory assembled transfer equipment with electronic control designed for surge voltage isolation, voltage sensors on all phases of all sources, linear operator,

permanently attached manual handles, positive mechanical and electrical interlocking, and mechanically held contacts. Transfer switches rated through 1000 amperes shall be equipped with permanently attached manual operating handles and quick-break / quick-make over-centre contact mechanisms suitable for safe manual operation under load.

3. Automatic Controls shall be solid-state and designed for a high level of immunity to power line surges and transients. Solid-state under-voltage sensors shall simultaneously monitor all phases of both sources. Pick-up and drop-out settings shall be adjustable. Voltage sensors shall allow for adjustment to sense partial loss of voltage on any phase. Voltage sensors shall have field calibration of actual supply voltage to nominal system voltage. Voltage sensors shall be temperature compensated. Automatic controls shall signal the engine-generator set to start upon signal from normal source sensors. Solid-state time delay start, adjustable from 0 to 5 seconds (factory set at 2 seconds) shall avoid nuisance start-ups. Battery voltage starting contacts shall be gold, dry type contacts factory wired to a field wiring terminal block. The maximum reaction time of 10 seconds permitted under CSA Standard C282 – (latest edition) shall include the adjustable 0 to 5 second delay. The switch shall retransfer the load to the normal source (after normal power restoration) after a time delay transfer, adjustable from 0 to 120 seconds. Retransfer time delay shall be immediately bypassed if the emergency power source fails. Factory set at 1 minute. The switch shall retransfer the load to the normal source if the generating set output interrupts after normal source restores voltage. Controls shall signal the engine-generator set to stop after a time delay, adjustable from 0 to 30 minutes, beginning on return to the normal source. Power for transfer operation shall be from the source to which the load is being transferred.
4. Retransfer – Momentary position to override retransfer time delay and cause immediate return to normal source.

## 26 50 00 LIGHTING

### 26 51 13 INTERIOR LIGHTING FIXTURES, LAMPS, AND BALLASTS

#### General

1. In general, lighting design shall consider sustainability and energy efficiency in order to meet the desired sustainability goals of the University.
2. Although this section makes reference to compact fluorescent lamps and fixtures, these are not preferred by the University. The preference is to use 4' long fluorescent lamps throughout the building, where possible. The use of LED down-lighting may be considered in some situations however, prior approvals must be obtained from the FMGT Department Representatives.
3. Lighting shall be designed to IES, B.C. Building Code and WCB requirements on all projects.

#### Lamps

1. Incandescent lamps:
  - i. Bulb shape A to 150W, medium base, inside frosted, 130V rated.
2. Halogen lamps:
  - i. PAR30S IR type lower wattage energy saving type lamps, 4,200 hours average life, minimum initial lumens:
    - a. 40W, Spot 10°, Flood 25°, Wide Flood 40° - 720 (equivalent to 60W non-IR)
    - b. 50W, Spot 10°, Flood 25°, Wide Flood 40° - 970 (equivalent to 75W non-IR)
    - c. 50W (130V long life), Spot 10°, Flood 25°, Wide Flood 40° - 650 (equivalent to 50W non-IR)
    - d. Manufacturer: GE Quartzline, Philips
  - ii. MR16 type to be 12V, solid nickel steel pins, and total infill ceramic base. Lamp life rated 4000 hours, enclosed reflector with clear glass cover, 3000K colour:
    - a. Narrow spot 10° to 13° beam angle
    - b. Spot 20° to 26° beam angle
    - c. Narrow flood 32° to 35° beam angle
    - d. Flood 38° to 45° beam angle
    - e. Wide Flood 55° to 65° beam angl
    - f. Manufacturer: EYE Iwasaki Electric Co. Ltd., Philips, Osram
3. Fluorescent Lamps
  - i. T8-Type:
    - a. Instant start 265 mA, bulb shape T8, medium bi-pin base, 20,000 hours life, 3500K, CRI 86 (min), Minimum initial lumens:
      1. 30W – 2950 lumens T8
    - b. Acceptable manufacturer: Philips Energy Advantage 835
  - ii. T5-Type:
    - a. Programmed start high output, bulb shape T5, miniature bi-pin base, 35,000 hours life, 3500K, CRI 98 (min), minimum initial lumens:
      1. 54W – 5000 lumens T5
    - b. Acceptable manufacturer: Philips F54T5
  - iii. PL Type:
    - a. Instant start, two pin base, double looped or quad, rated average life 10,000 hours, colour temperature 3500K, minimum initial lumens:
      1. 13W – 1250
      2. 26W – 1800
  - iv. Compact Fluorescent
    - a. Instant start, four pin base, twin tube, rated average life 20,000 hours, colour temperature 3500K, minimum initial lumens:
      1. 40W – 3150 lumens
4. Metal Halide:



- i. ED type bulb, mogul base for vertical mount and position oriented mogul base for horizontal use, 20,000 hours average life, colour temperature 3000 degrees K, minimum initial lumens:
    - a. 100W – 8000                      250W – 21500
    - b. 175W – 14000                    400W – 37000
    - c. Manufacturer: Philips M/3K/ALTO
5. High Pressure Sodium:
- i. Bulb shape E, mogul base, rated life 24,000 hours, colour corrected type, 2200K colour temperature, colour rendering index: 65, coated, minimum initial lumens:
    - a. 70W – 5985
    - b. 100W – 8800
    - c. 150W – 13500

Ballasts

1. Fluorescent electronic ballast:
  - i. All fluorescent ballasts are to be electronic, instant start or programmed start type, refer to luminaire schedule. Rating: 60Hz voltage as indicated. Suitable for lamp quantity as indicated in luminaire schedule.
  - ii. Totally encased and shall not exceed 25°C temperature rise over 40°C ambient.
  - iii. Ballast shall have a power factor of 90% or above.
  - iv. Ballast shall not contain PCBs.
  - v. Sequenced start progression which first heats cathode filaments and then ignites lamp.
  - vi. Sound rated: shall not exceed Class A.
  - vii. Mounting: integral with luminaire.
  - viii. Warranted for five years – date of installation to be marked on ballast.
  - ix. Input total harmonic distortion (THD) shall not exceed 10%.
  - x. Ballast shall have a frequency of operation of 20kHz or greater and operate without visible flickers.
  - xi. Electrical Contractor to provide 10 spare ballasts.
  - xii. Manufacturer: Advance Centium or Optanium or pre-approved equal.
2. Fluorescent Electronic 50/100 Step Dim Type Ballast
  - i. All fluorescent ballast's are to be electronic type. Rating: 60Hz voltage as indicated, for use with rapid start lamps, and shall have an average lamp current crest factor of 1.4.
  - ii. Ballast shall have a ballast factor of 95%.
  - iii. Sequenced start progression which first heats cathode filaments and then ignites lamp.
  - iv. Mounting: integral with luminaire.
  - v. Warranted for 5 years – date of installation to be marked on ballast.
  - vi. Input total harmonic distortion (THD) shall not exceed 10%.
  - vii. Ballast shall have a frequency of operation of 20 KHz or greater and operate without visible flickers.
  - viii. Step dim function to switch ballast between 50% and 100% output.
  - ix. Electrical Contractor to provide 10 spare ballasts.
  - x. Manufacturer: Advance Optanium or pre-approved equal.
3. Fluorescent Dimmable Ballast
  - i. All fluorescent ballast's are to be electronic type. Rating: 60Hz voltage as indicated, for use with rapid start lamps, and shall have an average lamp current crest factor of 1.4.
  - ii. Ballast shall have a power factor of 90% or above.
  - iii. Ballast shall not contain PCBs.
  - iv. Sequenced start progression which first heats cathode filaments and then ignites lamp.
  - v. Mounting: integral with luminaire.
  - vi. Warranted for 5 years – date of installation to be marked on ballasts.
  - vii. Input current Third Harmonic content shall not exceed 10%, and total harmonic distortion (THD) of less than 10%.
  - viii. Ballast shall have a frequency of operation of 20 KHz or greater and operate without visible flickers.
  - ix. Dimmable to 5% output.

- x. Electrical Contractor to provide 10 spare ballasts.
- xi. Manufacturer: Lutron or Advance Mark Series.
- 4. Metal Halide Ballast – Design Linear Type:
  - i. Rating: 60Hz voltage as indicated, for use with metal halide lamp.
  - ii. Totally encased and designed for 40°C ambient temperatures.
  - iii. Power factor: minimum 95% with 95% of rated lamp lumens.
  - iv. Type: constant wattage auto-transformer.
  - v. Capacitor: non PCB.
  - vi. Input voltage range: plus or minus 10% of nominal.
  - vii. Minimum starting temperature: minus 29°C at 90% line voltage.
  - viii. Mounting: indoor and outdoor integral with luminaire, or as noted.
  - ix. Crest factor: 1.8 minimum.
- 5. High Pressure Sodium Ballast: to ANSI C82.4-1978, Design Linear Type:
  - i. Rating: voltage as indicated, for use with high pressure sodium lamp.
  - ii. Totally encased and designed for 40°C ambient temperatures.
  - iii. Power factor: minimum 95% with 95% of rated lamp lumens.
  - iv. Type: constant wattage, isolated secondary magnetic regulated with matching igniter as recommended by manufacturer.
  - v. Capacitor: non-PCB.
  - vi. Input voltage range: plus 5% to minus 5%.
  - vii. Minimum starting temperature: minus 34°C at 90% line voltage.
  - viii. Mounting: indoor integral with luminaire, unless noted otherwise.

#### Finishes

- 1. Baked enamel finish:
  - i. Conditioning of metal before painting:
    - a. For corrosion resistance: conversion coating to ASTM F1137.
    - b. For paint base: conversion coating to ASTM F1137.
  - ii. Metal surfaces of luminaire housing and reflectors finished with high gloss baked enamel or alzak aluminum to give smooth, uniform appearance, free from pinholes or defects.
  - iii. Reflector and other inside surfaces finished as follows:
    - a. White, minimum reflection factor 85%.
    - b. Colour fastness: yellowness factor not above 0.02 and after 250 hours exposure in Atlas fade-ometer not to exceed 0.05.
    - c. Film thickness is not less than 0.03mm average and in no areas less than 0.025mm.
    - d. Gloss not less than 80 units as measured with Gardner 60E gloss meter.
    - e. Flexibility: withstand bending over 12mm mandrel without showing signs of cracking or flaking under 10 times magnification.
    - f. Adhesion: 24mm square lattice made of 3mm square cut through film to metal with sharp razor blade. Adhesive cellulose tape applied over lattice and pulled. Adhesion satisfactory if no coating removed.
- 2. Alzak finish:
  - i. Aluminum sheet fabricated from special aluminum alloys and chemically brightened, subsequently anodically treated to specifications established by Alcoa, to produce:
    - g. Finish for mild commercial service, minimum density of coating 7.8 g/m<sup>2</sup>, minimum reflectivity 83% for specular, 80.5% for semi-specular and 75% for diffuse.
    - h. Finish for regular industrial service, minimum density of coating 14.8 g/m<sup>2</sup>, minimum reflectivity 82% for specular and 73% for diffuse.
    - i. Finish for heavy duty service, minimum density of coating [21.8] g/m<sup>2</sup>, minimum reflectivity 85% for specular, 65% for diffuse.

#### Accessories

1. Pendant Mounting
  - i. Pendant mounting shall be with white enamelled luminaire tubing provided as an accessory with luminaire unless otherwise specified.
  - ii. Slope ceiling mounted adapters shall be white enamelled supports provided as an accessory with luminaire unless otherwise specified.
2. Wire Guards
  - i. Wire guards shall be spot welded at crossing of members and be a minimum of 4.5mm thick galvanized steel. Guards shall be hinged from either side and be secured using wing nuts.

#### Lenses

1. Refer to luminaire schedule.

#### Luminaires

1. For luminaire specifications, refer to luminaire schedule except for luminaires at white boards in teaching spaces.
2. Luminaires for whiteboards in teaching spaces shall be Insite Compact-5 Interior Architectural Fluorescent or equivalent with T5HO lamp placed continuously along the entire length of whiteboards. The switching arrangement shall be such that each 8 foot section can be switched separately. Whiteboard luminaires shall be wall mounted above whiteboards.

### **26 52 00 EMERGENCY LIGHTING**

#### Unit Equipment for Emergency Lighting

3. Emergency lighting equipment: to CSA C22.2 No. 141.
4. Supply voltage: (120) (347) V, ac.
5. Output voltage: 24 V dc.
6. Operating time: 30 minimum. Where a generator is placed indoor, provide emergency lighting battery pack a two lighting heads lasting a minimum of a 2 hour duration.
7. Battery: sealed, maintenance free.
8. Charger: solid state, multi-rate, voltage/current regulated, inverse temperature compensated, short circuit protected with regulated output of plus or minus 0.01V for plus or minus 10% input variations.
9. Solid state transfer circuit.
10. Low voltage disconnect: solid state, modular, operates at 80% battery output voltage.
11. Signal lights: solid state, for "AC Power ON".
12. Lamp heads: remote, 345 degrees horizontal and 180 degrees vertical adjustment. Lamp type: quartz 18 W.

13. Cabinet: suitable for direct or shelf mounting to wall and c/w knockouts for conduit. Removable or hinged front panel for easy access to batteries.
14. Finish: standard factory white.
15. Auxiliary equipment:
  - i. Ammeter.
  - ii. Voltmeter.
  - iii. Test switch.
  - iv. Time delay relay.
  - v. Battery disconnect device.
  - vi. AC input and DC output terminal blocks inside cabinet.
  - vii. Shelf or wall bracket.
  - viii. Cord and single twist-lock plug connection for AC.
  - ix. RFI suppressors.
16. Acceptable manufacturers: Ready-Lite, Emergi-Lite, Beghelli, Thomas & Betts.

### **26 53 00 EXIT SIGNS**

#### Standard Units

1. Exit lights: to CSA C22.2 No. 141 and CSA C860, packaged in accordance with the Canadian Code for Preferred Packaging Guidelines.
2. Housing: extruded aluminum housing, brush aluminum finish.
3. Face and back plates: extruded aluminum.
4. Lamps: multiple, LED-12W, 120 or 347 V.
5. Operation: designed for 50,000 hours of continuous operation without re-lamping.
6. Letters: 150mm high x 19mm, with 13mm thick stroke, red on die-cast aluminum face, reading EXIT.
7. Down-light: translucent acrylic in bottom of unit.
8. Face plate to remain captive for re-lamping.
9. Acceptable product: Ready Lite #CX5000 Series or Emergi-Lite, Beghelli and Thomas & Betts equal.

### **26 56 00 EXTERIOR LIGHTING**

#### Lighting Control Devices – Photoelectric – General

1. Each building exterior lighting system is to be controlled using a single photocell connected to contactors in appropriate quantity to control the lighting system designed by the consultant. Exterior lighting controls shall also include a time clock and a manual override switch.

#### Photoelectric Lighting Control

1. Photocells shall be cabinet wall mounted, capable of switching 1800 watts, 5000 operations at the rated voltage for the lighting system. The system shall also operate satisfactory between a plus or minus 10% voltage range and a temperature range: minus 40 °C to plus 40 °C.

Contactors

1. Contactors are to be waterproof cabinet mounted capable of switching multiple lamp circuits with total lighting load of 6000 watts.

Exterior Lighting Controls

1. All exterior luminaires, whether indicated on plans or not, must be provided with photocell and timer controls complete with manual override switch