

Part 1 General

1.1 GENERAL

- .1 This section covers items common to Sections of Divisions 26, 27 and 28. This section supplements requirements of Division 01.

1.2 REFERENCES

- .1 Comply with CSA Electrical Bulletins and Certification Standards in force at time of bid submission. While not identified and specified by number in this Division, these Bulletins and Standards are to be considered as forming part of related CSA Part II Standard.
- .2 All references to Codes and Standards refer to the latest edition in force at the time of bid unless specified otherwise.
- .3 Under no circumstances shall the Codes and Standards referred to above and herein, be interpreted to allow a lower standard than specified elsewhere herein.
- .4 Abbreviations for electrical terms: to CSA Z85.

1.3 DEFINITIONS

- .1 Electrical and electronic terms: unless otherwise specified or indicated, terms used in these specifications, and on drawings, are those defined by IEEE SP1122.

1.4 DESIGN REQUIREMENTS

- .1 Operating Voltages: to CAN3 C235.
- .2 Motors, electrical heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard. Equipment to operate in extreme operating conditions established in above standard without damage to equipment.

1.5 SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00 – Submittal Procedures.
- .2 Product Data: submit WHMIS MSDS in accordance with Section 02 81 01 – Hazardous Materials.
- .3 Submit for review single line electrical diagrams under plexiglass and located as follows:
 - .1 Electrical distribution system in main electrical room.
 - .2 Electrical power generation and distribution system in generator room.
- .4 Submit for review fire alarm riser diagram, plan and zoning of building under plexiglass at fire alarm control panel and annunciator.

- .5 Shop drawings:
 - .1 Submit wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure coordinated installation.
 - .2 Identify on wiring diagrams circuit terminals and indicate internal wiring for each item of equipment and interconnection between each item of equipment.
 - .3 Indicate of drawings clearances for operation, maintenance, and replacement of operating equipment devices.
- .6 Quality Control: in accordance with Section 01 45 00 – Quality Control
 - .1 Submit to the Electrical Inspection Department and Supply Authority the necessary number of drawings and specifications for examination and approval prior to commencement of work. Pay all fees associated with this examination and approval.
 - .2 Obtain and pay fees associated with all electrical inspections.
 - .3 Submit test results for all electrical system testing including manufacturer's factory and Materials and Equipment field test reports.

1.6 QUALITY ASSURANCE

- .1 All electrical work to be carried out by qualified, licensed electricians or apprentices as per the conditions of the Provincial Act respecting manpower vocational training and qualification. Employees registered in a provincial apprentices program shall be permitted, under the direct supervision of a qualified licensed electrician, to perform specific tasks – the activities permitted shall be determined based on the level of training attained and the demonstration of ability to perform specific duties.
- .2 The work of this division to be carried out by a contractor who holds a valid Master Electrical contractor license as issued by the Province that the work is being contracted.
- .3 Conduct a complete testing, start-up and commissioning program as specified in Division 01.
- .4 Submit a complete testing and commissioning schedule and notify the Engineer a minimum of 40 hours prior to performance of testing.
- .5 Submit a complete testing and commissioning report at completion of the Work.

1.7 DELIVERY, STORAGE AND HANDLING

- .1 Material Delivery Schedule: provide The Departmental Representative with schedule within four (4) weeks after award of Contract.
- .2 Construction/Demolition Waste Management and Disposal: separate waste materials for recycling in accordance with Section 01 74 21 – Construction/Demolition Waste Management and Disposal.

1.8 SYSTEM STARTUP

- .1 Instruct operating personnel in the operation, care and maintenance of systems, system equipment and components.
- .2 Arrange and pay for services of manufacturer's factory service representative to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.
- .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with all aspects of its care and operation.

1.9 OPERATING INSTRUCTIONS

- .1 Provide for each system and principal item of equipment as specified in technical sections for use by operation and maintenance personnel.
- .2 Operating instructions to include the following:
 - .1 Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
 - .2 Start up, proper adjustment, operating, lubrication, and shutdown procedures.
 - .3 Safety precautions.
 - .4 Procedures to be followed in event of equipment failure.
 - .5 Other items of instruction as recommended by manufacturer of each system or item of equipment.
- .3 Print or engrave operating instructions and frame under glass or in approved laminated plastic.
- .4 Post instructions where directed.
- .5 For operating instructions exposed to weather, provide weather-resistant materials or weatherproof enclosures.
- .6 Ensure operating instructions will not fade when exposed to sunlight and are secured to prevent easy removal or peeling.

Part 2 Products

2.1 MATERIALS AND EQUIPMENT

- .1 Provide materials and equipment in accordance with the requirements of General Conditions.
- .2 Equipment and material to be CSA certified, and manufactured to standard quoted.
- .3 Where there is no alternative to supplying equipment which is not CSA certified, obtain special approval from Inspection Department.
- .4 Factory assemble control panels and component assemblies.
- .5 Uniformity of manufacturer shall be maintained for any particular item or type of equipment throughout the building.

2.2 ELECTRIC MOTORS, EQUIPMENT AND CONTROLS

- .1 Supplier and Installer responsibility is indicated in Motor Control and Equipment Schedule on electrical drawings and related Mechanical responsibility is indicated on Mechanical Equipment Schedule on mechanical drawings.
- .2 Control wiring and conduit is specified in Division 26 except for conduit, wiring, and connections below 50V which are related to control systems specified in Division 23 and shown on mechanical drawings.
- .3 Housekeeping Pads
 - .1 All floor mounted electrical equipment shall be mounted on concrete housekeeping pads. Pads to be 100 mm high. Other trade shall paint pads and equipment floor with epoxy paint prior to equipment installation.

2.3 WARNING SIGNS

- .1 Provide warning signs, as specified or to meet requirements of Inspection Department and Departmental Representation.
- .2 Use decal signs, minimum 175 x 250 mm size.
- .3 Remove all temporary signs at the end of job.

2.4 WIRING TERMINATIONS

- .1 Lugs, terminals, screws used for termination of wiring to be suitable for copper or aluminium conductors.

2.5 EQUIPMENT IDENTIFICATION

- .1 Identify electrical equipment with nameplates as follows:
 - .1 Nameplates:
 - .1 Plastic laminate engraving sheet, 3 mm thick, black face, white core, self-adhesive. Nameplates identifying emergency power system circuits shall be red face with white core.
 - .2 Nameplate sizes:

Size 1	7 X 25 mm	1 line	3 mm high lettering
Size 2	7 x 40 mm	1 line	5 mm high lettering
Size 3	12 x 70 mm	2 lines	3 mm high lettering
Size 4	20 x 90 mm	1 line	8 mm high lettering
Size 5	20 x 90 mm	2 lines	5 mm high lettering
Size 6	25 x 100 mm	1 line	12 mm high lettering
Size 7	25 x 100 mm	2 lines	6 mm high lettering
 - .3 Wording on nameplates to be approved prior to manufacture.
 - .4 Allow for average of twenty-five (25) letters per nameplate.
 - .5 Identification to be English.
 - .6 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
 - .7 Nameplates for disconnects, pull boxes, splitters, starters, contactors and control stations shall indicate their function, and voltage.
 - .8 Nameplates for transformers shall indicate capacity, primary, and secondary voltages.
 - .9 All nameplates shall be mechanically attached with a minimum of two chrome self tapping screws as well as the self adhesive.

2.6 WIRING IDENTIFICATION

- .1 Identify wiring with permanent indelible identifying markings either numbered or coloured plastic tapes, on both ends of phase conductors or 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.

2.7 CONDUIT AND CABLE AND JUNCTION BOX IDENTIFICATION

- .1 Colour code conduits, boxes and metallic sheathed cables.
- .2 Code with 305 mm band of coloured spray paint at points where conduit or cable enters wall, ceiling, or floor, and at 15 m intervals.

Telephone	Light Green
Fire Alarm	Red
Emergency Power	Orange
Television Signal Distribution System	Pink
Building Security Control System	White
Computer Network (Data)	Blue
Communication Systems	Purple
- .3 Identify all system junction boxes with enamel spray paint on entire cover. Colour shall match those specified for conduit and cable identification.
- .4 Identify all junction boxes, containing branch circuit conductors, with black felt marker indicating panel and breaker number (i.e. "B-24").

2.8 FINISHES

- .1 Shop finish metal enclosures by removal of rust and scale, cleaning, application of rust resistant primer inside and outside, and at least two coats of finished enamel.
 - .1 Paint outdoor electrical equipment "grey" finish.
 - .2 Paint indoor switchgear and distribution enclosures light grey to EEMAC 2Y-1.
- .2 Clean and touch up surfaces to shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .3 Clean, prime, and paint exposed hangers, racks, fastenings to prevent rusting.
- .4 All electrical fittings, supports, hanger rods, pull boxes, channel fittings, conduit racks, outlet boxes, brackets, clamps, etc. shall either have a galvanized finish, or have a painted finish over corrosion resistant primer.
- .5 Where indicated herein and on drawings, provide finishes to match samples as provided by the Engineer.

Part 3 Execution

3.1 INSTALLATION

- .1 Complete installation in accordance with the latest edition of the Canadian Electrical Code Part I (CSA C22.1) and the Alberta Supplement, as well as Municipal and Provincial Codes and Regulations and the local authorities having jurisdiction. Where this specification is at variance with applicable Codes and Standards, the more stringent shall apply.
- .2 Complete overhead and underground systems in accordance with CSA C22.3 No. 1 and underground systems in accordance with C22.3 No. 7 except where specified otherwise.
- .3 Electrical Contractor (Division 26) will be responsible for installation of all control cabling, low voltage wires (cabling and wires supplied by Sections 27 51 23, 28 13 27, 28 13 29 and 28 23 00 Contractor).

3.2 NAMEPLATES AND LABELS

- .1 Manufacturer's nameplates and CSA labels to be visible and legible after equipment is installed.

3.3 CONDUIT AND CABLE INSTALLATION

- .1 Install cables, conduits, and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to minimum.
- .2 Conduit shall be laid out to avoid interference with other trades, and to maintain maximum headroom. Arrange conduit to conserve space, allow maintenance, and avoid crossovers where possible.
- .3 Holes through exterior walls and roof shall be flashed and made completely weatherproof.
- .4 Identify on as-built drawings locations both ends of all conduits.

3.4 LOCATION OF OUTLETS

- .1 Do not install outlets back-to-back in wall; allow minimum 150 mm horizontal clearance between boxes.
- .2 Change location of outlets at no extra cost or credit, providing distance does not exceed 3 meters, and information is given before installation.
- .3 Locate light switches on latch side of doors (determine direction of door swings from Architectural drawings). Locate disconnect devices in mechanical and elevator machine rooms on latch side of door.
- .4 Locate outlets in accordance with Section 26 05 32 – Outlet Boxes, Conduit Boxes and Fittings.

- .5 Coordinate the rough-in location of all outlets with Architectural, structural, and mechanical drawings. Ensure compatibility with finishes, accessories, and devices by others.

3.5 MOUNTING HEIGHTS

- .1 Mounting heights of equipment are from finished floor to centerline of equipment unless specified or indicated otherwise.
- .2 If mounting height of equipment is not indicated, verify before proceeding with installation.
- .3 Install electrical equipment at the following heights unless indicated otherwise.
 - .1 Local switches: 1200 mm (1300 mm in concrete block). Comply with CSA B651 with handicap washroom.
 - .2 Wall receptacles:
 - .1 General: 400 mm (500 mm in concrete block)
 - .2 Above top of continuous baseboard heater: 200 mm
 - .3 Above top of counters or splashback: 175 mm
 - .4 In mechanical rooms: 1400 mm
 - .5 For microwaves: coordinate with Architectural millwork.
 - .3 Panelboards: 1800 mm to top of panel
 - .4 Telephone outlets: 400 mm (500 mm in concrete block)
 - .5 Wall-mounted telephone outlets: 1500 mm
 - .6 Fire alarm pullstations: 1350 mm
 - .7 Audio/visual fire alarm signal device: 2100 mm
 - .8 End of line resistor for signal circuit: 1850 mm
 - .9 Television cable outlets: 450 mm (500 mm in concrete block)
 - .10 Computer outlets: 450 mm (500 mm in concrete block)
 - .11 Motor starters (loose): 1200 mm
 - .12 Wall mounted exit lights: 2200 mm

3.6 COORDINATION OF PROTECTIVE DEVICES

- .1 Ensure circuit protective devices such as overcurrent trips, relays, fuses, are installed to values and settings as indicated.

3.7 FIELD QUALITY CONTROL

- .1 Conduct following tests in accordance with Section 01 45 00 – Quality Control
 - .1 Power distribution system including phasing, voltage, grounding and load balancing.
 - .2 Circuits originating from branch distribution panels.
 - .3 Lighting and its control.
 - .4 Motors, heaters and associated control equipment including sequenced operation of systems where applicable.
 - .5 Systems: fire alarm system; communication systems.
 - .6 Insulation resistance testing:
 - .1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.
 - .2 Megger 350-600 V circuits, feeders and equipment with a 1000 V instrument.
 - .3 Check resistance to ground before energizing.
- .2 Load Balance
 - .1 Measure phase current to panelboards and distribution centres with all possible loads operating. Adjust branch circuit connections as required to obtain best balance of current between phases and record final measurements after adjustments have been completed. Load unbalance shall not exceed fifteen (15%) percent.
 - .2 Measure phase voltages at loads and adjust transformer taps to within two (2%) percent of rated voltage of equipment.
 - .3 Submit, on completion of work, a report listing phase and neutral currents on panelboards, dry type transformers, and motor control centres operating under normal load. State hour and date on which each load was measured, and voltage at time of test.
- .3 Carry out tests in presence of The Departmental Representative.
- .4 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.
- .5 Manufacturer's Field Services:
 - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 – SUBMITTALS.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

- .3 Schedule site visits, to review Work, as directed in PART 1 – QUALITY ASSURANCE.

3.8 CLEANING

- .1 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- .2 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

3.9 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate and recycle waste materials in accordance with Section 01 74 21 – Waste Management and Disposal, and with the Waste Reduction Workplan.
- .2 Collect and separate plastic, paper packaging and corrugated cardboard in accordance with Waste Management Plan.
- .3 Fold up metal banding, flatten and place in designated area for recycling.

3.10 BREAKDOWN AND PRICES

- .1 During the course of construction, when the Contractor is requested to submit a price for the performance of additional work, the price shall be broken down as requested by the Engineer to show quantity, material, and labour charges for each item.
- .2 Submit a Contract Price Breakdown to the Engineer within thirty (30) days of award of the contract, and with each monthly progress claim during construction. Submit invoices to support claims for material on site, when requested. Price breakdowns shall be submitted in a format acceptable to the Engineer.

3.11 OWNER'S EQUIPMENT

- .1 This Contractor is responsible for electrical service connections to all Owner's equipment being supplied and installed in the building and that are shown in the contract documents. All Owner's equipment will be supplied complete with starters and disconnects as required.

END OF SECTION

Part 1 General – Not Applicable

Part 2 Products

2.1 MATERIALS

- .1 All fixture and branch wiring joints in junction and outlet boxes shall be made with a CSA certified pressure type connector rated at 600 volts maximum. Connector body shall consist of a cone shaped coil spring insert, insulated with a colour coded flame retardant, thermoplastic shell, which shall be knurled for easy grip.
- .2 Lugs, terminals, and screws used for termination of conductors, shall be suitable for type of conductor used.
- .3 Wire connectors to CSA C22.2 No. 65.
- .4 Acceptable manufacturers: Buchanan or approved equal.

Part 3 Execution

3.1 INSTALLATION

- .1 Remove insulation carefully from ends of conductors and:
 - .1 Install mechanical pressure type connectors and tighten as recommended by Manufacturer as specified in CSA C22.2 No. 65. Installation shall meet secureness tests.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section 01 33 00 – Submittal Procedures.

1.2 OPERATING AND MAINTENANCE DATA

- .1 Provide data for incorporation into Electrical Maintenance Manual specified in Section 01 33 00 – Submittal Procedures.

Part 2 Products

2.1 GENERAL

- .1 Branch circuit wiring shall be building wire in conduit unless noted otherwise.
- .2 Drops to lighting fixtures and equipment requiring flexible connection shall be AC90.
- .3 Minimum power conductor size shall be #12 AWG.
- .4 Minimum control conductor size shall be #14 AWG.
- .5 Maximum lighting circuit conductor size shall be #10 AWG.
- .6 Cable installed in hazardous areas shall be approved for that classification.
- .7 Wire and cables for 600 volt wiring shall be insulated to 600 volts.
- .8 Wire and cables for 208 volt wiring shall be insulated to 600 volts.

2.2 BUILDING WIRES

- .1 Conductors: stranded for #8 AWG and larger.
- .2 Copper conductors sized as indicated with insulation of chemically cross-linked thermosetting polyethylene material rated R90, RW90 as noted on the drawings.

2.3 ARMOURED CABLE

- .1 Utilized in only completely dry areas and only in short distances.
- .2 Conductors: insulated copper, size as indicated on the drawings.
- .3 Type: AC90.
- .4 Insulation: cross-linked thermosetting polyethylene rated minus 40°C, RW90.
- .5 Armour: over-all interlocking.
- .6 Overall Covering: thermoplastic PVC, flame resistant.

2.4 CONDUCTORS

- .1 Conductors shall be colour coded in accordance with the following:

.1	Single Phase	Hot	Black or Red
		Neutral	White
.2	Two Phase	Hot	Red
		Hot	Black
.3	Three Phase	Neutral	White
		A Phase	Red
		B Phase	Black
		C Phase	Blue
.4	Ground Wires	Neutral	White
		Equipment	Green

Complete conductor insulation shall be the specified colour. Colour coding at the ends of the cable only will not be permitted.

- .2 Conductor phasing shall be made phases A, B, C from left to right when facing equipment.

2.5 WIRE AND CABLE ACCESSORIES

- .1 Provide wire pulling compound which is compatible with the conduit system and the cable insulation.
- .2 Provide Buchanan B-Cap type wire connectors, sized for the conductor for connection of lighting circuit connectors.
- .3 Provide watertight cable connectors with hazardous location rating where required.
- .4 Wire markers shall be mylar/cloth adhesive strip type. Ideal Cat No. 43-xxx or equal.
- .5 Cable ties for indoor use shall be natural 6/6 nylon type with minimum 30 lb tensile strength. Cable ties for outdoor use shall be weather resistant nylon 12 type with minimum 90 lbs tensile strength. Acceptable Products - Panduit 'Pan-Ty', T & B 'Ty-Rap'.

2.6 CONNECTORS

- .1 Pressure type wire connectors with current carrying parts of copper alloy sized to fit copper conductors as indicated.
- .2 Fixture type splicing connectors with fixture type current carrying parts of copper sized to fit copper #10 AWG or less.
- .3 Compression lugs shall be used for motor leads and power connections.

2.7 FASTENINGS

- .1 One hole galvanized straps to secure surface cables 50 mm and smaller. Two hole galvanized straps for surface cables larger than 50 mm.

Part 3 Execution

3.1 INSTALLATION - GENERAL

- .1 Install the following as one continuous length, splices will not be permitted.
 - .1 Motor feeders from source to load.
 - .2 From junction/outlet box to junction/outlet box.
- .2 Install wire and cables without damage to the insulation or conductor. Ensure maximum permissible pulling tensions recommended by the manufacturer are not exceeded.
- .3 All wiring, except at motors and wiring devices shall be terminated on terminal blocks.
- .4 Install wire markers at both ends of the wire and cable and conduit and wherever splices are made.
- .5 Wire Numbering
 - .1 All cables and wires shall be numbered in accordance with the wiring schematics or diagrams.
 - .2 Wire numbers shall increase only after passing through a contact, relay, solenoid or other device. No change in wire number is required after a junction point or terminal.
 - .3 Single phase loads shall be identified as per the panelboard circuit numbers they are fed from.
- .6 Install cable connectors in accordance with manufacturer's recommended method.
- .7 Compression lugs for motor leads and power connections shall be bolted together using cadmium plated or anodized bolts.
- .8 All motor connections shall be adequately insulated.
- .9 Each wire entering a box, whether being terminated, spliced or pulled through, shall be left with at least 150mm of slack to facilitate future alterations.
- .10 Conductors in wireways, control panels and cabinets, etc. shall be secured with nylon cable ties, lacing with string or plastic tape is not acceptable.
- .11 Conductor length for parallel feeders shall be identical.
- .12 Electrical Contractor (Division 26) will be responsible for installation of all control cabling, low voltage wires.

3.2 INSTALLATION OF BUILDING WIRES

- .1 Install in conduit systems in accordance with Section 26 05 34, using wire pulling compound as required.
- .2 Conductors drawn into conduit shall not be pulled more than 16 metres nor through more than three 90° bends without pullboxes.

3.3 INSTALLATION OF CABLES

- .1 Group cables wherever possible on channels. Secure cables to channels with galvanized clamps.
- .2 Install cables in cabletray where indicated. Pull cable into cable tray using approved cable pulling equipment and corner rollers. Secure cables to tray with cable ties.
- .3 Clamp or tie cables every 1500 m or closer if required for a neat installation.
- .4 Install cables with minimum space between cables of 25% of the larger cable diameter as required to maintain cable ampacity.

3.4 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 26 05 00 – Common Work Results for Electrical.

END OF SECTION

Part 1 General

1.1 GROUNDING

.1 General

- .1 Grounding shall meet the Canadian Electrical Code Requirements.
- .2 Ground wire shall be bare soft drawn, standard copper.
- .3 Inaccessible ground system connections shall be made using exothermic connections.
- .4 All conduit runs containing feeders and branch circuits shall be complete with an insulated green ground wire bounded to all outlet boxes, junction boxes, pull boxes, equipment enclosures, etc. The conduit system shall be continuous but shall not be relied on to serve as the equipment grounding means.
- .5 Multi-conductor TECK feeders shall utilize the integral ground conductor or sheath unless otherwise noted.

Part 2 Products

2.1 MATERIALS

- .1 Grounding equipment to: CSA C22.2 No. 41.
- .2 Copper grounding conductors to: ASA G7.1. Minimum size #12 AWG.

2.2 EQUIPMENT

- .1 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:
 - .1 Grounding and bonding bushings.
 - .2 Protective type clamps.
 - .3 Bolted type conductor connectors.
 - .4 Compression connectors.
 - .5 Bonding jumpers, straps.
 - .6 Pressure wire connectors.
- .2 Clamps for grounding of conductor, (size as required) to electrically conductive underground water pipe.
- .3 #3/0 Copper conductor between rod electrodes, bare, stranded, un-tinned, soft annealed.
- .4 Rod electrodes, copper clad steel, 19 mm diameter by 3000 mm long (minimum three rods spaced at 3 metres on centre).

Part 3 Execution

3.1 INSTALLATION – GENERAL

- .1 Install a complete permanent continuous grounding system including electrodes, conductors, connectors, accessories, as indicated, to conform to requirements of The Departmental Representative and local authority having jurisdiction over installation.
- .2 Install connectors to Manufacturer's instructions.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .5 Soldered joints not permitted.
- .6 Install bonding wire for flexible conduit, connected at both ends to grounding bushing, solderless lug, clamp of cup washer and screw. Neatly cleat bonding wire to exterior or flexible conduit.
- .7 Install separate insulated green ground conductor in each conduit system. The conduit system will not be considered as providing an adequate ground.
- .8 Each motor shall be provided with a separate insulated (green) ground conductor originating at the panel or Motor Control Centre from which the motor is energized.
- .9 Install a continuous green insulated ground conductor (#6 AWG minimum), the entire length of cable tray. Bond the conductor to each section of the cable tray. Terminate the ground conductor at the main building ground grid.
- .10 Install a separate bonding conductor with each equipment branch circuit.

3.2 COMMUNICATION SYSTEMS

- .1 Install grounding connections for telephone, computer, sound, fire alarm, and intercommunication systems as follows:
 - .1 Telephones: make telephone grounding system in accordance with telephone company's requirements. Install #6 insulated green copper grounding conductor from main telephone service entrance plywood to the main building ground grid.
 - .2 Computer, sound, fire alarm and intercommunication systems shall each be provided with a separate ground conductor originating at the main building ground grid.

3.3 EQUIPMENT GROUNDING

- .1 Install grounding connections to typical equipment included in, but not necessarily limited to the following list. Service equipment, transformers, switchgear, duct systems, frames of motors, motor control centres, starters, cable trays, control panels, building steel work, generators, elevators and escalators, distribution panels, and outdoor lighting.

3.4 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 26 05 01.
- .2 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of The Departmental Representative and local authority having jurisdiction over installation. Ground resistance to be maximum 5 ohms prior to connections being completed at the ground grid.
- .3 Perform tests before energizing electrical system.

END OF SECTION

Part 1 General – Not Applicable

Part 2 Products

2.1 SUPPORT CHANNELS

- .1 Support channels, length as indicated, U-shape, size 41 mm x 41 mm, 2.5 mm thick, surface mounted or suspended.

2.2 MANUFACTURERS

- .1 Acceptable Manufacturers: Burndy Ltd., Electrovert Ltd., Unistrut Ltd.

2.3 INSTALLATION

- .1 Secure equipment to solid masonry, tile and plaster surfaces with #12 drill plugs, "Hilti HKD", or "Hilti Kwik" bolts. Lead anchors and nylon shields will not be permitted.
- .2 Secure equipment to poured concrete with expandable inserts.
- .3 Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.
- .4 Secure surface mounted equipment with twist clip fasteners to inverted "T" bar ceilings. Ensure that "T" bars are adequately supported to carry weight of equipment specified before installation of same.
- .5 Support equipment, conduit or cables using clips, spring-loaded bolts, cable clamps designed as accessories to basic channel members.
- .6 Fasten conduit or cables to building construction or support system using straps.
 - .1 One-hole steel straps to secure surface conduits and cables 50 mm and smaller.
 - .2 Two-hole steel straps for conduits and cables larger than 50 mm.
 - .3 Beam clamps to secure conduit to exposed steel work.
- .7 Suspended support systems:
 - .1 Support individual cable or conduit runs with 6 mm diameter threaded rods and spring clips.
 - .2 Support 2 or more cables or conduits on channels supported by 6 mm diameter threaded rod hangers where direct fastening to building construction is impractical.
- .8 Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.

- .9 Provide adequate support for raceways and cables dropped vertically to equipment where there is no wall support.
- .10 Do not use wire lashing or perforated strap to support or secure raceways or cables.
- .11 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of the Departmental Representative.
- .12 Install fastenings and supports as required for each type of equipment cables and conduits, and to Manufacturer's installation recommendations.
- .13 Do not install screws through upper flute portion of metal roof deck when roof membrane is located directly on top of metal roof deck. Confirm with general contractor.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data for cabinets in accordance with Section 01 33 00 – Submittal Procedures.

1.2 OPERATING AND MAINTENANCE DATA

- .1 Provide data for incorporation into Electrical Maintenance Manual specified in Division 01.

Part 2 Products

2.1 SPLITTER BOXES

- .1 Splitter box: to CSA C22.2 No. 76-M92 (latest revision), sheet metal, welded corners and formed hinged cover suitable for locking in closed position.
- .2 Main and branch lugs to match required size and quantity of incoming and outgoing conductors as indicated.
- .3 At least three spare terminals on each set of lugs in splitters less than 400A.
- .4 Full length of equipment arrangement except where indicated.

2.2 JUNCTION AND PULL BOXES

- .1 Junction and pull boxes: to CSA C22.2 No. 40-M1989 (latest revision), welded steel construction with screw-on flat covers for surface mounting.
- .2 Covers with 25 mm minimum extension all around, for flush-mounted pull and junction boxes.

2.3 CABINETS

- .1 Type T: sheet steel cabinet with hinged door, latch, lock (2 keys), containing 19mm G1S painted plywood backboard, suitable for flush or surface mounting as noted. Provide drip shield where cabinet is exposed to fire protection sprinklers.

Part 3 Execution

3.1 SPLITTER INSTALLATION

- .1 Install splitters as indicated and mount plumb, true and square to the building lines.

3.2 JUNCTION AND PULL BOXES

- .1 Install junction and pull boxes in accessible locations.
- .2 Support boxes independently of connecting conduits. Secure boxes to building structure.
- .3 Mount cabinets with top not greater than 2 m above finished floor.
- .4 In open office areas containing free standing furniture provide a junction box above the accessible T-bar ceiling. Provide one junction box for each group of workstations interconnected together.

3.3 IDENTIFICATION

- .1 Junction, pull boxes, and splitters with size 2 identification labels indicating system name, ampacity, voltage and phase in accordance with Section 26 05 00.
- .2 Identify all 100 mm square or 100 mm octagon junction boxes, containing branch circuit conductors, with black felt marker indicating panel and breaker number (i.e. "B-24").
- .3 Pull boxes and junction box covers shall be provided with colour markings and/or permanent marker printing to indicated contents of designated purpose (power, communication, data and voice, fire alarm CCTV, etc.). Colour marking shall be approved by Departmental Representative prior to implementation.

END OF SECTION

Part 1 General

1.1 DEFINITIONS

- .1 Outlet box: means sheet steel enclosure for either electric wiring or fittings, having knockout openings in either sides or back, or both, for entrance of wire in conduit, electrical metallic tubing, cable, or flexible tubing. Cover is fastened by screws, not hung on hinges.
- .2 Conduit box: means cast box having threaded openings for rigid conduit or cable connectors.
- .3 Fitting: means fitting intended to secure rigid conduit or electrical metallic tubing to enclosure or to adjacent length of rigid conduit or electrical metallic tubing. Such fitting may be integral part of conduit or outlet box.
- .4 Conduit outlet body: means cast fitting installed in conduit systems to act as pull outlets for conductors being installed or to make 90° bends.

1.2 GENERAL

- .1 Provide and set for each fixture, switch, wall receptacle or other outlet, a box suitable for the location and designed to accept its particular components.
- .2 Before locating the outlet boxes, check all of the architectural, structural, process and mechanical drawings for type of construction and to make sure that there is no conflict with other equipment. The outlet boxes shall be symmetrically located according to room layout and shall not interfere with other work or equipment. Also note any detail of the outlets shown on the drawings.
- .3 Outlets located in the finished areas of the building shall be installed in outlet boxes. Outlets located in the crawlspace and mechanical room or outdoors shall be installed in conduit boxes.

Part 2 Products

2.1 MATERIALS

- .1 Outlet boxes, conduit boxes conduit outlet bodies and fittings shall be approved to CSA Standard C22.2 No. 18.
- .2 Size boxes in accordance with CSA Standard C22.1-12.
- .3 Provide blank coverplates for boxes without wiring devices.
- .4 Provide 347 V rated boxes for 347 V switching devices.
- .5 Provide combination boxes with barriers where outlets for more than one system are grouped.

2.2 OUTLET BOXES

- .1 Outlet boxes shall be made of electro-galvanized sheet steel unless otherwise noted or required by the Canadian Electrical Code (2009). Single or multi-gang flush device boxes shall be used for flush installations, minimum size 76 x 50 x 38 mm or as indicated. 102 mm square outlet boxes shall be used when more than one conduit enters one side with extension and plaster rings as required.
- .2 The outlet boxes shall be complete with raised device covers as required to accept device installed. All outlet boxes must be securely fastened in position with the exposed edge of the raised device cover set flush with the finished surface. Approved factory-made knockout seals shall be installed where knockouts are not intact.
- .3 Electro-galvanized steel utility boxes (handy boxes) shall be used for outlets connected to surface mounted EMT conduit, minimum size 102 x 54 x 48 mm.
- .4 102 mm square or octagonal outlet boxes shall be used for lighting fixture outlets and as pull boxes or circuit junction boxes.
- .5 102 mm square outlet boxes with branch extension and plaster rings for flush mounting devices in finished walls.
- .6 Electro-galvanized steel masonry gang boxes for devices flush mounted in concrete block walls.

2.3 CONDUIT BOXES

- .1 Conduit boxes shall be made of zinc plated cast iron.
- .2 Provide 100 mm round conduit boxes for mounting lighting fixtures, Fire Alarm devices and other ceiling mounted devices and as branch circuit junction boxes. Boxes shall be complete with surface mounting lugs and neoprene cover gaskets.
- .3 Provide Type FS or FD conduit boxes for installation of wiring devices. Boxes shall be complete with threaded hubs suitable for the application, surface mounting lugs and neoprene cover gaskets.

2.4 CONDUIT OUTLET BODIES

- .1 Conduit Outlet Bodies shall be made of galvanized cast iron complete with threaded hubs and neoprene cover gaskets.
- .2 Provide conduit outlet bodies as pull outlets and to provide taps for branch conduit runs. Do not use conduit outlet bodies for making splices and taps in conductors.

2.5 FITTINGS

- .1 Provide bushings and connectors with nylon insulated throats.
- .2 For rigid conduit provide threaded type galvanized fittings.

- .3 For EMT provide set screw type fittings with double locknuts for connection to sheet metal boxes and liquid tight fittings for connection to type FS or FD conduit boxes.

Part 3 Execution

3.1 INSTALLATION

- .1 Support boxes independently of connecting conduits.
- .2 During construction fill boxes with paper or foam to prevent entry of construction material.
- .3 For flush installations mount outlets flush with finished wall using plaster rings to permit wall finish to come within 6 mm of opening.
- .4 Provide correct size of openings in boxes for conduit and cable connections. Reducing washers not allowed.
- .5 Do not install coverplates until paint or other finish is applied.

3.2 IDENTIFICATION

- .1 Identify all junction boxes as per Section 26 05 00.

3.3 ELECTRICAL OUTLETS IN MASONRY WALLS

- .1 Install electrical outlet boxes in steel block units in concrete masonry unit walls for all electrical, communications, security, etc. outlets.
- .2 Install outlet boxes in the steel block units square and plumb. Tack weld the outlet box to the steel block units and grind welds smooth.
- .3 Steel blocks shall be grout filled and re-enforced with steel reinforcing bar.
- .4 Coordinate installation of boxes in steel blocks with the steel block supplier and installer.

END OF SECTION

Part 1 General – Not Applicable

Part 2 Products

2.1 CONDUITS

- .1 Rigid metal conduit: to CSA C22.2 No. 45.
- .2 Electrical metallic tubing (EMT): to CSA C22.2 No. 83.
- .3 Flexible metal conduit and liquid-tight flexible metal conduit: to CSA C22.2 No. 56.
- .4 Rigid PVC Type DB2 duct for ductbanks and direct burial: sized as indicated on drawings, to CSA C22.2 No. 211.1.
- .5 Rigid PVC conduit: sized as indicated on drawings to CSA C22.2 No. 211.2.
- .6 Flexible non-metallic tubing: to CSA C22.2 No. 227.3.
- .7 Minimum 19mm trade size conduits for lighting and power.

2.2 CONDUIT FASTENING

- .1 One hole galvanized steel straps to secure surface conduits 50mm and smaller. Use two hole galvanized steel straps for conduits larger than 50mm.
- .2 Beam clamps to secure conduits to exposed steel work.
- .3 Channel type supports for two or more conduits at the following maximum spacings:
 - 1500 mm for 13 mm and 19 mm conduits
 - 2000 mm for 25 mm and 32 mm conduits
 - 3000 mm for 40 mm and larger conduits
- .4 6 mm diameter threaded rods to support suspended channels.
- .5 Conduit clamps for conduits on channels.

2.3 CONDUIT FITTING

- .1 Fittings for raceways: to CSA C22.2 No. 18.
- .2 Fittings manufactured for use with conduit specified.
- .3 Factory "ells" where 90 degree bends are required for 19 mm and larger conduits.

Part 3 Execution

3.1 INSTALLATION

- .1 Drawings do not show all conduits. Those shown are in diagrammatic form. Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
- .2 Main indoor feeders and sub-feeders shall be installed in EMT Conduit with steel fittings and all wiring shall be copper. Alternative piping methods shall meet the requirements of the Canadian Electrical Code.
- .3 Branch wiring shall be minimum 21mm EMT conduit. All conduits shall have a spare capacity of at least 20% or three No. 12 gauge insulated wires, whichever is greater.
- .4 An insulated green ground wire shall be installed in all conduit runs.
- .5 Major multiple conduit runs shall be grouped on suspended channels (Unistrut or approved equal) with minimum of 25% spare space for future runs.
- .6 Conceal conduits except in unfinished areas and concealed ceiling spaces.
- .7 Use rigid conduit in any location which, in the opinion of Engineer is subjected to mechanical damage or corrosion and where conduit is exposed in an inmate area.
- .8 Use flexible metal conduit or armoured cable only for the following:
 - .1 Lighting circuits shall be in EMT conduit and wire, using BX only for the last 1 metre connection to fixtures when appropriate.
- .9 Use P.V.C. underground or in concrete slabs.
- .10 Use flexible non-metallic tubing in concrete slabs only. Flexible non-metallic tubing is not acceptable above concrete floor slab (adapt to EMT).
- .11 Use liquid-tight flexible metal conduit and liquid-tight connectors for connection to all motors.
- .12 Bend conduits cold, so that conduit at any point is not flattened more than 1/10th of its original diameter. Consider conduits bent more than this or kinked as defective and replace.
- .13 Mechanically bend steel conduit over 19mm diameter.
- .14 Field threads on rigid conduit shall be sufficient length to draw conduits up tight.
- .15 Provide polypropylene fish cord in empty conduits to facilitate pulling wiring in future.

- .16 Run 3 – 25 mm spare conduits up to ceiling space from each flush panel. Terminate these conduits in 152 x 152 x 102 mm junction boxes located in the accessible ceiling space above or in case of an exposed concrete slab, terminate each conduit in a surface type box mounted on the underside of the slab.
- .17 Where conduits become blocked, use of corrosive agents is prohibited. Remove and replace blocked section.
- .18 Dry conduits out thoroughly before installing wire.
- .19 Conduits shall not pass through structural members without the knowledge and consent of the structural Engineer.
- .20 Locate conduits not less than 75 mm parallel to steam or hot water lines with a minimum of 25 mm at crossovers.
- .21 All conduit connectors shall be complete with a nylon insulated throat wherever conduit terminates in an outlet or junction box.
- .22 Conduit shall be secured to building structure. Do not fasten conduit to suspended ceiling or its support.
- .23 Run conduit parallel or perpendicular to building lines, when installed exposed or in ceiling spaces.
- .24 Locate conduits a minimum of 1.5 metres from infrared or gas fired heaters.
- .25 Conduits to be run in flanged portion of structural steel.
- .26 Group conduits wherever possible on surface channels.
- .27 Install CSA approved expansion fittings complete with grounding jumpers where conduits cross building expansion joints. Provide offsets in conduit adjacent to building expansion joints, where conduit is installed above suspended ceilings.
- .28 Conduits installed between heated and unheated spaces shall be sealed internally with a silicone sealant at the wall between the two spaces.
- .29 Install conduit sealing fittings in hazardous areas. Fill with compound.
- .30 Electrical Contractor (Division 26) will be responsible for installation of all control cabling, low voltage wires (cabling and wires supplied by Sections 27 51 23, 28 13 27, 28 13 29 and 28 23 00 Contractor).

3.2 CONCEALED CONDUITS

- .1 Horizontal runs are not permitted in masonry walls.
- .2 Conduits are not permitted in terrazzo or concrete toppings.

3.3 CONDUITS IN CAST-IN-PLACE CONCRETE

- .1 Locate to suit reinforcing steel. Install in centre one third of slab.
- .2 Protect conduits from damage where they stub out of concrete.
- .3 Provide sleeves in advance of concrete pour where conduits pass through slab or walls.
- .4 Do not use EMT conduit in concrete slabs in contact with the earth.
- .5 Where conduits pass through waterproof membrane provide oversize sleeve before membrane is installed. Use cold mastic between sleeve and conduit.
- .6 Conduits to be completely encased in concrete.

3.4 CONDUITS IN CAST-IN-PLACE SLABS ON GRADE

- .1 PVC Conduits 25 mm and larger to be run below slab and encased in 75 mm concrete envelope. Provide 50 mm of sand over concrete envelope below floor slab.

3.5 CONDUITS UNDERGROUND

- .1 Slope conduits to provide drainage.

3.6 IDENTIFICATION

- .1 Refer to General Provisions – Conduit and Cable Identification: Section 26 05 00.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section 01 33 00.
- .2 Include time-current characteristic curves for breakers with ampacity of 400 and over.

1.2 OPERATION AND MAINTENANCE DATA

- .1 Provide data for incorporation into Electrical Maintenance Manual specified in Section 01 33 00.

Part 2 Products

2.1 BREAKERS – GENERAL

- .1 Moulded case circuit breakers: to CSA C22.2 No. 5.1.
- .2 Bolt-on moulded case circuit breaker, quick-make, quick break type, for manual and automatic operation.
- .3 Common-trip breakers with single handle for multi pole applications.
- .4 Magnetic instantaneous trip elements in circuit breakers to operate only when the value of current reaches setting. Trip settings on breakers with adjustable trips to range 3 – 10 times current rating.
- .5 Breakers shall trip to "centre" position.

2.2 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 under overload conditions and instantaneous magnetic tripping for short circuit protection.

2.3 BREAKER ENCLOSURES

- .1 Breaker enclosures shall be surface mounted unless otherwise noted. The breaker shall be capable of being padlocked either in the "ON" or "OFF" position.

2.4 MANUFACTURERS

- .1 Acceptable Manufacturers: Schneider Canada, Siemens Canada Ltd., Cutler Hammer Canada Ltd., General Electric.

Part 3 Execution

3.1 INSTALLATION

- .1 Install circuit breakers as indicated.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section 01 33 00.
- .2 Drawings shall include rating and enclosure dimensions.

1.2 OPERATIONS AND MAINTENANCE DATA

- .1 Provide data for incorporation into Electrical Maintenance Manual specified in Section 01 33 00.

Part 2 Products

2.1 EQUIPMENT

- .1 Enclosed manual air break switches in non-hazardous locations: to CSA C22.2 No. 4.
- .2 Fuseholder assemblies: to CSA C22.2 No. 39.
- .3 Fusible and non-fusible disconnect switch in CSA Enclosure 1 as indicated.
- .4 Provision for padlocking in "OFF" switch position.
- .5 Mechanically interlocked door to prevent opening when handle in 'ON' position.
- .6 Fuseholders in each switch suitable without adaptors, for type of fuse as indicated.
- .7 Quick-make, quick-break action.
- .8 ON-OFF switch position indication on switch enclosure cover.
- .9 Fusible and non-fusible disconnect switch shall be complete with solid neutral lug assembly.

2.2 EQUIPMENT IDENTIFICATION

- .1 Size 4 nameplate in accordance with Section 26 05 00 indicating name of load controlled.

2.3 MANUFACTURERS

- .1 Acceptable Manufacturers: Cutler-Hammer, Siemens Canada Ltd., Schneider Canada, General Electric.

Part 3 Execution

3.1 INSTALLATION

- .1 Install disconnect switches complete with fuses as indicated.
- .2 Mount securely at 1800 mm above finished floor to top of switch. Provide a minimum of 1000 mm clear floor space in front of the switch.

3.2 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Section Identification 26 05 00.
- .2 Nameplate for each disconnect switch Size 5 engraved in accordance with Section 26 05 00. Indicate disconnect load, amperage, voltage, and phase (i.e., rooftop unit, 60 amp, 120/208V, 3 phase).
- .3 Identify circuit number on disconnect switch (i.e. "B-36").

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section 01 33 00.
- .2 Indicate:
 - .1 Mounting method and dimensions.
 - .2 Starter size and type.
 - .3 Layout of identified internal and front panel components.
 - .4 Enclosure types.
 - .5 Wiring diagram for each type of starter.
 - .6 Interconnection diagrams.

1.2 OPERATION AND MAINTENANCE DATA

- .1 Provide data for incorporation into Maintenance Manual specified in Section 01 33 00.
- .2 Include operation and maintenance data for each type of starter.

1.3 MAINTENANCE MANUALS

- .1 Provide listed spare parts for each different size and type of starter.
 - .1 One (1) contact, auxiliary.
 - .2 Two (2) fuses.

Part 2 Products

2.1 MATERIALS

- .1 Starters to CSA C22.2 No. 14, EEMAC E14-1.
 - .1 Half size starters not acceptable.
 - .2 Control transformers - to CSA C22.2 No. 66.
 - .3 Resistors - to EEMAC 13E-1.
 - .4 Auto transformers - to CSA C22.2 No. 47.

2.2 MANUAL STARTING SWITCHES

- .1 Single phase manual motor starters of size, type, rating, and enclosure type as required, with components as follows:
 - .1 Switching mechanism, quick-make and break.
 - .2 One overload heater, manual reset, trip indicating handle.

.2 Accessories

- .1 Toggle switch heavy duty labelled as indicated.
- .2 Indicating light: heavy duty neon type and red colour.
- .3 Locking tab to permit padlocking in "ON" or "OFF" position.

2.3 FULL VOLTAGE MAGNETIC STARTER

- .1 Magnetic and combination starters of size, type, rating and enclosure type as indicated with components as follows:
 - .1 Contactor solenoid operated, rapid action type.
 - .2 Motor overload protective device in phase, manually reset from outside enclosure.
 - .3 Power and control terminals.
 - .4 Wiring and schematic diagram inside starter enclosure in visible location.
 - .5 Identify each wire and terminal for external connections, within starter, with permanent number marking identical to diagram.
- .2 Combination type starters to be circuit breaker with operating handle on outside of enclosure to control circuit breaker, and provision for:
 - .1 Locking in "OFF" position with up to 3 padlocks.
 - .2 Locking in "ON" position.
 - .3 Independent locking of enclosure door.
 - .4 Provision for preventing switching to "ON" position while enclosure door open.
- .3 Accessories:
 - .1 Selector switches: heavy duty H.O.A. unless otherwise indicated.
 - .2 Indicating lights: heavy duty neon type and red colour.
 - .3 1-N/O and 1-N/C spare auxiliary contacts unless otherwise indicated.

2.4 CONTROL TRANSFORMER

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

2.5 FINISHES

- .1 Apply finish to enclosure in accordance with Section 26 05 00.

2.6 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Section 26 05 00.
- .2 Provide a size 1 plastic laminate identifying both name of motor as well as motor designation (i.e. "EXHAUST FAN EF-1").

2.7 MANUFACTURERS

- .1 Acceptable Manufacturers are: Allen-Bradley Canada Company, Siemens Canada Ltd., Cutler-Hammer Canada Ltd., Schneider Canada, General Electric, or approved equal.

Part 3 Execution

3.1 INSTALLATION

- .1 Install starters, connect power and control as indicated.
- .2 Ensure correct fuses and overcurrent device elements are sized to accommodate actual motor loading.
- .3 Provide the necessary conduit for mechanical heating and ventilation control to the starters as required under the mechanical contract. Confirm with the Mechanical Contractor the conduit requirements prior to installation.
- .4 The Electrical Contractor shall complete all control wiring required which is not specifically related to the controls systems as outlined in the mechanical specifications. All control wiring outlined in the mechanical specifications as part of the controls systems shall be completed by the Controls Contractor. The Electrical Contractor shall supply all control equipment specifically noted on plans or specifications. All other equipment required shall be supplied by Mechanical or other trades. The Electrical Contractor shall cooperate with the Mechanical trades to ensure that all control sequences and equipment are correct. The Electrical Contractor shall be supplied with all electrical equipment from other trades and shall verify that its characteristics are correct. It will be the responsibility of the Electrical Contractor to obtain from the Mechanical Contractor, and all other trades, complete detailed wiring diagrams for all equipment supplied by these trades requiring electrical wiring by the Electrical Contractor's work and the work of other trades. It is the Electrical Contractor's responsibility to point out immediately any discrepancies in these diagrams or any reason they cannot be adhered to. All control equipment such as immersion type thermostats, coil freeze protection, pneumatic control devices, etc. shall be installed by the trade responsible for its supply and operation.
- .5 It is the responsibility of the electrical contractor to provide a dedicated line voltage power source where required for control systems.
- .6 It is the responsibility of the electrical contractor to provide all control devices such as pushbutton stations, when they do not form part of a control panel.

3.2 TESTS

- .1 Perform tests in accordance with Section 26 05 00.
- .2 Perform tests in accordance with Manufacturer's instructions.
- .3 Operate switches, contactors to verify correct functioning, related starters, equipment, control devices, operate as indicated.
- .4 Perform starting and stopping sequences of contactors and relays.
- .5 Check that sequence controls, interlocking with other separate related starters, equipment, control devices, operate as indicated.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

- .1 Shop drawings and product data in accordance with Section 26 05 01.
- .2 Manufacturer shall provide a complete set of shop drawings for this specific project. Drawings shall include, but not limited to, dimensioned outline drawing, schematic diagram, power and control connection diagram, full list of features, installation instructions, and operating instructions produced specifically for this project. Drawings shall be approved by the Engineer before fabrication and supply of equipment.

1.2 OPERATING AND MAINTENANCE DATA

- .1 Provide data for incorporation into Electrical Maintenance Manual specified in Section 26 05 01.
- .2 Submit a detailed operating, maintenance and testing procedure document prepared specifically for this project.
- .3 The Owner's operating personnel shall be instructed in the operation of the systems for a minimum of one (1) hour. Written documentation bearing name and signature of Owner's personnel who received the above instructions shall be included in the operating instructions and service manuals.
- .4 All AFD parameter settings shall be documented in the operating and maintenance manual.

1.3 SUPPLIER QUALIFICATIONS

- .1 The supplier shall be fully qualified in the performance of work specified herein. Service personnel shall be located within the Province of Alberta and shall be experienced in the installation and operation of the system.

1.4 VERIFICATION

- .1 The AFD manufacturer shall supply on site start-up, commissioning and operator training. Allow for all cost and labour for as many trips as necessary to complete these requirements. Labour, expenses and all parts shall be at the AFD suppliers cost until the warranty period expires. Warranty shall be for a minimum of twenty-four (24) months after shipment or 18 months after energization.
- .2 Upon completion of installation of the system, a factory trained manufacturer's representative shall perform a completion verification and inspection of all installed equipment. A certificate of verification confirming that the commissioning and inspection have been performed, shall be submitted.
- .3 The factory trained manufacturer's representative shall witness all connections between building automated controls system (BACS) and the AFD and shall assist the controls contractor with all input and output connections between the AFD and the BACS.

1.5 STANDARDS

- .1 The AFD shall be designed, manufactured and tested in accordance with the latest applicable standards of IEC, UL, CUL, CSA and NEMA.

Part 2 Products

- .1 The adjustable frequency drive operation shall be based on Pulse Width Modulation (PWM) design utilizing insulated gate bi-polar transistors (IGBT's). Each unit shall be built to CSA Z299.3 level of quality control or equivalent. The AFD shall be complete with a digital control system.
- .2 All AFD's shall use the same common logic for all units as specified for this project.
- .3 The AFD shall be rated for continuous duty while operating standard squirrel cage induction motors as listed in the motor schedule. The AFD shall have a continuous current rating at least 10% in excess of the motor full load amp rating. An overload service factor of 110% for one minute duty (variable torque) must be supplied to ensure adequate safety margins for all applications.
- .4 For maintenance and testing purposes, the AFD shall have a test mode whereas the AFD shall be capable of stable operation over entire speed range (starting, stopping, running) with the motor disconnected.
- .5 The AFD efficiency shall be a minimum of 95% for all inverters when operated at full speed and load.
- .6 Input voltage shall be rated for the system voltage and have a minimum voltage tolerance of +10% from nominal, and a line frequency variation of 48 to 62 Hz. The output voltage shall vary linearly with the speed to maintain the motors design voltage to frequency ratio from zero speed to 60 hertz. Frequency stability shall be maintained within 1% over the entire speed range.
- .7 AFD shall be enclosed in the motor control centres unless otherwise noted.
- .8 The AFD shall maintain the line side displacement power factor at no less than 0.96 regardless of speed or load.
- .9 The AFD shall be capable of starting a spinning motor. The AFD shall be able to determine the motor speed in any direction and resume operation without tripping.
- .10 Protective devices to be incorporated are:
 - .1 Main incoming door interlocked circuit breaker or disconnect switch.
 - .2 The AFD shall be protected by three Class J high interrupting capacity fuses to supply fault protection of the drive for faults up to 100,000 amps RMS symmetrical.
 - .3 A fully rated external AC line reactor to minimize line current harmonics and provide transient protection for a minimum of 5000 volts, 50 microseconds pulse in accordance with ANSI C42-61.

- .4 Integral electronic motor overload protection adjustable from 50 to 110% of the drive rating to coordinate with actual motor full load ampere rating. Current in excess of this setting will cause a timed overload trip to occur.
- .5 Instantaneous output short circuit protection for phase to phase and phase to ground faults.
- .6 Over voltage DC Bus monitor/protection.
- .7 Supply under voltage protection as required to maintain logic and control during power dips and power loss conditions, such as transfer switch operations.
- .8 Loss of supply voltage and loss of phase protection.
- .9 AFD heat sink over temperature detection circuit to shut down the AFD and provide an O/T fault indication.
- .10 Capable of operating without a motor over the entire frequency range for maintenance and testing purposes.
- .11 Accepts the motor output circuit being opened, while the motor is operating without damaging inverter.
- .12 The following motor protection shall be provided for the motor. The following protection shall be related to the specific motor and not the AFD.
 - separate I^2t overload protection (AFD overload protection not acceptable for motor overload.)
 - stall protection.
 - phase to ground fault protection.
 - instantaneous overcurrent protection.
 - phase to phase fault protection.
 - adjustable torque limit setpoints.
- .13 The AFD shall have an active current limit to prevent the motor from operating in an overload condition. When the current limit setting is reached, the output frequency is reduced such that the load reduces to less than the current limit setpoint. When the actual load decreases, the speed will ramp back to process setpoint.

- .14 Provide an output isolation contactor to provide for a positive isolation between the motor and the inverter. The contactor shall remain energized for power interruptions of up to 0.5 seconds.
- .11 Operational Features
 - .1 Regenerative override circuit to allow deceleration of high inertia loads without nuisance shutdowns.
 - .2 Instantaneous fault shutdown.
 - .3 Automatic restart after power outage, if the run command is maintained closed.
 - .4 Automatic attempt to restart after any fault. If unable to restart, the drive shall lockout the inverter after 3 unsuccessful attempts within a 90 second time period. The Fault counter will reset to zero automatically after 3 minutes of continuous operation.
 - .5 Adjustable minimum speed setting from 0-70% and a maximum speed setpoint from 50-100% of the 60 hertz rating.
 - .6 Separately adjustable accelerating and deceleration ramp rates programmable between 1 and 300 seconds. A fast acceleration to minimum speed shall be used on all starts.
 - .7 Input speed reference signal shall be 4-20mA DC for remote auto mode operation and local potentiometer or keypad entry for manual mode of operation. The 4-20mA input shall be isolated such that either input line can be grounded or both floating.
 - .8 Output speed monitoring shall be by a 4-20mA isolated signal.
 - .9 Output load monitoring shall be by a 4-20mA isolated signal.
 - .10 Provide digital or analog displays for the following functions on each AFD front panel:
 - speed reference input
 - speed output (%)
 - motor frequency (hertz)
 - current (%)
 - motor voltage (%)
 - .11 High performance inner current loop regulator.
 - .12 Optimized tuning of air gap flux.
 - .13 Programmable V/Hz profiles.

- .14 The AFD shall have a "SELF TUNE MODE" which will automatically do the calibration of motor parameters to match AFD regulator settings.
- .15 AFD shall indicate date and time display of all trips (or the time elapsed since failure displayed).
- .16 AFD shall have elapsed time meter (non-re-settable) or indicate hours and minutes of operation (inverter running).
- .17 The AFD shall have a rotating restart circuit that will allow for a safe start into a motor that is rotating in the forward or reverse direction and accelerate it to the desired speed in the proper direction.
- .18 Audible noise generated by AFD shall not exceed 85 dBA at 1 metre intervals around AFD.
- .12 Environmental Capabilities
 - .1 The drive shall operate without mechanical or electrical damage under any combination of the following conditions:
 - .1 Ambient temperature 0-40°C.
 - .2 Humidity 0-95% (non condensing).
 - .3 Vibration up to 0.5 G.
 - .4 Altitude 0-1000 metres.
 - .13 AFD self cooled by natural convection shall automatically shutdown if heat sink temperature exceeds setpoint. If forced air cooling is used the AFD shall provide immediate shutdown on cooling air loss and provide annunciation of this shutdown.
 - .14 The AFDs shall limit harmonic distortion reflected onto the utility system by utilizing standard 3% nominal impedance integral ac three-phase line reactors.
 - .15 Customer terminal blocks for control wires shall be separated from power wire connections and shall be able to accept connections for 12 AWG wires. Printed circuit board terminal blocks are not acceptable.
 - .16 The AFD shall be manufactured and tested to quality control CSA Z299.3 standards or better. Each unit shall be full load tested in heat chamber at 40°C for a minimum of four hours of continuous operation without any trips or faults.
 - .17 Bypass
 - .1 Provide a bypass control scheme to safely apply full voltage to the driven motor in the event of a failure to the Adjustable Frequency Drive. The bypass scheme shall meet the following requirements:
 - .1 Provide a sectional CSA Approved enclosed cabinet or use the AFD cabinet with proper shrouding of all live parts, to provide isolation for maintenance of the AFD when in bypass mode.

- .2 Provide a separate circuit disconnect in parallel to the AFD circuit disconnect to feed the 3 phase power to the bypass section only.
 - .3 Provide high interrupting capacity fuses on the load side of the circuit disconnect for fault clearing capability of 100,000 Amperes RMS Symmetrical.
 - .4 Provide a door mounted Line-Off-AFD selections switch to select operations at constant speed or at adjustable speed.
 - .5 Provide two mechanically and electrically interlocked contactors for line and AFD operations.
 - .6 Provide a thermal overload relay which will protect the motor in either mode of operation.
 - .7 Provide a separate start/stop pushbutton to start the bypass mode manually. In auto mode, the same run command from the DDC will start and stop the motor in either mode.
 - .8 Provide all the necessary control logic, time delay relays and interlocks to provide a safe reliable bypass control scheme. The control scheme shall provide a safe transfer to either mode of operation for all possible operating conditions.
 - .9 Control logic shall maintain all external interlocks active in either mode of operation.
- .18 The AFD shall be complete with a communication card for interface with the building management system (i.e. Johnson N2, Modbus RTU, DeviceNet, Interbus-S, Profibus-DP, Lonworks, IMPAAC, Staefa etc.).
- .19 The AFD shall be complete with an input EMI filter to minimize conducted electrical noise to meet the requirements of IEC 61800-3.
- .20 Control Functions
- .1 Frequently accessed AFD programmable parameters shall be adjustable from a digital operator keypad located on the front of the AFD. When the AFD is located in a motor control centre, the digital operator keypad shall be located on the face of the motor control centre. The AFDs shall have a 3 line x 16 character alphanumeric programmable display with status indicators. Display shall be adjustable for contrast with large characters easily visible in normal light.
 - .2 Standard advanced programming and trouble-shooting functions shall be available by using a personal computer's RS-232 port and Windows TM based software. In addition, the software shall permit control and monitoring via the AFD's RS232 port. The manufacturer shall supply a compact disk with the required software. An easily understood instruction manual and software help screens shall also be provided. The computer software shall be used for modifying the drive set-up and reviewing diagnostic and trend information.

- .3 The operator shall be able to scroll through the keypad menu to choose between the following:
 - .1 Monitor
 - .2 Operate
 - .3 Parameter set-up
 - .4 Actual parameter values
 - .5 Active faults
 - .6 Fault history
 - .7 LCD contrast adjustment
 - .8 Information to indicate the standard software and optional features software loaded.
- .4 The following set-ups and adjustments, at a minimum, are to be available:
 - .1 Start command from keypad, remote or communications port
 - .2 Speed command from keypad, remote or communications port
 - .3 Motor direction selection
 - .4 Maximum and minimum speed limits
 - .5 Acceleration and deceleration times, two settable ranges
 - .6 Critical frequency avoidance
 - .7 Torque limit
 - .8 Multiple attempt restart function
 - .9 Multiple pre-set speeds adjustment
 - .10 Catch a spinning motor start or normal start selection
 - .11 Programmable analog output
 - .12 DC brake current magnitude and time
 - .13 Proportional / integral process control
- .5 The AFDs shall have the following system interfaces:
 - .1 Inputs – a minimum of six (6) programmable digital inputs, two (2) analog inputs and serial communications interface shall be provided with the following available as a minimum:
 - .1 Remote manual / auto
 - .2 Remote start / stop
 - .3 Remote forward / reverse
 - .4 Remote pre-set speeds
 - .5 Remote external trip
 - .6 Remote fault reset
 - .7 Process control speed reference interface, 4-20mA_{dc}
 - .8 Potentiometer and 0-10 V_{dc} speed reference interface
 - .9 RS232 (or DPI Scanport) programming and operation interface port
 - .10 Serial communications port or DPI Scanport (c/w communications module)

.2 Outputs – a minimum of two (2) discrete programmable digital outputs, and one (1) programmable analog output shall be provided, with the following available at minimum:

.1 Programmable relay outputs with one (1) set of Form C contacts for each, selectable with the following available at minimum:

- .1 Fault
- .2 Run
- .3 Ready
- .4 Reversing
- .5 At speed
- .6 In torque limit
- .7 Motor rotation direction opposite of commanded
- .8 Overtemperature

.2 Programmable analog output signal, selectable with the following available at minimum:

- .1 Output current
- .2 Motor speed
- .3 Motor torque
- .4 Motor power
- .5 Motor voltage
- .6 DC link voltage

.6 Monitoring and Displays

.1 The AFD's display shall be a LCD type capable of displaying the following indicators:

- .1 Run
- .2 Forward
- .3 Reverse
- .4 Stop
- .5 Ready
- .6 Alarm
- .7 Fault

.2 The AFD's LCD display shall be capable of indicating the following monitoring functions at a minimum:

- .1 Output frequency
- .2 Output speed
- .3 Motor current
- .4 Motor torque
- .5 Motor power
- .6 Motor voltage
- .7 DC-link voltage
- .8 Heatsink temperature
- .9 Total operating days counter
- .10 Total megawatt hours

- .11 Voltage level of analog input
- .12 Current level of analog input
- .13 Digital inputs status
- .14 Digital relay outputs status
- .15 Motor temperature rise, percentage of allowable
- .3 Diagnostic Features
 - .1 Fault History
 - .1 Recorded and log faults
 - .2 Indicate the most recent first, and store up to 4 faults
- .21 Acceptable Manufacturers: Cutler Hammer "SVX9000", Schneider Electric "Altivar", Rockwell "Powerflex 700", "Siemens Micromaster" or approved equivalent.

Part 3 Execution

3.1 INSTALLATION

- .1 Install AFD according to manufacturer's recommendations.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 Canadian Environmental Protection Act (CEPA)
 - .1 CCME PN 1326-[2008], Environmental Code of Practice for Aboveground and Underground Storage Tank Systems for Petroleum Products and Allied Petroleum Products.
- .2 CSA International
 - .1 CSA-B139-[09], Installation Code for Oil Burning Equipment.
 - .2 CAN3-Z299.3-[85(R2006)], Quality Assurance Program - Category 3.
- .3 International Organization for Standardization (ISO)
 - .1 ISO 3046-1-[2002], Reciprocating internal combustion engines - Performance - Part I: Declarations of power, fuel and lubricating oil consumptions, and test methods - Additional requirements for engines for general use.
 - .2 ISO 3046-4-[1997], Reciprocating internal combustion engines - Performance - Part 4: Speed governing.
- .4 National Electrical Manufacturers Association (NEMA)
 - .1 NEMA MG1-[2006(R2007)], Motors and Generators.
- .5 Underwriters' Laboratories of Canada (ULC)
 - .1 CAN/ULC-S601-[07], Standard for Shop Fabricated Steel Aboveground Horizontal Tanks for Flammable and Combustible Liquids.
 - .2 ULC-S603-[00], Standard for Steel Underground Tanks for Flammable and Combustible Liquids.

Part 2 Products

2.1 SYSTEM DESCRIPTION

- .1 Provide automatic, unattended, emergency power supply system consisting of:
 - .1 Liquid cooled 600VAC diesel electric generating unit with combined control.
 - .2 Replace existing generator paralling control with new. Coordinate exact Central Logic details with PWGSC and generator manufacturer.
 - .3 Emergency generator to be the same manufacturer as existing generators.
- .2 Provide design, fabrication, testing, transportation, demonstration and equipment warranty.

2.2 DESIGN CRITERIA

- .1 Design equipment to meet following requirements:
 - .1 Total load: 1200 kW.
 - .2 Voltage: 600 V.
 - .3 Frequency: 60 Hz.
 - .4 3 Phase/ 4Wire.
 - .5 Power factor: 0.8.
 - .6 Load harmonic content: 20% THD.
 - .7 Duty rating: full load continuous plus 10% overload for 1 hour in every 12 hours period.
 - .8 Performance: automatic.
- .2 Design unit capable of starting, attaining settled voltage and frequency limits and accepting 80% rated load with voltage and frequency settling to specified steady state bands, within 15 seconds for any temperature between 0 degree C to 40 degrees C.
- .3 Use engine manufacturer's standard, published continuous (prime) horsepower rating in assessing engine capacity and derate this rating for specified conditions and engine driven accessories in accordance with ISO 3046-1.

2.3 ASSEMBLY

- .1 Provide items as follows plus other items necessary to make unit complete:
 - .1 Diesel engine.
 - .2 Diesel engine accessories.
 - .3 Baseplate and drip pan.
 - .4 Vibration isolators.
 - .5 Governor.
 - .6 Engine exhaust system.
 - .7 Remote Engine cooling system.
 - .8 Engine ventilating system.
 - .9 Starting motor.
 - .10 Batteries and rack.
 - .11 Battery charger.
 - .12 Generator and exciter.
 - .13 Voltage regulator and accessories.
 - .14 Combined control, transfer by-pass panel.
 - .15 Generator controllers to control/manage all generators on site.

2.4 MOUNTING

- .1 Emergency generator to be mounted on existing pad in the generator building. Vibration isolators to be located within the dimensions of the existing pad.
- .2 Baseplate: rigid material to maintain alignment of engine-generator shafts and frames under shipping, installation and service conditions.

- .3 Install machine engine-generator feet and baseplate sole plates parallel and true.
 - .1 Shims: steel type, installed under generator feet.
- .4 Support baseplate on spring type isolating fixtures from welded side brackets located to support bottom of baseplate 25 mm above supporting floor.
 - .1 Isolators: cast iron housings, complete with levelling bolts, adjustable oil proof snubbers and minimum 6 mm sound pads.
 - .2 Isolation efficiency 95% minimum.
- .5 Determine quantity and location of isolators.
 - .1 Locate each isolator to carry equal proportion of weight and that pressure exerted on floor by each isolator does not exceed 345 kPa.
- .6 Ship isolators loose for installation at project site.

2.5 DIESEL ENGINE

- .1 Full diesel, heavy duty, cold start, liquid cooled, vertical in-line or vee, and current manufacture of a type and size that has been service as a prime mover for electric power generation for not less than two years.
 - .1 Turbo supercharged engine acceptable providing brake mean effective pressure (BMEP) at rated output does not exceed 1800 kPa (225 psi).
 - .2 Mechanically driven superchargers not acceptable.
- .2 Engine: minimum of four (4) cylinders.
- .3 Engine with auxiliary starting aids (i.e., glow plug assist start) not acceptable.
- .4 Equip engine air intakes with dry type heavy duty air cleaners located close to inlet manifold.
 - .1 Cleaner element: directly replaceable with elements of Canadian manufacture.
- .5 Provide engine wiring in liquid-tight conduit and fittings with insulated bushings.
 - .1 Use stranded, minimum No.14 AWG, TEW 105 degree C and coloured coded wires.
 - .2 Terminate wiring with coded, insulated terminals flanged fork type. Terminal blocks heavy duty, screw type.
 - .3 Wire markers of slip on oil proof type.

- .6 Provide high quality lubricating oil pressure gauge, lubricating oil temperature gauge, tachometer, coolant temperature gauge, and other standard gauges and instruments.
 - .1 Calibrate and scale gauges and instrument in both metric and imperial units and symbols.
 - .2 Mount oil temperature sensors on engine full flow pressure line.
 - .3 Hoses or tubing for gauges: high pressure reinforced type.
- .7 Mount unit accessories, including gauges, instruments, and protective sensors, to isolate or dampen vibrations.
- .8 Dynamically balance complete engine-flywheel generator arrangement after assembly.
 - .1 Torsional or other vibration tolerance within 10% above or below rated speed of unit, when operating unloaded or connected to any load within its rating.
- .9 Provide engine flywheel with graduated marking around its periphery to facilitate fuel injection and valve timing.
- .10 Provide removable wet type cylinder liners.
 - .1 Furnish cylinder head with removable valve seat insert and guides.
- .11 Provide personnel safety guards for exposed moving parts and exhaust manifolds.
 - .1 Provide platform for servicing upper part of engine where applicable.
- .12 Engine control panel complete with:
 - .1 Lubricating oil pressure gauge.
 - .2 Lubricating oil temperature gauge.
 - .3 Coolant temperature gauge.
 - .4 Low coolant level gauge.
 - .5 Engine switch auto-off-crank-start selector switch and crank pushbutton.
 - .6 D.C. main power supply circuit breaker.
 - .7 Terminal blocks for connection to D.C. power supply, engine monitoring and shutdown device.
 - .8 Provide low oil pressure, high coolant temperature, low coolant level and overspeed protection to shut down engine on manual operation.

2.6 COOLING AND VENTILATING SYSTEM

- .1 Provide complete cooling (remote radiator) and ventilating system for unit as indicated.

- .2 Thermostatically control system and maintain coolant, ethylene glycol, within engine manufacturer's tolerance, 88 degree C with unit operating at rated load under specified conditions. Cooling system remote radiator type.
 - .1 Design and supply complete ventilating system where engine mounted radiator is required.
 - .1 Radiator cooling fan to be pusher type, minimum two belt drive with belt adjuster.
 - .2 Fan, pulley and belt with removable protective cage.
 - .2 Provide multi-fan system suitable for indoor or outdoor installation complete with electrical controls and breaker type combination starters.
 - .1 Motor of splash proof enclosure.
 - .2 Provide braided corrugated flexible lines for pipe terminations at radiator and engine, isolating valves, fittings and pipe for installation of radiators.
- .3 Provide drain valves for draining coolant from engine block and radiator.
 - .1 Drain coolant conveniently into large container through flexible extensions.
 - .2 Dripping valves or leaking connections will not be permitted.
- .4 Ventilation system: complete with canvas connections, mounting hardware, modulating damper motors, dampers, inlet and outlet hoods, bird/insect/screen, air filters, manual potentiometer, damper linkages, low voltage transformer, thermostat, fan motor.

2.7 LUBRICATION SYSTEM

- .1 Provide full pressure lubricating system complete with filters and oil cooler.
- .2 Oil pump: engine driven gear type complete with strainer.
- .3 Equip filters with automatic by-pass valve and full flow filter elements conveniently located for servicing and directly replaceable with elements of Canadian manufacture.
 - .1 Cooler to have sufficient capacity to maintain oil temperature within engine manufacturer's tolerances with unit operating at rated load under conditions specified.
- .4 Equip engine oil sump with oil drain pipe, gate valve and pipe cap.
 - .1 Permit complete drainage in a convenient manner.

- .5 Ensure unit is able to start and assume full rated load within the specified time period when, operational requirements are such that unit may lay idle for periods up to one month.
 - .1 Provide electrical motor driven, integrally mounted, gear type oil priming pump with interval timer and breaker type combination starter.
 - .2 Lubrication oil pressure switch to stop priming pump when engine is running.
- .6 Metallic oil hoses: steel reinforced rubber type with crimped or swaged end fittings.

2.8 FUEL SYSTEM

- .1 Provide complete fuel system including pump and filters in accordance with CSA-B139.
 - .1 Filter elements to be directly replaceable with elements of Canadian manufacture.
- .2 Bring fuel supply and return lines to extreme forward part of baseplate with drop ear elbows.
 - .1 Connect other end of each elbow with 1 m of flexible neoprene hose.
- .3 Non-metallic fuel hoses: steel reinforced rubber type with crimped or swaged end fittings.

2.9 EXHAUST SYSTEM

- .1 Provide complete exhaust system including heavy duty industrial type silencer with condensate drain, plug and flanged couplings; stainless steel, corrugated expansion joints, length to suit, to absorb both vertical and horizontal expansion; flanges, bolts, gaskets, adjustable hangers and pipe and pipe-thimble to permit projection of pipe beyond wall.
- .2 Arrange exhaust system to suit openings as indicated.
 - .1 Where schedule of dimensions does not indicate location of opening, arrange exhaust run best suited to engine.
- .3 Provide exhaust pyrometers located on common exhaust manifold or two pyrometers on separate manifolds.
 - .1 Pyrometer range to include temperature at 110% load.

2.10 JACKET COOLANT HEATER

- .1 Provide engine jacket coolant heater(s) complete with 20 degree C to 60 degree C adjustable immersion type thermostat.
 - .1 Size heater(s) to maintain coolant at 40 degree C in an ambient temperature of 0 degree C.

- .2 Obtain circulation of heated coolant on thermosyphon principle.
 - .1 However, if this does not provide sufficient circulation to avoid hot spots in system, provide electrical motor driven circulating pump to operate automatically when heater is energized.
 - .2 Motor: 120 V single phase splash-proof type complete with breaker type combination starter.

2.11 SPEED GOVERNOR

- .1 Provide full electronic governor with speed changer and dry type actuator.
 - .1 Governing system: in accordance with ISO 3046-4.
- .2 Governor with following features:
 - .1 Ten (10) turn locking type manual speed adjustment.
 - .2 Speed regulation, steady state, no-load to full load and vice versa: $\pm 0.25\%$.
 - .3 Transient peak, no-load to full-load and vice versa $\pm 10\%$.
 - .4 Recovery time to steady state condition on application of 80% from no load not to exceed 3 seconds.
 - .5 Frequency: externally adjustable from zero to 5% while engine is running.
 - .6 Class A accuracy.

2.12 STARTING SYSTEM

- .1 Provide complete starting system including cranking starting motors, batteries, battery stand, heavy-duty battery cables and battery charger.
- .2 Provide positive engaging type cranking motors.
 - .1 Cranking motor and flywheel ring gear arrangements which may permit tooth to tooth abutment not acceptable.
- .3 Provide lead acid battery with sufficient capacity in ambient room temperature of 0 degree C to crank unit at engine manufacturer's recommended cranking starting speed for period of 3 minutes.
 - .1 Voltage measured at starting motor terminals at end of 3 minutes cranking, with cranking current flowing, not less than 1.75 V per cell.
 - .2 Size battery to suit engine and battery manufacturer's published data.
 - .3 Batteries: dry charged, specific gravity of electrolyte 1.220 when fully charged at 27 degree C.

- .4 Battery termination: bolt-on or study type.
- .5 Protect terminals and exposed electrical connections from accidental short circuit by falling conductive objects on battery.
- .4 Provide battery stand coated with acid resistant paint and fabricated from angle irons with 20 mm plywood bottom and heavy duty casters for ease of movement.
- .5 Provide battery charger with 120 volt AC input and output equal to 1.20 of ampere-hour capacity of battery based on 8 hour rate.
 - .1 Output voltage ripple: 3% or less.
 - .2 Provide AC input circuit breaker and 24 hours terminating equalizer timer with approximately 4 m of connecting cord and permanent connectors for connecting to battery terminals.
 - .3 Provide 5 spare fuses inside charger panel.
 - .4 Charger: CSA approved.
- .6 Provide necessary heavy duty, maintenance-free battery cables and connectors.
 - .1 Select cable wire size on the basis of allowing not more than 5% voltage drop at time of peak load.
 - .2 Cable length sufficient to allow battery location on either side of engine.
- .7 Fit turbocharged engines with one spring actuated, two stage accumulator per turbocharger to automatically provide pre-start and post run lubrication to turbocharger[s].

2.13 GENERATOR

- .1 Provide generator, drip proof, single bearing and close coupled to engine with SAE housing: to NEMA MG 1.
 - .1 Generator: full amortisseur winding, direct connected brushless exciter with easily removable bolt-on diodes with surge protection.
- .2 Maximum deviation of open circuit terminal voltage waveform not to exceed 5%.
- .3 Provide permanent magnet generator (PMG) for generator short circuit sustaining capability not less than 2.4 times rated current.
- .4 Generator winding insulation: Class F; winding temperature rise not to exceed 80 degree C as measured by resistance in ambient temperature of 40 degree C.

- .5 Identify generator windings with metal tags.
 - .1 Bring windings to insulated terminals in metal junction box mounted on side or top of generator.
 - .2 Size junction box to permit mounting of engine and generator low voltage controls and wiring terminals blocks.
 - .3 Provide barrier in junction box to separate low and high voltage wiring.
- .6 Provide voltage regulation system complete with auto/manual control module.
 - .1 Voltage regulator: capable of withstanding continuous vibration, 15 G shock and temperature up to 50 degree C while maintaining accuracy to plus/minus 1%.
- .7 Steady-state voltage regulation not to exceed 1%.
 - .1 Transient voltage regulation, when full load is applied or removed, not to exceed 10% when measured by oscilloscope or high speed strip chart recorder with recovery time to steady-state less than 3 seconds.
- .8 Design equipment to minimize radio frequency interference (RFI) under operating conditions.
 - .1 Balanced telephone influence factor (TIF) to: NEMA MG 1.

2.14 CONTROL PANEL

- .1 Provide control panel for controlling engine generator unit.
- .2 Provide 1 cm x 4 cm horizontal copper ground bus for whole length of enclosure, and two ground lugs; one at each end.
 - .1 Lug: capable of accepting grounding conductor of range from No. 8 to No. 2/0 AWG.
- .3 Terminal blocks: CSA approved, clamp type, serrated for positive grip and of tough, non-brittle unbreakable nylon material; maximum two wires per terminal block.
 - .1 Use factory made terminal block jumpers wherever necessary.
- .4 Provide circuit breakers for equipment protection: use fuses where breakers are not applicable.
- .5 Provide top and bottom entry for power and control cables.

2.15 SIGNS

- .1 Provide at front top of each panel and on each generator junction box, lamacoid or metal engraved identification nameplate.
 - .1 Provide nameplates with letter and number identification designation to be given at time of acceptance tests.
- .2 Provide and attach to unit in prominent location, bilingual warning sign.
- .3 Where metric tools are required to service engine-generator unit, provide bilingual warning sign.

2.16 QUALITY OF WORK

- .1 Manufacture and construct equipment free from blemishes, defects, burrs and sharp edges; accuracy of dimensions and marking of parts and assemblies; thoroughness of welding, brazing, painting and wiring, alignment of parts and tightness of assembly screws and bolts.

2.17 QUALITY CONTROL

- .1 General: before acceptance, assemble and set up the unit, complete with specified equipment, for tests at the supplier's plant.
 - .1 Ensure tests are witnessed by Departmental Representative on mutually agreed date.
 - .2 Provide suitable test area with adjustable loading facilities.
 - .3 Ensure that engine has run in sufficiently prior to load test, test forms completed, system debugged and recorders connected.
- .2 Product examination: complete mechanical and electrical examination to determine compliance with specification and drawings with respect to materials, workmanship, dimensions and marking.
- .3 Non-operational tests and checks: perform following test and checks before starting the unit:
 - .1 Shaft alignment, end float, angular and parallel.
 - .2 Cold resistance of generator windings.
 - .3 Belt tensioning.
 - .4 Equipment grounds.
 - .5 Electrical wiring.
 - .6 All grease lubricating points.
 - .7 Personnel safety guards.
 - .8 Air cleaner.
 - .9 Coolant.
 - .10 Lubricating oil type and level.
 - .11 Type of fuel.

- .12 Vibration isolator adjustment.
 - .13 Temperature and pressure sensors.
 - .14 Engine exhaust system.
 - .15 Tools.
 - .16 Spares.
- .4 Operation test and check: on completion of non-operational tests and checks, start unit cold. Provide multi-channel recorder and record following:
- .1 Time for unit to start and reach settled voltage and frequency.
 - .2 Time from initiation of start to full load application, with voltage and frequency settled.
 - .3 Voltage and frequency transient and steady state limits for full load to no load, 3/4 load to no load, load to no load, 1/4 load to no load and vice versa. Measure machine vibration levels under the same load conditions.
 - .4 Record battery voltage drop during cranking.
- .5 Protection and control demonstration: on completion of operation test and check, demonstrate following:
- .1 Overheat protection.
 - .2 Low oil pressure protection.
 - .3 Cranking cut out.
 - .4 Overcrank protection (3 tries).
 - .5 Overspeed protection.
 - .6 Under and over frequency.
 - .7 Under and over voltage.
 - .8 Electrical fault protection:
 - .1 Failure to close breaker.
 - .2 Failure to build up voltage.
 - .3 Generator short circuit and overcurrent.
 - .9 All control functions.
- .6 Load tests: load test the unit for 24 hours at full rated load and further 1 hour at 110% rated load in ambient room temperature of 40 degree C. Take following data at start of load test and every one hour interval thereafter:
- .1 Frequency.
 - .2 Voltage.
 - .3 Current.
 - .4 Kilowatts.
 - .5 Generator winding temperature.
 - .6 Generator frame temperature.
 - .7 Engine coolant temperature.
 - .8 Oil temperature and pressure.
 - .9 Manifold pressure.
 - .10 Ambient room temperature.
 - .11 Generator cooling air outlet temperature.

- .12 Exciter field current and voltage.
 - .13 Vibration displacement.
 - .14 Ambient air temperature inside panel with doors closed.
- .7 Miscellaneous: provide accurate means for determining fuel and lubricating oil consumption.
- .1 Provide strip chart recorders for monitoring frequency, voltage and load.
 - .2 Provide recorder with ability to select speeds to allow accurate measurement of voltage, frequency and time during tests.
 - .3 Calibrate recorder by the recorder manufacturer (or designated representative) within three months of factory testing.
- .8 Interpretation of ambient room temperature: consider ambient room temperature as that temperature, which is lowest temperature registered out of a group of three thermometers when placed in engine room as follows:
- .1 One thermometer located on each side of engine block, approximately two-thirds of length of block back from front (radiator) end of block, 900 mm out from block and at height equal to height of block.
 - .2 Locate third thermometer over end of exciter on unit centre line, approximately 150 mm above top of exciter.
 - .3 Take thermometer showing lowest temperature to give true ambient air temperature.
 - .4 Adjust temperature to maintain this thermometer at 40 degree C during heat test.
- .9 Voltage and frequency regulation tests: on completion of load tests take hot resistance reading of generator windings.
- .1 Subject the unit to hot voltage and frequency regulation tests for full load to no load, 3/4 load to no load, load to no load, 1/4 load to no load and vice versa.
- .10 Panel performance and functions : check sequence of operation under service conditions.
- .1 Make provision for supplying and connecting required levels of voltage for primary circuits.
 - .2 Test overcurrent relays by impressing current in secondary circuits.
- .11 Hi-pot tests: perform over potential tests on primary and secondary wiring in accordance with NEMA.
- .12 Additional tests: perform tests, consistent with contract, which Departmental Representative may require to satisfy adequacy and satisfactory operation of the unit.

- .13 Record test data, recording charts and manufacturers' test forms and be complete with diagrams and description of test results, deficiencies and corrective action.

- .1 Ensure test data sheets signed by supplier and Departmental Representative.

Part 3 Execution

3.1 EXAMINATION

- .1 Verification of Conditions:
 - .1 Verify that substrate conditions, which have been previously installed under other sections or contracts, are acceptable for product installation in accordance with manufacturer's instructions prior to installation of liquid cooled diesel electric generating units.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied.

3.2 INSTALLATION

- .1 Install liquid cooled Diesel electric generating units to CAN3-Z299.3 and in accordance with manufacturer's written instructions.

3.3 CLEANING

- .1 Clean in accordance with Section 01 74 11 - Cleaning.
 - .1 Remove surplus materials, excess materials, rubbish, tools and equipment.
- .2 Waste Management: separate waste materials for recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

3.4 CLOSEOUT ACTIVITIES

- .1 Demonstration and Training:
 - .1 As directed by Departmental Representative.
 - .2 Provide familiarization training of operating and maintenance staff.
 - .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with aspects of its care and operation.
 - .4 Provide fuel required for performing site test and top-up after acceptance test completion.

3.5 MAINTENANCE - CLEARANCES

- .1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer and CSA-B139.

END OF SECTION