

Part 1 General

1.1 Related Requirements

- .1 This Section covers items common to Sections of Division 26, 27 and 28. These sections supplement requirements of Division 1.

1.2 References

- .1 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.
- .2 Reference Standards:
 - .1 CSA Group
 - .1 CSA C22.1-15, Canadian Electrical Code, Part 1 (23rd Edition), Safety Standard for Electrical Installations.
 - .2 CSA C22.2.
 - .3 CAN3-C235-83, Preferred Voltage Levels for AC Systems, 0 to 50,000 V.
 - .2 Institute of Electrical and Electronics (IEEE)/National Electrical Safety Code Product Line (NESC)
 - .1 IEEE SP1122, The Authoritative Dictionary of IEEE Standards Terms, 7th Edition.

1.3 Action And Informational Submittals

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for review and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Submit for review fire alarm riser diagram, plan and zoning of building at fire alarm control panel and annunciator.
- .4 Submit for review Fire Alarm Verification Report.
- .5 Submit for review single line electrical diagrams and locate as indicated.
- .6 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 co-ordinated 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 on drawings clearances for operation, maintenance, and replacement of operating equipment devices.
- .4 Submit required number of copies of required size drawings to authority having jurisdiction. One set to the Office of the Fire Commissioner (OFC) for review.
- .5 If changes are required, notify Departmental Representative of these changes before they are made.
- .7 Certificates:
 - .1 Provide CSA certified equipment.
 - .2 Where CSA certified equipment is not available, submit such equipment to authority having jurisdiction or inspection authorities for special approval before delivery to site.
 - .3 Submit test results of installed electrical systems and instrumentation.
 - .4 Permits and fees: in accordance with General Conditions of contract.
 - .5 Submit, upon completion of Work, load balance report as described in PART 3 - LOAD BALANCE.
 - .6 Submit certificate of acceptance from authority having jurisdiction upon completion of Work to Departmental Representative.
- .8 Manufacturer's Field Reports: submit to Departmental Representative manufacturer's written report, within 3 days of review, verifying compliance of Work and electrical system testing, as described in PART 3 - FIELD QUALITY CONTROL.
- .9 Sustainable Design Submittals:
 - .1 Building Energy and Water Consumption: submit Measurement and Verification Plan following IPMVP for monitoring end-uses as follows:
 - .1 Lighting systems and controls.
 - .2 Constant and variable motor loads.
 - .3 Cooling load.
 - .4 Building-related process energy systems and equipment.

1.4 Closeout Submittals

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for incorporation into manual.
 - .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 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.

1.5 Delivery, Storage And Handling

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect equipment from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.

Part 2 Products

2.1 Design Requirements

- .1 Operating voltages: to CAN3-C235.
- .2 Motors, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard.
 - .1 Equipment to operate in extreme operating conditions established in above standard without damage to equipment.
- .3 Language operating requirements: provide identification nameplates and labels for control items in English.

2.2 Materials And Equipment

- .1 Provide material and equipment in accordance with Section 01 61 00 - Common Product Requirement.
- .2 Material and equipment to be CSA certified. Where CSA certified material or equipment is not available, obtain special approval from authority having jurisdiction or inspection authorities before delivery to site and submit such approval as described in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS.
- .3 Factory assemble control panels and component assemblies.
- .4 Electrical equipment shall be new and of the type and quality specified.

- .5 Electrical equipment shall be CSA approved and shall carry the CSA label or CSA testing laboratory listing. Where there is no alternative to supplying equipment which is not CSA certified, obtain special approval from appropriate Inspection Department.
- .6 Provide labour, materials, transportation, equipment and facilities, etc. required for the complete electrical installation as indicated or implied on the drawings and specifications.

2.3 Voltage Rating

- .1 Operating voltages: to CAN3-C235.
- .2 Motors, electric 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.

2.4 Electric Motors, Equipment And Controls

- .1 Verify installation and co-ordination responsibilities related to motors, equipment and controls, as indicated.
- .2 Control wiring and conduit: Control Devices except for conduit, wiring and connections below 50 V which are related to control systems are specified in mechanical sections or as shown on mechanical drawings.
- .3 Supplier and installer responsibility is generally indicated on the electrical drawings.
- .4 Refer also to mechanical drawings and specifications for all related electrical work and include in tender price.
- .5 Control wiring and conduit with exception to equipment supplied by Divisions 25 is the responsibility of Division 26. All conduit, wiring and connections which are related to control systems specified in Division 25 is the responsibility of the controls contractor.

2.5 Wiring Terminations

- .1 Ensure lugs, terminals, screws used for termination of wiring are suitable for either copper or aluminum conductors.

2.6 Equipment Identification

- .1 Identify electrical equipment with labels as follows:
 - .1 Nameplates: lamacoid 3 mm thick plastic engraving sheet, black face, white core, lettering accurately aligned and engraved into core mechanically attached with self tapping screws.
 - .2 Sizes as follows:

NAMEPLATE SIZES			
Size 1	10 x 50 mm	1 line	3 mm high letters
Size 2	12 x 70 mm	1 line	5 mm high letters
Size 3	12 x 70 mm	2 lines	3 mm high letters
Size 4	20 x 90 mm	1 line	8 mm high letters
Size 5	20 x 90 mm	2 lines	5 mm high letters
Size 6	25 x 100 mm	1 line	12 mm high letters

Size 7	25 x 100 mm	2 lines	6 mm high letters
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- .2 Wording on nameplates labels to be approved by Departmental Representative . prior to manufacture.
- .3 Allow for minimum of twenty-five (25) letters per nameplate.
- .4 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
- .5 Identify equipment with Size 3 labels engraved "ASSET INVENTORY NO. " as directed by Departmental Representative ..
- .6 Disconnects, starters and contactors: indicate equipment being controlled and voltage.
- .7 Terminal cabinets and pull boxes: indicate system and voltage.
- .8 Transformers: indicate capacity, primary and secondary voltages.

2.7 **Operation And Maintenance Data**

- .1 Provide operation and maintenance data for incorporation into operation and maintenance manuals. Operation and maintenance manuals shall be submitted to Owner.
- .2 Include detail of design elements, construction features, components function and maintenance requirements, to permit effective start-up, operation, maintenance, repair, modification, extension and expansion of any portion or feature of installation.
- .3 Include technical data, product data, supplement by bulletins, component illustration, exploded views, technical description of items, and parts lists. Advertising or sales literature not acceptable.
- .4 Include wiring and schematic diagrams and performance curves.
- .5 Include name and addresses of local supplier for items included in maintenance manuals.
- .6 Maintenance manuals to be submitted to Departmental Representative for review. Manuals that are incomplete shall be returned to electrical subcontractor for completion. Completed manual must be submitted, to the satisfaction of the Departmental Representative, before final payment may be considered to be due.

2.8 **Shop Drawings, Product Data And Samples**

- .1 Submit shop drawings, product data and samples for review by Departmental Representative. Manufacture of equipment must not commence until shop drawings have been reviewed.
- .2 Indicate detail construction, dimension, capacities, weights and electrical performance characteristics of equipment or material.
- .3 Include wiring, single line and schematic diagrams, wherever applicable.
- .4 Include wiring drawings or diagrams showing interconnection with work of other sections.
- .5 Shop drawing submissions shall include a photocopy of all applicable specification sections showing a complete compliance/non-compliance listing.

- .6 Each drawing submission to bear following signed stamp, and include name of project, equipment supplier and clause number equipment is specified under.

CONTRACTORS CERTIFICATION

This drawing has been reviewed by
(firm name)

All dimensions have been checked and found compatible with the contract drawings
and all capacities, quantities, sizes and other data contained in the contract
documents have been listed by the supplier on this drawing and have been checked
by the undersigned and found correct.

Date

Per

- .7 Clearly show division of responsibility. No item, equipment or description of work shall be indicated to be supplied or work to be done 'By Others' or 'By Purchaser'. Any item, equipment or description of work shown on shop drawings shall form part of the contract, unless specifically noted to the contrary.
- .8 Provide field dimensions required by electrical supplier and sub-subcontractors. In cases where fabrication is required prior to field dimensions being available, check all related drawings and obtain clarification from Departmental Representative if necessary.
- .9 Check all shop drawings carefully and make all necessary changes, prior to submission to the Departmental Representative for review. If re-submission is required, the Contractor shall ensure that the supplier's drawings have been changed to comply before returning them to Departmental Representative for another review. If the drawings still do not comply, and require additional review by the Departmental Representative, the Departmental Representative shall be reimbursed by the Contractor for the time required for such additional reviews.
- .10 Review of the shop drawings by the Departmental Representative shall not relieve the Contractor from responsibility for errors and omissions therein.
- .11 Shop drawings reflecting additional design or change in design shall be reviewed by the Departmental Representative and Owner.
- .12 Provide shop drawings for all electrical components, including but not limited to wiring devices, receptacles, lamps, starters, luminaires, etc.
- .13 Main distribution and utility metering shop drawings must be approved by local utility prior to submission to Departmental Representative.
- .14 Quality Control:
- .1 Provide CSA or equivalent certified equipment and material.
- .2 Where CSA or equivalent certified equipment and material is not available, submit such equipment and material to authority having jurisdiction for special approval before delivery to site.

- .3 Submit test results of installed electrical systems and instrumentation.
- .4 Permits and fees: in accordance with General Conditions of contract.
- .5 Submit, upon completion of Work, load balance report.
- .6 Submit certificate of acceptance from authority having jurisdiction upon completion of Work.
- .7 Other requirements as listed in specification.

2.9 **Quality Assurance**

- .1 Quality Assurance: in accordance with Front End specifications.
- .2 Qualifications: electrical Work to be carried out by qualified, licensed electricians or apprentices in accordance with authorities having jurisdiction and as per the conditions of Provincial or Territorial Act respecting manpower vocational training and qualification.

2.10 **Wiring Identification**

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

2.11 **Conduit And Cable Identification**

- .1 Colour code conduits, boxes and metallic sheathed cables.
- .2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 15 m intervals.
- .3 Colours: 25 mm wide prime colour and 20 mm wide auxiliary colour.

Prime	Auxiliary	
up to 250 V	Yellow	
up to 600 V	Yellow	Green
Telephone	Green	
Other Communication Systems	Green	Blue
Fire Alarm	Red	
Emergency Voice	Red	Blue
Other Security Systems	Red	Yellow

2.12 **Finishes**

- .1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.

Part 3 Execution

3.1 Examination

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative ..
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

3.2 Installation

- .1 Do complete installation in accordance with CSA C22.1 except where specified otherwise.

3.3 Nameplates And Labels

- .1 Ensure manufacturer's nameplates, CSA labels and identification nameplates are visible and legible after equipment is installed.

3.4 Location Of Outlets

- .1 Locate outlets in accordance with Section 26 05 32 - Outlet Boxes, Conduit Boxes and Fittings.
- .2 Do not install outlets back-to-back in wall; allow minimum 150 mm horizontal clearance between boxes.
- .3 Change location of outlets at no extra cost or credit, providing distance does not exceed 3000 mm, and information is given before installation.
- .4 Locate light switches on latch side of doors.

3.5 Mounting Heights

- .1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
- .2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.
- .3 Install electrical equipment at following heights (Above finished floor AFF) unless indicated otherwise.
 - .1 Local switches: 1200 mm.
 - .2 Wall receptacles:
 - .1 General: 450 mm.
 - .2 Above top of continuous baseboard heater: 200 mm.
 - .3 Above top of counters or counter splash backs: 175 mm.
 - .4 In mechanical rooms: 1400 mm.

- .3 Panelboards: as required by Code or as indicated.
- .4 Telephone and interphone outlets: 450 mm.
- .5 Fire alarm stations: 1150 mm.
- .6 Fire alarm horns: 2300 mm or min. 150mm from ceiling to top of device.
- .7 Fire Alarm Strobes: 2300mm
- .8 As per Architectural Specifications.

3.6 Co-Ordination Of Protective Devices

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

3.7 Field Quality Control

- .1 Load Balance:
 - .1 Measure phase current to panelboards with normal loads (lighting) operating at time of acceptance; adjust branch circuit connections as required to obtain best balance of current between phases and record changes.
 - .2 Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment.
 - .3 Provide upon completion of work, load balance report as directed in PART 1 - ACTION AND INFORMATIONAL SUBMITTALS, phase and neutral currents on panelboards, dry-core transformers and motor control centres, operating under normal load, as well as hour and date on which each load was measured, and voltage at time of test.
- .2 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 and communications.
 - .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.
- .3 Carry out tests in presence of 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 - ACTION AND INFORMATIONAL 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.

3.8 System Startup

- .1 Instruct Departmental Representative and operating personnel care and maintenance of systems, system equipment and components.
- .2 Arrange and pay for services of manufacturer's factory service engineer 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 aspects of its care and operation.

3.9 Cleaning

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 - Cleaning.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

PART 1 General

1.1 Related Work

- .1 Refer to all sections of the specification for related work.

1.2 Coordination

- .1 The existing building shall remain open and remain in normal operation during the construction period.
- .2 Contractor shall allow for off-hours work as required.
- .3 Where existing services or systems, such as electrical power, telephone system, data systems, fire alarm system, etc. are required to be disrupted and/or shut-down, coordinate the shut-downs with Departmental Representative and carry out the work at a time and in a manner acceptable to them. Carefully schedule all disruptions and/or shutdowns and ensure the duration of same is kept to the absolute minimum. Submit for review, a written concise schedule of each disruption at least 120 hours in advance of performing work and obtain written consent prior to implementing.
- .4 Should any temporary connections be required to maintain services or systems during work in the existing building, supply and install all necessary material and equipment and provide all labour at no extra cost. Should any existing equipment or system be damaged, make full repairs without extra cost, and to the satisfaction of the Departmental Representative.
- .5 Comply with instructions regarding working hours necessary to maintain the building in operation.
- .6 Refer to Note-1, Drawing E1 for direction and coordination on temporary heating.

1.3 Existing Devices In New Construction

- .1 Disconnect and remove existing electrical equipment made obsolete due to the renovations. Remove associated wiring and conduits back to source panel.
- .2 Where existing devices (receptacles, switches, etc.) are presently mounted on a wall which will be covered with a new finish, provide an extension ring, coverplate, etc., as required, to mount the device to the new wall finish.
- .3 Identify all existing electrical equipment to remain, which is located in or on portions of existing walls, ceilings or floors being modified and/or demolished, devices shall be relocated to the nearest wall. This equipment shall include cabinets, lighting, panels, switches, fire alarm and life safety devices, receptacles, etc.
- .4 Where existing conduits, which are in use, pass vertically or horizontally through a wall being demolished, relocate those conduits and conceal in a new wall or surface mount in a service area. Extend conduit, wiring, etc. as required.

- .5 Identify work or equipment installation/removal located in designated/special walls and inform Departmental Representative for directions before commencing work.
- .6 Where new ceilings are to be installed, relocate all existing ceiling mounted devices down or to suit new ceiling. This equipment shall include but not be limited to smoke detectors, heat detectors, speakers, luminaires, etc. Extend existing conduit and wiring as required.
- .7 All existing junction boxes in walls and ceiling spaces required to maintain existing circuits shall remain accessible.
- .8 Include all costs to x-ray existing floors or building surfaces to be drilled or sleeved to ensure no existing services are severed or damaged. Damages could be very serious. Any damages resulting from failure to x-ray (or scan) is the Contractor's responsibility.

1.4 Schedule Of Work

- .1 Confirm Schedule of work and include all requirements to conform to it.

PART 2 Products

2.1 Materials

- .1 Provide all materials required for the complete interface and reconnection installation as herein described and as indicated on the drawings.
- .2 New wiring required to interconnect new devices to existing systems shall be provided to suit the manufacturer's requirements and instructions.
- .3 Add modules, switches, hardware, software, etc., in any existing control panels as required, Electrical Contractor to allow for modifications and extend existing systems to the new or designated areas.

PART 3 Execution

3.1 Installation

- .1 Install boxes, conduit and wiring through existing areas as required for the new installation.
- .2 Patch and repair walls and ceilings in existing building that have been damaged or cut open due to the new electrical installation.
- .3 Patch and make good existing walls which are to remain where existing electrical devices have been removed.
- .4 Where new cables or conduits have been installed through existing fire rated walls, seal opening around cables and conduit to maintain fire rating.

END OF SECTION

Part 1 General

1.1 Related Requirements

- .1 This Section covers items common to Sections of Division 26 and 28. These sections supplement requirements of Division 1.

1.2 References

- .1 CSA Group
 - .1 CSA C22.1-15, Canadian Electrical Code, Part 1 (23rd Edition), Safety Standard for Electrical Installations.
 - .2 CSA C22.2.
 - .3 CAN/CSA-C22.3 No.1-10, Overhead Systems.
 - .4 CAN3-C235-83(R2010), Preferred Voltage Levels for AC Systems, 0 to 50,000 V.
- .2 Institute of Electrical and Electronics (IEEE)/National Electrical Safety Code Product Line (NESC)
 - .1 IEEE SP1122-[2000], The Authoritative Dictionary of IEEE Standards Terms, 7th Edition.

1.3 Product Data

- .1 Provide product data in accordance with Section 01 33 00 - Submittal Procedures.

1.4 Delivery, Storage And Handling

- .1 Packaging Waste Management: remove for reuse by manufacturer of pallets, crates, padding and packaging materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

Part 2 Products

2.1 Building Wires

- .1 Conductors: stranded for 10 AWG and larger. Minimum size: 12 AWG.
- .2 Copper conductors: size as indicated, with 1000 V insulation of cross-linked thermosetting polyethylene material rated RW90 XLPE Jacketted.
- .3 Copper conductors: size as indicated, with thermoplastic insulation type TWH rated at 600 V.
- .4 Neutral supported cable: 1, 2, 3 phase insulated conductors of Copper and one neutral conductor of Copper reinforced, size as indicated. Type: Insulation: Type NSF-2 flame retardant rated 600 V.

2.2 Teck 90 Cable

- .1 Cable: in accordance with Section 26 05 00 - Common Work Results for Electrical.

- .2 Conductors:
 - .1 Grounding conductor: copper.
 - .2 Circuit conductors: copper, size as indicated.
- .3 Insulation:
 - .1 Ethylene propylene rubber EP.
 - .2 Cross-linked polyethylene XLPE.
 - .3 Rating: 1000 V.
- .4 Inner jacket: polyvinyl chloride material.
- .5 Armour: interlocking galvanized steel.
- .6 Overall covering: thermoplastic polyvinyl chloride, compliant to applicable Building Code classification for this project.
- .7 Fastenings:
 - .1 One hole steel straps to secure surface cables 50 mm and smaller. Two hole steel straps for cables larger than 50 mm.
 - .2 Channel type supports for two or more cables spaced as per CEC.
 - .3 Threaded rods: 6 mm diameter to support suspended channels.
- .8 Connectors:
 - .1 Watertight approved for TECK cable.

2.3 Armoured Cables

- .1 Conductors: insulated, copper size as indicated.
- .2 Type: AC90.
- .3 Armour: interlocking type fabricated from aluminum strip.
- .4 Type: ACWU90 flame retardant jacket over thermoplastic armour and compliant to applicable Building Code classification for this project.
- .5 Connectors: anti short connectors.
- .6 Utilize for final lighting luminaires connections only.

2.4 Aluminum Sheathed Cable

- .1 Conductors: copper size as indicated.
- .2 Insulation: cross linked polyethylene type RA90 rated 600V.
- .3 Sheath: aluminum applied to form continuous sheath.
- .4 Outer jacket: thermoplastic applied over sheath and to be compliant to applicable Building Code classification for this project.
- .5 Fastenings for aluminum sheathed cable:
 - .1 One hole steel straps to secure surface cables 25 mm and smaller. Two hole steel straps for cables larger than 25 mm. Use aluminum strap only with single conductor cable.
 - .2 Channel type supports for two or more cables.

- .3 Threaded rods: 6 mm diameter to support suspended channels.

2.5 Variable Frequency Drive Cable:

- .1 Cable:
 - .1 Variable frequency drive cable to CAN/CSA C22.2 No. 131.
- .2 Conductors:
 - .1 Copper power and ground.
- .3 Ground conductors:
 - .1 Three bare ground conductors spaced evenly around circumference of cable (sectored ground).
- .4 Insulation:
 - .1 Cross linked polyethylene, 1000V.
- .5 Armour:
 - .1 Continuous aluminum sheath formed into corrugates seamless heath.
- .6 Outer jacket:
 - .1 PVC, UV resistant.
- .7 Fire rating: FT4, HL and AG14.
- .8 Connectors:
 - .1 As for RA90.

2.6 Control Cables

- .1 Type: LVT: 2 soft annealed copper conductors, sized as indicated:
 - .1 Insulation: thermoplastic.
 - .2 Sheath: thermoplastic jacket.
- .2 Type: low energy 300 V control cable: solid or stranded (as required) annealed copper conductors sized as indicated LVT: 2 soft annealed copper conductors
- .3 Type: 600 V stranded annealed copper conductors, sizes as indicated:
 - .1 Insulation: TWH butyl rubber insulation type RW90 (x-link)
 - .2 Shielding: non-magnetic tape conductors.

2.7 VARIABLE FREQUENCY DRIVE CABLE

- .1 Cable:
 - .1 Variable frequency drive cable to CAN/CSA C22.2 No. 131.
- .2 Conductors:
 - .1 Copper power and ground.
- .3 Ground conductors:

- .1 Three bare ground conductors spaced evenly around circumference of cable (sectored ground).
- .4 Insulation:
 - .1 Cross linked polyethylene, 1000V.
- .5 Armour:
 - .1 Continuous aluminum sheath formed into corrugates seamless heath.
- .6 Outer jacket:
 - .1 PVC, UV resistant.
- .7 Fire rating: FT4, HL and AG14.
- .8 Connectors:
 - .1 As for RA90.

Part 3 Execution

3.1 Field Quality Control

- .1 Perform tests in accordance with Section 26 05 00 - Common Work Results for Electrical.
- .2 Perform tests using method appropriate to site conditions and to approval of Departmental Representative and local authority having jurisdiction over installation.
- .3 Perform tests before energizing electrical system.

3.2 General Cable Installation

- .1 Lay cable in cable trays in accordance with Section 26 05 36 - Cable Trays for Electrical Systems.
- .2 Terminate cables in accordance with Section 26 05 20 - Wire and Box Connectors - (0-1000 V).
- .3 Cable Colour Coding: to Section 26 05 00 - Common Work Results for Electrical.
- .4 Conductor length for parallel feeders to be identical.
- .5 Lace or clip groups of feeder cables at distribution centres, pull boxes, and termination points.
- .6 Wiring in walls: typically drop or loop vertically from above to better facilitate future renovations. Generally wiring from below and horizontal wiring in walls to be avoided unless indicated.
- .7 Branch circuit wiring for surge suppression receptacles and permanently wired computer and electronic equipment to be 2-wire circuits only, i.e. common neutrals not permitted.
- .8 Provide numbered wire collars for control wiring. Numbers to correspond to control shop drawing legend. Obtain wiring diagram for control wiring.

3.3 Installation Of Building Wires

- .1 Install wiring as follows:
 - .1 In conduit systems in accordance with Section 26 05 34 - Conduits, Conduit Fastenings and Conduit Fittings.
 - .2 In surface and lighting fixture raceways in accordance with Section 26 09 43.

3.4 Installation Of Teck90 Cable (0 -1000 V)

- .1 Group cables wherever possible on channels.
- .2 Install cable concealed, securely supported by straps and hangers.

3.5 Installation Of Armoured Cables

- .1 Group cables wherever possible on channels.
- .2 Type AC90 armoured cable will not be permitted with the exception of the final connection from the junction box to light fixture when the distance from the junction box to the light fixture is not more than 1.8m, for final connection from junction box to motors and equipment, within millwork and for vertical drop within walls and partitions to receptacles. Looping of BX from fixture to fixture or from receptacle to receptacle will not be accepted.

3.6 Installation Of Aluminum Sheathed Cable

- .1 Group cables wherever possible on channels.

3.7 Installation Of Variable Frequency Drive Cable

- .1 Install variable frequency drive cable from VFD to associated motor.
- .2 Route cables from distribution to variable frequency drive along a physically separate path than from cables from VFD to associated motor.
- .3 Other installation requirements as for RA90.

3.8 Installation Of Control Cables

- .1 Install control cables in conduit.
- .2 Ground control cable shield.

3.9 Installation Of Non-Metallic Sheathed Cable

- .1 Install cables.
- .2 Install straps and box connectors to cables as required.

END OF SECTION

Part 1 General

1.1 Related Requirements

- .1 Refer to all sections of the specification for related work.

1.2 References

- .1 American National Standards Institute /Institute of Electrical and Electronics Engineers (ANSI/IEEE)
 - .1 ANSI/IEEE 837-02, IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding.
- .2 CSA International

1.3 Action And Informational Submittals

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for grounding equipment and include product characteristics, performance criteria, physical size, finish and limitations.

1.4 Closeout Submittals

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for grounding equipment for incorporation into manual.

1.5 Delivery, Storage And Handling

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect grounding equipment from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.

Part 2 Products

2.1 Equipment

- .1 Clamps for grounding of conductor: size to electrically conductive underground water pipe.

- .2 Grounding conductors: bare stranded copper, soft annealed. Verify grounding impedance to meet CEC required values.
- .3 Insulated grounding conductors: green, copper conductors.
- .4 Ground bus: copper, complete with insulated supports, fastenings, connectors.
- .5 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 Thermit welded type conductor connectors.
 - .5 Bonding jumpers, straps.
 - .6 Pressure wire connectors.

Part 3 Execution

3.1 Examination

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for grounding equipment installation in accordance with manufacturer's written instructions.
 - .1 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .2 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

3.2 Installation General

- .1 Test for permanent, continuous grounding system including, conductors, connectors, accessories. Correct if necessary. Where EMT is used, run ground wire in conduit.
- .2 Install connectors in accordance with manufacturer's instructions.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Make buried connections if necessary, and connections to conductive water main, electrodes, using copper welding by thermit process.
- .5 Use mechanical connectors for grounding connections to equipment provided with lugs.
- .6 Soldered joints not permitted.
- .7 Install bonding wire for flexible conduit, connected at both ends to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .8 Install flexible ground straps for bus duct enclosure joints, where such bonding is not inherently provided with equipment.
- .9 Avoid loop connections.

- .10 Bond single conductor, metallic armoured cables to cabinet at supply end.
- .11 Ground secondary service pedestals.

3.3 System And Circuit Grounding

- .1 Install system and circuit grounding connections to secondary 120/600 V system.

3.4 Equipment Grounding

- .1 Install grounding connections to typical equipment included in, but not necessarily limited to following list. Service equipment, transformers, duct systems, frames of motors, starters, control panels, building steel work, distribution panels, cable trays.

3.5 Grounding Bus

- .1 Ground items of electrical equipment in electrical room and IT equipment in communication equipment room to ground bus with individual bare stranded copper connections size 2/0AWG.

3.6 Communication Systems

- .1 Install grounding connections for sound, fire alarm, security systems, intercommunication systems as follows:
 - .1 Sound, fire alarm, security systems, intercommunication systems as indicated.
 - .2 Make connections to pipes on building side of main valves and tanks. Connect jumpers across boilers to supply and return hot water heating pipes.

3.7 Field Quality Control

- .1 Perform tests in accordance with Section 26 05 00 - Common Work Results for Electrical.
- .2 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of Departmental Representative and local authority having jurisdiction over installation.
- .3 Perform tests before energizing electrical system.
- .4 Disconnect ground fault indicator during tests.

3.8 Cleaning

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 - Cleaning.

END OF SECTION

Part 1 General

1.1 Related Requirements

- .1 Refer to all sections of the specification for related work.

1.2 References

- .1 Canadian Standards Association (CSA International)
 - .1 CSA C22.1-15, Canadian Electrical Code, Part 1, 23rd Edition.

1.3 Action And Informational Submittals

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

1.4 Delivery, Storage And Handling

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements.

Part 2 Products

2.1 Outlet And Conduit Boxes General

- .1 Size boxes in accordance with CSA C22.1.
- .2 102 mm square or larger outlet boxes as required.
- .3 Gang boxes where wiring devices are grouped.
- .4 Blank cover plates for boxes without wiring devices.
- .5 347 V outlet boxes for 347 V switching devices.
- .6 Combination boxes with barriers where outlets for more than one system are grouped.

2.2 Galvanized Steel Outlet Boxes

- .1 One-piece electro-galvanized construction.
- .2 Single and multi gang flush device boxes for flush installation, minimum size 76 x 50 x 38 mm or as indicated. 102 mm square outlet boxes when more than one conduit enters one side with extension and plaster rings as required.
- .3 Utility boxes for outlets connected to surface-mounted EMT conduit, minimum size 102 x 54 x 48 mm.
- .4 102 mm square or octagonal outlet boxes for lighting fixture outlets.
- .5 Extension and plaster rings for flush mounting devices in finished walls.

2.3 Conduit Boxes

- .1 Cast FS, FD aluminum boxes with factory-threaded hubs and mounting feet for surface wiring of devices.

2.4 Outlet Boxes For Non-Metallic Sheathed Cable

- .1 Electro-galvanized, sectional, screw ganging steel boxes, minimum size 76 x 50 x 63 mm with two double clamps to take non-metallic sheathed cables.

2.5 Fittings - General

- .1 Bushing and connectors with nylon insulated throats.
- .2 Knock-out fillers to prevent entry of debris.
- .3 Conduit outlet bodies for conduit up to 35 mm and pull boxes for larger conduits.
- .4 Double locknuts and insulated bushings on sheet metal boxes.

Part 3 Execution

3.1 Installation

- .1 Support boxes independently of connecting conduits.
- .2 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of work.
- .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, armoured cable connections. Do not install reducing washers.
- .5 Vacuum clean interior of outlet boxes before installation of wiring devices.
- .6 Identify systems for outlet boxes as required.

END OF SECTION

Part 1 General

1.1 Related Requirements

- .1 Refer to all related sections 26, 27, 28.

1.2 References

- .1 CSA International
 - .1 CSA C22.2 No.40-M1989(R2009), Cutout, Junction and Pull Boxes.

1.3 Action And Informational Submittals

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for raceway and boxes and include product characteristics, performance criteria, physical size, finish and limitations.

1.4 Closeout Submittals

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for raceway and boxes for incorporation into manual.

1.5 Delivery, Storage And Handling

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect raceway and boxes from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.
- .4 Develop Construction Waste Management Plan related to Work of this Section.
- .5 Packaging Waste Management: remove for reuse by manufacturer of pallets, crates, padding, packaging materials as specified in Construction Waste Management Plan in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

Part 2 Products

Part 3 Execution

3.1 Examination

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for raceway and boxes installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative .
 - .2 Inform Departmental Representative, DCC Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

3.2 Installation

- .1 Install splice boxes at cable joint, on floor of trench. Tighten armour clamps and fill with compound.
 - .1 Ground splice boxes as required.
- .2 Install junction boxes on trench floor around cable splice to CSA C22.2 No.40. Connect cable terminals to box contacts.
 - .1 Ground junction boxes as required.
 - .2 Fasten lid securely and check for air leaks before trench is backfilled.
- .3 Install power level boxes as follows:
 - .1 Cast iron type: on trench floor, connect cable terminals to box contacts, fasten lid and fill with compound before trench is backfilled.
 - .2 Steel type: mount on wall of [maintenance holes; connect cables to box terminals; install disconnect links, fasten lid securely check for air leaks.
 - .3 Ground power level boxes as required.

3.3 Cleaning

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 - Cleaning.
 - .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

Part 1 General

1.1 Related Requirements

- .1 Refer to all sections of the specification for related work.

1.2 References

- .1 Canadian Standards Association (CSA International)
 - .1 CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware, A National Standard of Canada.
 - .2 CSA C22.2 No. 45, Rigid Metal Conduit.
 - .3 CSA C22.2 No. 56, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
 - .4 CSA C22.2 No. 83, Electrical Metallic Tubing.
 - .5 CSA C22.2 No. 211.2-M1984(R2003), Rigid PVC (Unplasticized) Conduit.
 - .6 CAN/CSA C22.2 No. 227.3-05, Nonmetallic Mechanical Protection Tubing (NMPT), A National Standard of Canada (February 2006).

1.3 Action And Informational Submittals

- .1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product data: submit manufacturer's printed product literature, specifications and datasheets.
 - .1 Submit cable manufacturing data.
- .3 Quality assurance submittals:
 - .1 Test reports: submit certified test reports.
 - .2 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - .3 Instructions: submit manufacturer's installation instructions.

Part 2 Products

2.1 Conduits

- .1 Rigid metal conduit: to CSA C22.2 No. 45, galvanized steel or hot dipped rigid galvanized steel threaded.
- .2 Epoxy coated conduit: to CSA C22.2 No. 45, with zinc coating and corrosion resistant epoxy finish inside and outside.
- .3 Electrical metallic tubing (EMT): to CSA C22.2 No. 83, with couplings or expanded ends.
- .4 Rigid pvc conduit: to CSA C22.2 No. 211.2.
- .5 Flexible metal conduit: to CSA C22.2 No. 56, liquid-tight flexible metal.

- .6 FRE conduit
- .7 Flexible metal conduit: to CSA C22.2 No. 56, liquid-tight flexible metal steel.
- .8 Flexible pvc conduit: to CAN/CSA-C22.2 No. 227.3

2.2 Conduit Fastenings

- .1 One hole steel straps to secure surface conduits 50 mm and smaller.
 - .1 Two hole steel straps for conduits larger than 50 mm.
- .2 Beam clamps to secure conduits to exposed steel work.
- .3 Channel type supports for two or more conduits.
- .4 Threaded rods, 6 mm diameter, to support suspended channels.

2.3 Conduit Fittings

- .1 Fittings: to CAN/CSA C22.2 No. 18, manufactured for use with conduit specified.
Coating: same as conduit.
- .2 Ensure factory "ells" where 90 degrees bends for 25 mm and larger conduits.
- .3 Watertight connectors and couplings for EMT.
 - .1 Set-screws are not acceptable.

2.4 Expansion Fittings For Rigid Conduit

- .1 Weatherproof expansion fittings with internal bonding assembly suitable for 200 mm linear expansion.
- .2 Watertight expansion fittings with integral bonding jumper suitable for linear expansion and 19 mm deflection.
- .3 Weatherproof expansion fittings for linear expansion at entry to panel.

2.5 Fish Cord

- .1 Polypropylene.

Part 3 Execution

3.1 Manufacturer's Instructions

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 Installation

- .1 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.
- .2 Conceal conduits except in mechanical and electrical service rooms.
- .3 Surface mount conduits in existing walls.

- .4 Use rigid galvanized steel threaded conduit except where specified otherwise.
- .5 Use epoxy coated conduit in corrosive areas.
- .6 Use electrical metallic tubing (EMT) except in cast concrete above 2.4 m not subject to mechanical injury.
- .7 Use rigid pvc conduit in corrosive areas.
- .8 Use flexible metal conduit for connection to motors in dry areas, connection to recessed incandescent fixtures without prewired outlet box, connection to surface or recessed fluorescent fixtures or work in movable metal partitions.
- .9 Use liquid tight flexible metal conduit for connection to motors or vibrating equipment in damp, wet or corrosive locations.
- .10 Minimum conduit size for lighting and power circuits: 21 mm.
- .11 Install EMT conduit from computer room branch circuit panel to outlet boxes.
- .12 Bend conduit cold:
 - .1 Replace conduit if kinked or flattened more than 1/10th of its original diameter.
- .13 Mechanically bend steel conduit over 19 mm diameter.
- .14 Field threads on rigid conduit must be of sufficient length to draw conduits up tight.
- .15 Install fish cord in empty conduits.
- .16 Remove and replace blocked conduit sections.
 - .1 Do not use liquids to clean out conduits.
- .17 Dry conduits out before installing wire.

3.3 Surface Conduits

- .1 Run parallel or perpendicular to building lines.
- .2 Locate conduits behind infrared or gas fired heaters with 1.5 m clearance.
- .3 Run conduits in flanged portion of structural steel.
- .4 Group conduits wherever possible on suspended or surface channels.
- .5 Do not pass conduits through structural members except as indicated.
- .6 Do not locate conduits less than 75 mm parallel to steam or hot water lines with minimum of 25 mm at crossovers.
- .7 Install surface conduits in mechanical/electrical rooms only.

3.4 Concealed Conduits

- .1 Run parallel or perpendicular to building lines.
- .2 Do not install horizontal runs in masonry walls.
- .3 Do not install conduits in terrazzo or concrete toppings.

3.5 Cleaning

- .1 Proceed in accordance with Section 01 74 11 - Cleaning.
- .2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 General

1.1 Related Work

- .1 Refer to all Sections of the specification for related work.
- .2 Mechanical Divisions.

1.2 Requirements

Motor Size	Voltage System
3/4 HP (0.562 kW) and larger	208V/1Ø, 208V/3Ø and 600 V, 3Ø
1/2 HP (0.373 kW) and smaller	120 V, 1Ø

- .1 Provide a complete system of power wiring to motors and controls.
- .2 Unless specifically noted otherwise, wire and leave in operation all electrically operated equipment supplied under this Contract. Examine the drawings and shop drawings of all Divisions for the extent of electrically operated equipment supplied by other Divisions.
- .3 Where control wiring diagrams are shown illustrate typical control circuits applicable to the equipment. Control circuits may vary with different manufacturers of equipment. Verify all control circuits with the suppliers of the equipment and make any corrections that may be required.
- .4 Unless specifically noted otherwise, supply all pushbuttons, relays, starters, etc. necessary for the operation of equipment. Check all starters, relay coils and thermal elements to ensure that they provide the necessary protection for motors.
- .5 Do not operate motors and controls until approval is obtained from the trade providing equipment.
- .6 Examine drawings and shop drawings of other Divisions to obtain exact location of motors and equipment shown on other Division drawings and specifications. Where necessary, obtain conduit locations from other trades' drawings & shop drawings. The complete list of motors may not be shown on the electrical drawings. Verify and confirm motor sizes and electrical protection before installation.
- .7 Assist in placing in operation all mechanical equipment having electrical connections.
- .8 Provide three phase starters with primary and secondary fused 120 volt control transformers and overload relays.

- .9 In general, wiring for freezestats, firestats, EP switches P.E. switches, dampers, temperature controllers, flow switches, solenoid valves, etc., for heating, ventilating and air conditioning equipment will be by Mechanical Contractor, from control panels supplied and installed by Mechanical Contractor. Provide terminations in starters for control wiring, so that starter control circuits may be extended by Mechanical Contractor. Where 120 volt power is required for mechanical equipment, i.e.: for roll type filters, refrigerated aftercoolers, control cabinets, etc., wiring to the equipment terminals is the work of the Electrical Contractor. Electrical Contractor to wire all 120V internal lighting and receptacles, condensers and rooftops weatherproof outdoor receptacles.

PART 2 Products

2.1 3Ø Motor Disconnect Switches

- .1 Industrial Type "A" having quick-make, quick-break visible blade mechanism, cover interlocks and padlocking switch in the closed or open position. Use EEMAC-4 enclosures outdoors, EEMAC-1 indoors and drip proof shield watertight for areas exposed to sprinklers. Switches to be kW rated, Square "D" Type A heavy duty.

2.2 120V 1Ø Disconnect Switches

- .1 Manual starter without overload relay.

2.3 208V 1Ø Motor Disconnect Switches

- .1 Manual starter without overload relay.

PART 3 Execution

3.1 General

- .1 For all motors, provide disconnect switches adjacent to the motors.
- .2 Wall mount disconnects adjacent to equipment or floor mount at motor locations. Wall mounted disconnects to be 1400 mm above floor.

3.2 Control Cabinets & Controls

- .1 Verify the location of all control cabinets, and provide power wiring to each cabinet from the nearest electrical panel where not specifically shown from a particular panel.
- .2 Power wiring for mechanical equipment is the responsibility of the Electrical Contractor. Provide circuits and wiring to suit the controls contractor requirements. All control power wiring requirements may not be specifically shown on the drawings.
- .3 All control wiring shall be run in conduit. Coordinate with controls subcontractor.

3.3 Commissioning

- .1 Do not start motors until the supplier of the equipment has verified that the electrical connection has been made in accordance with the nameplate information.
- .2 Extreme caution must be taken in connection of motors with nameplates having multiple connection diagrams i.e.: WYE-DELTA Start, MULTISPEED.
- .3 Be responsible for replacement of motors or other equipment damaged by starting-up prior to being checked by equipment supplier.

END OF SECTION

Part 1 General

1.1 Related Requirements

- .1 This Section covers items common to Sections of Divisions 26 and 28. These Sections supplement requirements of Division 1.

1.2 References

- .1 CSA International
 - .1 CAN/CSA-C22.2 No.47-M90(R2007), Air-Cooled Transformers (Dry Type).
 - .2 CSA C9-02(R2007), Dry-Type Transformers.
 - .3 CAN/CSA-C802.2-06, Minimum Efficiency Values for Dry Type Transformers.
- .2 National Electrical Manufacturers Association (NEMA)

1.3 Action And Informational Submittals

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for dry type transformers and include product characteristics, performance criteria, physical size, finish and limitations.

1.4 Closeout Submittals

- .1 Submit in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Operation and Maintenance Data: submit operation and maintenance data for dry type transformers for incorporation into manual.

1.5 Delivery, Storage And Handling

- .1 Deliver, store and handle materials in accordance with Section 01 61 00 - Common Product Requirements and with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground, indoors, in dry location, and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Store and protect dry type transformers from nicks, scratches, and blemishes.
 - .3 Replace defective or damaged materials with new.

Part 2 Products

2.1 Design Description

- .1 Design.
 - .1 Type: ANN.
 - .2 3 phase, kVA as indicated on drawings, 600V input, 120/208 V output, 60 Hz.
 - .3 Voltage taps: 2x2.5% FCAN and 2x2.5% FCBN.
 - .4 Insulation: Class 220, 150 degrees C temperature rise.
 - .5 Basic Impulse Level (BIL): standard.
 - .6 Hipot: standard.
 - .7 Average sound level: standard
 - .8 Impedance at 17 degrees C: standard
 - .9 Enclosure: NEMA, removable metal front panel.
 - .10 Mounting: as indicated.
 - .11 Finish: in accordance with Section 26 05 00 - Common Work Results for Electrical.
 - .12 Copper windings.
 - .13 Winding configuration to be as noted on drawings.
 - .14 K4-Rated Transformers as indicated on drawings.
 - .15 Voltage Regulation to be 4% or better.
 - .16 Provide housekeeping pad.
 - .17 Provide internal and external vibration isolators.
 - .18 Sprinklerproof

2.2 Equipment Identification

- .1 Provide equipment identification in accordance with Section 26 05 00 - Common Work Results for Electrical.
- .2 Label size: 7.

Part 3 Execution

3.1 Examination

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for dry type transformers installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.

3.2 Installation

- .1 Mount dry type transformers up to 75 kVA as indicated.
- .2 Mount dry type transformers above 75 kVA on floor.
- .3 Ensure adequate clearance around transformer for ventilation.
- .4 Install transformers in level upright position.
- .5 Remove shipping supports only after transformer is installed and just before putting into service.
- .6 Loosen isolation pad bolts until no compression is visible.
- .7 Make primary and secondary connections in accordance with wiring diagram.
- .8 Energize transformers after installation is complete.
- .9 Make conduit entry into bottom 1/3 of transformer enclosure.

3.3 Cleaning

- .1 Progress Cleaning: clean in accordance with Section 01 74 11 - Cleaning.
 - .1 Leave Work area clean at end of each day.
- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11 - Cleaning.

3.4 Protection

- .1 Protect installed products and components from damage during construction.
- .2 Repair damage to adjacent materials caused by dry type transformers installation.

END OF SECTION

Part 1 General

1.1 Section Includes

- .1 This section defines dry-type enclosed and ventilated low voltage low loss transformers designed constructed and to supply power to variable speed AC drive.

1.2 Related Sections

- .1 Refer to Section 26 05 00 - Common Work Results - Electrical for related Sections applicable to this Project.

1.3 Standards

- .1 Refer to Section 26 05 00 - Common Work Results - Electrical for standards applicable to this project.

1.4 Shop Drawings And Product Data

- .1 Submit shop drawings and product data in accordance with Section 25 05 00 - Common Work Results - Electrical.
- .2 Product Data including kVA rating, average winding temperature rise, detailed enclosure dimensions, primary & secondary nominal voltages, primary voltage taps, no load & full load losses, impedances, unit weight, warranty.
- .3 Percentage regulation at 35% & 100% load at 80% & 100% power factor.

1.5 Storage And Handling

- .1 Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in the transformer housing and if necessary, apply temporary heat where required to obtain suitable service conditions.
- .2 Handle transformer using proper equipment for lifting and handling, use when necessary lifting eye and/or brackets provided for that purpose.

Part 2 Products

2.1 General Construction

- .1 All three phase transformers shall be constructed with three coils and a single core. The primary side of each transformer shall, if applicable, be provided with taps that meet or exceed NEMA standards. Transformer windings shall be designed suitable for 150% overload for 60 seconds OR 200% overload for 30 seconds, once every hour. Three-phase, common core construction. Convection air cooled.
- .2 Transformers shall be designed, constructed and rated for drive isolation use. General dry type transformers are not acceptable.

2.2 Voltage And Kva Requirements

- .1 Primary Voltage: 600 Volts
- .2 Secondary Voltage: 600 Volts
- .3 kVA Rating: As indicated on motor schedule
- .4 System Frequency: 60 Hertz

2.3 Key Requirements

- .1 Typical impedance at 60Hz: 4% to 6.5%.
- .2 Nameplate Rating: Linear load, 60Hz.

2.4 Transformers

- .1 Use transformers of one manufacturer throughout project and in accordance with CAN/CSA-C22.2 No.47 and CSA-C9.
- .2 Insulation Class: 220°C system
- .3 Temperature Rise: 150°C
- .4 Taps: 2 x $\pm 2.5\%$ (2FCAN, 2FCBN)
- .5 Transformer core construction: high grade non-aging, fully processed silicon steel laminations or better.
- .6 Coil conductors: copper windings, with terminations brazed, welded or bolted.
- .7 Impregnation: vacuum impregnated core & coils.
- .8 Inrush current: 10 times full load rating (max.)
- .9 Sound level: 3dB below NEMA ST-20.

- .10 Enclosure: ventilated, Type 3R.
- .11 Finish: in accordance with Section 26 05 00 - Common Work Results – Electrical
- .12 Transformers shall terminate in mounting pads. Bring out primary and secondary terminations to terminals on the same side of the transformer mounted on separate insulated support. Provide mechanical lugs on primary, secondary and neutral for customer terminations. Mounting lugs will be included on all copper units up to and including 270 amp ratings. Contractors shall provide all necessary lugs not already provided with transformer.
- .13 Anti-vibration pads/isolators shall be used between the transformer core and coil and the enclosure. Complete with sound absorbing pads installed between case and floor. Standard of acceptance: "Korfund Dynamics" R-series flush type neoprene mounting.
- .14 UL listed, CSA approved
- .15 Built to NEMA ST-20 and in accordance with all applicable UL, CSA and ANSI/IEEE standards.
- .16 Ground core & coil assembly to enclosure with a flexible copper grounding strap or equivalent.
- .17 Thermostat: Over-temperature switches wired to internal terminal strip.
- .18 Mounting:
- .19 Ventilated units up to 750 lbs.: Suitable for wall, floor or ceiling mounting.
- .20 Ventilated units over 750 lbs.: Suitable for floor mounting only.
- .21 Transformer to be c/w Electrostatic Shielding.
- .22 Two winding or T-connected transformers are not acceptable.

2.5 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Section 26 05 00 - Common Work Results - Electrical.
- .2 Label size: 7
- .3 Nameplate wording: as indicated

Part 3 Execution

3.1 Installation

- .1 The installing contractor shall install the Drive Isolation Transformer per the manufacturer's recommended installation practices as found in the installation, operation and maintenance manual and comply with all applicable codes.
- .2 Floor-mount transformers on 100mm concrete housekeeping pads where indicated.
- .3 Ensure minimum clearance of 300mm between transformer and wall for ventilation as per CEC.
- .4 Install transformers in level upright position.
- .5 Remove shipping supports only after transformer is installed and just before putting into service.
- .6 Loosen isolation pad bolts until no compression is visible.
- .7 Make primary and secondary connections in accordance with wiring diagram.
- .8 Check for damage and loose connections.
- .9 Mount transformer to comply with all applicable codes.
- .10 Install vibration isolation pads between transformer enclosure and the mounting surface.
- .11 Coordinate all work in this section with all work of other sections.
- .12 Prior to energizing transformer, verify secondary voltages and if necessary adjust secondary taps.

END OF SECTION

PART 1 General

1.1 Related Work

- .1 Refer to all sections of the specification for related work.

1.2 Shop Drawings And Product Data

- .1 Submit shop drawings and product data in accordance with 26 05 00 Common Work Results – Electrical.
- .2 Drawings to include electrical detail of panel, branch breaker type, quantity, ampacity and enclosure dimension.
- .3 Provide shop drawing of specific product and clearly select equipment model and number. General catalogues' information is not acceptable.

1.3 Operation And Maintenance Data

- .1 Provide operation and maintenance data for incorporation into manual specified in Section 26 05 00 Common Work Results – Electrical.

1.4 Plant Assembly

- .1 Install circuit breakers in panelboards before shipment.
- .2 In addition to CSA requirements manufacturer's nameplate must show fault current that panel including breakers has been built to withstand.

PART 2 Products

2.1 Panelboards

- .1 Panelboards: product of one manufacturer throughout project.
- .2 120/208V branch circuit panelboards bus and breakers rated "minimum" 22 KA RMS or as required.
- .3 Sequence phase bussing such that circuit breakers shall be numbered vertically in consecutive order, with each breaker identified by permanent number identification as to circuit number and phase.
- .4 Panelboards: mains, number of circuits, and number and size of branch circuit breakers as required.
- .5 Two keys for each panelboard and key panelboards alike.
- .6 Copper bus with neutral of same ampere rating as mains.

- .7 Mains: suitable for bolt-on breakers.
- .8 Trim and door finish: baked grey enamel.
- .9 Flush or surface-mounted tubs as required.
- .10 Load centres shall not be accepted.
- .11 All surface mounted panelboards shall be sprinklerproof.

2.2 Breakers

- .1 Breakers: to Section 26 28 21 Moulded Case Circuit Breakers.
- .2 Breakers with thermal and magnetic tripping in panelboards except as indicated otherwise.

2.3 Equipment Identification

- .1 Provide equipment identification in accordance with Section 26 05 00 Common Work Results – Electrical.
- .2 Nameplate for each branch circuit panelboard size 4 engraved to indicate panel designation and voltage.
- .3 Nameplate for each circuit in distribution panelboards size 3 engraved to indicate each respective load.
- .4 Complete circuit directory with typewritten legend showing location and load of each circuit.

2.4 Manufacturers

- .1 Acceptable manufacturers: Cutler Hammer, Schneider, Square D, Siemens.

PART 3 Execution

3.1 Installation

- .1 Locate panelboards as indicated and mount securely, plumb, true and square to adjoining surfaces.
- .2 Install surface mounted panelboards on plywood painted backboards. Where practical, group panelboards on common backboard.
- .3 Mount panelboards to height specified in Section 26 05 00 Common Work Results – Electrical or as required.
- .4 Connect loads to circuits as indicated.

- .5 Connect neutral conductors to common neutral bus. Common neutrals shall be shared by vertically adjacent breakers. Common neutrals shall be identified with mylar/cloth wire markers showing circuit numbers of the circuits sharing the neutral.

END OF SECTION

PART 1 General

1.1 Related Work

- .1 Refer to all sections of the specification for related work.

1.2 References

- .1 CSA International
 - .1 CSA C22.2 No. 5-[09], Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures (Tri-national standard with UL 489, and NMX-J-266-ANCE-2010).

1.3 Action And Informational Submittals

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for circuit breakers and include product characteristics, performance criteria, physical size, finish and limitations.
- .3 Include time-current characteristic curves for breakers with interrupting capacity of 22,000 A symmetrical (rms) and over at system voltage with ampacity of 400A and over.
- .4 Certificates:
 - .1 Prior to installation of circuit breakers in either new or existing installation, Contractor must submit 3 copies of a production certificate of origin from the manufacturer. Production certificate of origin must be duly signed by factory and local manufacturer's representative certifying that circuit breakers come from this manufacturer and are new and meet standards and regulations.
 - .1 Production certificate of origin must be submitted to Departmental Representative for approval.
 - .2 Delay in submitting production of certificate of origin will not justify any extension of contract and additional compensation.
 - .3 Any work of manufacturing, assembly or installation to begin only after acceptance of production certificate of origin by Departmental Representative. Unless complying with this requirement, Departmental Representative reserves the right to mandate manufacturer listed on circuit breakers to authenticate new circuit breakers under the contract, and to Contractor's expense.
 - .4 Production certificate of origin must contain:
 - .1 Manufacturer's name and address and person responsible for authentication. Person responsible must sign and date certificate.
 - .2 Licensed dealer's name and address and person of distributor responsible for Contractor's account.

- .3 Contractor's name and address and person responsible for project.
- .4 Local manufacturer's representative name and address. Local manufacturer's representative must sign and date certificate.
- .5 Name and address of building where circuit breakers will be installed. Include:
 - .1 Project title:
 - .2 List of circuit breakers

1.4 Shop Drawings And Product Data

- .1 Submit shop drawings and product data in accordance with Section 26 05 00 - Common Work Results - Electrical

PART 2 Products

2.1 Breakers – General

- .1 Moulded-case circuit breakers, ground-fault circuit-interrupters to CSA C22.2 No. 5
- .2 Bolt-on moulded case circuit breaker: quick- make, quick-break type, for manual and automatic operation [with temperature compensation for 40 degrees C ambient].
- .3 Plug-in moulded case circuit breakers: quick- make, quick-break type, for manual and automatic operation [with temperature compensation for 40 degrees C ambient].
- .4 Common-trip breakers: with single handle for multi-pole applications.
- .5 Bolt-on moulded case circuit breakers, quick-make, quick-break type, for manual and automatic operation with temperature compensation for 40°C (104°F) ambient.
- .6 Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting. Trip settings on breakers with adjustable trips to range from 3-10 times current rating.
- .7 Circuit breakers with interchangeable trips as required.
- .8 To be of same manufacturer as panelboards.

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 and instantaneous tripping for short circuit protection.

Acceptable Manufacturers: To Be Compatible With Existing Panels.

PART 3 Execution

3.1 Examination

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied [and after receipt of written approval to proceed from Departmental Representative.

3.2 Installation

- .1 Install circuit breakers according to manufacturer's recommendations.
- .2 Install on-off locking devices for breakers feeding fire alarm panel, security panels, etc.
- .3 Paint fire alarm breaker red.

END OF SECTION

PART 1 General

1.1 Related Work

- .1 Refer to all sections of the specification for related work.

1.2 Shop Drawings And Product Data

- .1 Submit shop drawings and product data in accordance with Section 26 05 00
Common Work Results - Electrical.

PART 2 Products

2.1 Disconnect Switches

- .1 Fusible and non-fusible disconnect switch in EEMAC `3R' enclosure for interior
sprinkler proof application, unless otherwise indicated.
- .2 Provision for padlocking in on-off position.
- .3 Mechanically interlocked door to prevent opening when handle in ON position.
- .4 Fuses: size as required.
- .5 Fuseholders: suitable without adaptors, for type and size of fuse indicated.
- .6 Quick-make, quick-break action.
- .7 ON-OFF switch position indication on switch enclosure cover.

2.2 Emergency Stop Pushbuttons

- .1 30.5mm red/gray button.
- .2 ASA61 Gray die-cast zinc enclosure
- .3 Industrial Grade
- .4 Single 21mm in NPT conduit entrance
- .5 Labels: white lettering on red background
- .6 Pushbutton to include operator, enclosure, contact blocks and labelling.
- .7 Contact block to include 2 NO and 2 NC contacts.

2.3 Equipment Identification

- .1 Provide equipment identification in accordance with Section 26 05 00 Common Work Results - Electrical.
- .2 Indicate name of load controlled on size 4 nameplates.

2.4 Approved Manufacturers

- .1 Approved manufacturers: Cutler Hammer, Square D, Siemens.

PART 3 Execution

3.1 Installation

- .1 Install disconnect switches complete with fuses only where specifically indicated.
- .2 Install circuit disconnect switches where indicated or where required by the inspection authorities and/or for equipment supplied by other trades.

END OF SECTION

PART 1 General

1.1 Related Work

- .1 Refer to all sections of the specification for related work.

1.2 References

- a. IEEE 519-1992: Guide for harmonic content and control
 - 2. Underwriters Laboratories (UL508C: Power Conversion Equipment)
- a. UL
- b. CUL
 - 3. National Electrical Manufacturer's Association (NEMA)
- a. ICS 7.0: Industrial Controls & Systems for AFD.
 - 4. IEC 61800-2 and -3. EN 50082-1 and -2
- a. Fulfill all EMC immunity requirements

1.3 Action And Informational Submittals

- .1 Submit in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's instructions, printed product literature and data sheets for variable speed drives and include product characteristics, performance criteria, physical size, finish and limitations.

1.4 Shop Drawings And Product Data

- .1 Submit shop drawings and product data in accordance with Section 26 05 00 - Common Work Results - Electrical

PART 2 Products

2.1 Passive Harmonic Filter

- .1 Provide tuned harmonic filter consisting of a tuned harmonic capacitor section and a tuned shunt reactor. Provide fuses between the capacitors and the reactors. The harmonic filter shall be housed in a single enclosure. Individually mounted components are not acceptable.
- .2 The filter shall be UL- and cUL-Listed under UL 508A.
- .3 Harmonic filter shall be mounted in the same enclosed as the AFD and be fully prewired inside the enclosure.
 - .1 The filter shall have a fuse monitoring option to provide fuse status via a NO/NC dry contact. The fuse status signal shall be suitable for integration

- into facility monitoring systems for enhanced automation and reduced maintenance time.
- .2 The filter shall consist of inductive element(s) in series with the load and an inductive-capacitive network in shunt with the load. The shunt circuit shall be tuned to 4.7 times the fundamental frequency.
 - .3 The Total Demand Distortion (TDD) of the current at the input terminals of the filter, in combination with the variable frequency drive, shall not exceed 5% THD at full rated load and given the filter is correctly applied.
 - .4 The Total Harmonic Voltage Distortion (THVD) at the input terminals of the filter in combination with the variable frequency drive shall not exceed the limits defined in Table 10-2 of IEEE-519. The filter supplier shall not be responsible for pre-existing voltage distortion caused by other harmonic sources
 - .1 High-endurance capacitor cells shall have a voltage rating capable of handling continuously the nominal system voltage plus 10% of the over voltage tolerance. These capacitor cells shall also operate under the worst case voltage gain due to the leading nature of the capacitive current. Dielectric material shall be low-loss (less than 0.25 watts per kVAR). High-endurance capacitor cells themselves shall be rated to operate at a temperature of 65°C on the capacitor case.
 - .2 Both shunt circuit inductors and series line reactors shall be designed for harmonic filtering service and for slowing the rate of rapid current changes. The inductors shall be UL component-recognized or listed and shall be built to comply to UL 508. Construction shall be of copper wire-wound on magnetic steel cores. Inductors shall be three-phase. Series line reactors shall be sized appropriately for the total connected load. Design maximum temperature rise for inductors shall be 115°C on bobbin wound and 155°C on form wound devices at rated current.
Voltage harmonics shall be:

I1=100%	I11=0.24%	I19=0.55%
I5=3.76%	I13=1.1%	I23=0.55%
I7=1.65%	I17=0.80%	I23=0.80%

2.2 Adjustable Frequency Drives

- .1 Where shown on the drawings, adjustable frequency drives 1 through 250 Horsepower (HP), Constant Torque (CT) / Variable Torque (VT), shall have the following features:
 - .1 The AFD shall be rated for 120VAC or 600 VAC (to match voltages shown on mechanical equipment schedule). The AFD shall provide microprocessor-based control for single or three-phase induction motors. The controller's full load output current rating shall be based on 50° C (CT) / 40° C (VT) ambient and 3.6 kHz switching frequency and above to reduce motor noise and avoid increased motor losses as standard.
 - .2 The AFD shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. Adjustable Current Source AFD are not acceptable. Insulated Gate Bipolar Transistors (IGBT's) shall be used in the inverter section. Bipolar Junction Transistors, GTO's or SCR's are not acceptable. The AFD shall run at the above listed switching frequencies.

- .3 The AFD shall have efficiency at full load and speed that exceeds 95% for AFD below 15-HP. The efficiency shall exceed 90% at 50% speed and load.
- .4 The AFD shall maintain the line side displacement power factor at no less than 0.96, regardless of speed and load.
- .5 The AFD shall have a one (1) minute overload current rating of 150% and a two (2) second overload current rating of 200% for constant torque drives. The AFD shall have a one (1) minute overload current rating of 110% for variable torque drives.
- .6 The AFD shall be capable of operating of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a horsepower and current rating within the capacity of the AFD.
- .7 Provide an input EMI filter to minimize conducted electrical noise to meet the requirements of IEC 61800-3.
- .8 The AFD shall limit harmonic distortion reflected onto the utility system to a voltage and current level as defined by IEEE 519 for general systems applications, by utilizing the standard 5% DC link choke with input surge protection with a two coil design integrally mounted in the AFD enclosure
- .9 Any harmonic calculations shall be done based on the kVA capacity, X/R ratio and the impedance of the utility transformer feeding the installation, as noted on the drawings, and the total system load. The calculations shall be made with the point of common coupling being the point where the utility feeds multiple customers.
- .10 Total harmonic distortion shall be calculated under worst-case conditions in accordance with the procedure outlined in IEEE standard 519-1992. Copies of these calculations are to be made available upon request. The contractor shall provide any needed information to the AFD supplier three (3) weeks prior to requiring harmonic calculations.
- .11 AFD to have 100kAIC short circuit withstand rating
- .12 Include all metal conduit plate and rubber grommets
- .13 The system containing the AFD shall comply with the 5% level of total harmonic distortion of line voltage and the line current limits as defined in IEEE 519-1992. If the system cannot meet the harmonic levels with the with the AFD provided with the standard input line reactor or optional input isolation transformer, the AFD manufacturer shall supply an eighteen pulse, multiple bridge rectifier AC to DC conversion section with phase shifting transformer for all drives 50-HP and above. This eighteen-pulse rectifier converter shall result in a multiple pulse current waveform that will more nearly approximate a true sine-wave to reduce voltage harmonic content on the utility line. The phase shifting transformer shall be of a single winding type to optimize its KVA rating and harmonic cancellation capability.
- .14 The AFD shall be able to start into a spinning motor (flying start). The AFD shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the AFD shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor to the preset speed.
- .15 Standard operating conditions shall be:

- .1 Incoming Power: Single Phase 120VAC or Three-phase, 600VAC (+10% to -15%) and 50/60 Hz (+/-5 Hz) power to a fixed potential DC bus level.
- .2 Frequency stability of +/-0.05% for 24 hours with voltage regulation of +/-1% of maximum rated output voltage.
- .3 Speed regulation of +/- 0.5% of base speed.
- .4 Load inertia dependant carryover (ride-through) during utility loss.
- .5 Insensitive to input line rotation.
- .6 Humidity: 0 to 95% (non-condensing and non-corrosive).
- .7 Altitude: 0 to 3,280 feet (1000 meters) above sea level without de-rating
- .8 Ambient Temperature: -10 to 50 °C (CT), -10 to 40 °C (VT) with de-ratings up to 60 °C
- .9 Storage Temperature: -40 to 70 °C.
- .16 Diagnostic Features
 - .1 Fault History
 - .1 Record and log faults
 - .2 Indicate the most recent first, and store up to 30 faults with day and time stamp
- .17 Optional features to be included in the AFD:
 - .1 HMCP or thermal magnetic breaker to provide a disconnect means. Operating handle shall protrude through the door. The disconnect shall not be mounted on the door. The handle position shall indicate ON, OFF, and TRIPPED condition. The handle shall have provisions for padlocking in the OFF position with at least three (3) padlocks. Interlocks shall prevent unauthorized opening or closing of the AFD door with the disconnect handle in the ON position. Door handle interlock can be defeated by qualified maintenance personnel.
 - .2 AC input line current limiting fuses shall provide a means of disconnecting the AFD from the line under fault conditions.
 - .3 The AFD enclosure shall be NEMA 3R. The AFD shall have complete front accessibility with easily removable assemblies.
 - .4 Three contactor bypass shall include a drive input disconnect, an AFD input isolation contactor, bypass contactor and an AFD output contactor that is electrically and mechanically interlocked with the bypass contactor. This circuit shall include control logic, status lights and motor over-current relays. The complete bypass system Hand-Off-Auto with Inverter-Bypass selector switch(s), and Inverter/Bypass pilot lights shall be packaged with the AFD. The unit may be set up for Manual bypass operation upon an AFD trip.
 - .5 AC output contactor to provide a means for positive disconnection of the drive output from the motor terminals.
 - .6 Fused space heaters with thermostat for oversize enclosures to minimize condensation potential upon drive shutdown.
 - .7 Pneumatic process follower allowing motor speed control proportional to a 3-15PSIG pneumatic signal.

- .8 120 VAC control to allow AFD to interface with remote dry contacts.
- .9 Motor over-current relay to provide sensing of a given level of load current.
- .10 Input isolation transformers, separately mounted, with NEMA 3R enclosure.
- .11 Motor filter for use on motor cable runs exceeding 100 feet for motors with a peak voltage insulation rating less than 1600 Vac.
- .12 Dynamic braking control circuitry shall be provided to decelerate the motor faster than the internal losses can absorb. Dynamic braking shall cause an optional resistor bank, when specified, to be switched onto the DC link as required to absorb the regenerative energy. This shall allow the fastest controlled deceleration and/or stop without an over-voltage condition. The resistor bank, when specified, shall be located external to the drive enclosure to prevent overheating of the drive.
- .13 Resistor bank for dynamic braking load rated for ≥ 150 percent braking torque for a $\geq (20)$ percent duty cycle based on a sixty-second cycle time.
- .18 Keypad
 - .1 The keypad shall include a Local/Remote pushbutton selection. Both start/ stop source and speed reference shall be independently programmable for Keypad, Remote I/O, or Field Bus.
 - .2 Upon initial power up of the AFD, the keypad shall display a start up guide that will sequence all the necessary parameter adjustments for general start up.
 - .3 Frequently accessed AFD programmable parameters shall be adjustable from a digital operator keypad located on the front of the AFD. The AFD shall have a 3 line alphanumeric programmable display with status indicators. Keypads must use plain English words for parameters, status, and diagnostic messages. Keypads that use only alphanumeric code and tables are not acceptable. Keypads shall be adjustable for contrast with large characters easily visible in normal ambient light.
 - .4 The navigation interface shall include four independent direction navigation keys up, down, left and right with a center "OK" key. The interface keypad shall include additional independent keys for "Local/Remote", "Back/Reset", "Start", "Stop". Include two additional soft keys that allow for menu shortcuts.
 - .5 The interface keypad shall include three independent status LEDs. The three are "Remote", "Run", and "Fault".
 - .6 The display is a multi-line LED backlight display.
 - .7 Keypad shall be removable with Ethernet communications for remote mounting
 - .8 The keypad must serve as a Copy/Paste module that can hold two sets of parameters
 - .9 The operator shall be able to scroll through the keypad menu to choose between the following screens:

- .1 Parameters
- .2 Keypad control
- .3 Active faults
- .4 Fault history
- .5 System menu
- .6 Expander boards
- .7 Monitor
- .8 Operate menu
- .19 The AFD keypad shall be capable of displaying the following monitoring functions at a minimum:
 - .1 Output frequency
 - .2 Frequency reference
 - .3 Motor speed
 - .4 Motor current
 - .5 Motor torque
 - .6 Motor voltage
 - .7 DC-bus voltage
 - .8 Unit temperature
 - .9 Calculated motor temperature
 - .10 Voltage level of analog input
 - .11 Current level of analog input
 - .12 Digital inputs status
 - .13 Digital and relay outputs status
 - .14 Analog input
- .20 Protective Functions
 - .1 The AFD shall include the following protective features at minimum:
 - .1 Over-current
 - .2 Over-voltage
 - .3 Inverter fault
 - .4 Under-voltage
 - .5 Input phase loss
 - .6 Output phase loss
 - .7 Under-temperature
 - .8 Over-temperature
 - .9 Motor stalled
 - .10 Motor over-temperature
 - .11 Motor under-load
 - .12 Logic voltage failure
 - .13 Microprocessor failure
- .21 The AFD shall provide ground fault protection during power-up, starting, and running. AFD with no ground fault protection during running are not acceptable.

- .22 On-board Communications
 - .1 The AFD shall include the following communication as standard. Ethernet I/P, Modbus TCP, Modbus RTU, BACnet MS/TP
 - .2 The AFD shall have the following communication protocols as an optional card. Profibus DP, CANopen, Devicenet, Profinet, Smartwire DT, Lonworks.
- .23 Input/Output
 - .1 The AFD shall include the follow as standard:
 - .1 Eight (8), 24VDC digital input as standard
 - .2 One (1), open collector 24VDC digital output
 - .3 Two (2) 4 to 20mA analog inputs
 - .4 Two (2) 4 to 20 mA analog outputs
 - .5 Three (3) dry relay contacts rated for 250VAC at 2A or 250VDC at 0.4mA
 - .2 The AFD shall offer the following optional expansion cards
 - .1 Three (3) digital inputs and three (3) digital outputs
 - .2 One (1) isolated analog input and two (2) analog outputs
 - .3 Three (3) dry contact relay outputs
 - .4 Three (3) RTD inputs
 - .5 Six (6) digital inputs rated for 240VAC
 - .3 All field inputs and output connections to the interface board shall use quick-connect terminals
 - .4 All input/output are field programmable
- .24 Circuit boards
 - .1 All circuit boards shall be conformal coated as standard for moisture and temperature protection
- .25 Harmonic mitigation
 - .1 Provide an integrated 5% DC link choke. External choke is not acceptable. The choke shall be a two coil design. DC choke shall include input surge protection.
- .26 EMI Filter
 - .1 Provide integrated EMI filter. Filter shall meet IEC/EN 61800-3 EMC Category 2.
 - .2 Filter mounting is disconnect able by removing a single screw for compatibility with corner grounded systems and IT systems.
- .27 Real time clock
 - .1 AFD software shall include a real time clock function for a day and time stamp of fault occurrence, start time stamp, stop time stamp, and operating hours.
 - .2 Time clock to include battery back-up
- .28 Energy Control
 - .1 AFD software shall include energy optimization algorithm. The software algorithm shall compare output voltage to the motor load. The output voltage is optimized to reduce the motor core losses and

- maintain a high enough voltage to prevent the motor from becoming unstable.
 - .2 Includes onboard energy savings calculator that allows local kW cost.
- .29 Safe torque off
 - .1 AFD shall include safe torque off where IGBTs can be directly deenergized. Safe torque off shall be SIL1 certified (IEC/EN 61800-5-2 and DIN EN ISO 13849 Category 1, Level
- .30 Cold Weather Functionality
 - .1 AFD shall have the ability to warm IGBTs for starting to a temperature of -30°C
- .31 AFD Software
 - .1 Manufacturer to include programming and monitoring configuration software as no extra charge
 - .2 Software applications to include Standard, Multi-Fan and Pump, Multi-PID and Multi-purpose
- .2 Acceptable Manufacturers
 - .1 Eaton's Cutler Hammer
 - .2 ABB
 - .3 Allen Bradley

PART 3 Execution

3.1 Examination

- .1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for installation in accordance with manufacturer's written instructions.
 - .1 Visually inspect substrate in presence of Departmental Representative.
 - .2 Inform Departmental Representative of unacceptable conditions immediately upon discovery.
 - .3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Departmental Representative.
- .2 Factory Testing
 - .1 The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.
 - .1 All printed circuit boards shall be functionally tested via automatic test equipment prior to unit installation.
 - .2 After all tests have been performed, each AFD shall undergo a burn-in test. The drive shall be burned in at 100% inductive or motor load without an unscheduled shutdown.
 - .3 After the burn-in cycle is complete, each AFD shall be put through a motor load test before inspection and shipping.

- .2 The manufacturer to provide certified copies of factory test reports.

3.2 Field Quality Control

- .1 Provide the services of a qualified manufacturer's employed Field Service Engineer to assist the Contractor in installation and start-up of the equipment specified under this section. Field Service personnel shall be factory trained with periodic updates and have experience with the same model of AFD on the job site. Sales representatives will not be acceptable to perform this work. The manufacturer's service representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, installation as specified in manufacturer's installation instructions, wiring, application dependant adjustments, and verification of proper AFD operation.
- .2 The Contractor under the technical direction of the manufacturer's service representative shall perform the following minimum work.
 - .1 Inspection and final adjustments.
 - .2 Operational and functional checks of AFD and spare parts.
 - .3 The contractor shall certify that he has read the drive manufacturer's installation instructions and has installed the AFD in accordance with those instructions.
- .3 The Contractor shall provide three (3) copies of the manufacturer's field start-up report before final payment is made.

3.3 Maintenance/Warranty Service

- .1 Warranty to commence 24 months from the date of start-up, not to exceed 36 months from the date of shipment, and include all parts, labor, and travel time.

3.4 Field Testing

- .1 The AFD manufacturer shall perform harmonic measurements at the point where the utility feeds multiple customers (PCC) to verify compliance with IEEE519-1992. A report of the voltage THD and current TDD shall be sent to the engineer. The contractor shall provide labor, material, and protection as needed to access the test points. The readings shall be taken with all drives and all other loads at full load, or as close as field conditions allow.

END OF SECTION