

Part 1 General

1.1 GENERAL

- .1 This Section covers items common to Sections of Division 16. This section supplements requirements of Division 1.
- .2 All Drawings and all sections of the Bid Opportunity and Specifications shall apply to and form an integral part of this section.

1.2 CODES AND STANDARDS

- .1 Do complete installation in accordance with CSA C22.1 except where specified otherwise.
- .2 Abbreviations for electrical terms: to CSA Z85.
- .3 The electrical installation shall comply with the requirements of the Electrical Supply Authority, the latest edition of the Canadian Electrical Code, with all Provincial and Municipal Laws, Rules and Ordinances, and to the satisfaction of those persons having jurisdiction over same.
- .4 Notify the Contract Administrator of any discrepancies or conflicts with any regulation seven (7) Working days before Bid Opportunity closes. Failing such notification, meet all such requirements without change to the Contract price.
- .5 In no instance shall the standard established by these Specifications and Drawings be reduced by any of the codes, rules or ordinances.

1.3 CARE, OPERATION AND START-UP

- .1 Upon completion of the project, demonstrate the operation of all equipment in the presence of The City, or his representative, and the Contract Administrator. Obtain signed certification from The City that such equipment was shown to be fully operational and that all necessary operating instructions have been provided.
- .2 Arrange and pay for services of manufacturer's factory service engineer to supervise start-up of installation, check, adjust, balance, calibrate, test and commission components as specified in subsequent sections.
- .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with all aspects of its care and operation.
- .4 Carefully examine all plans and Specifications pertaining to this Contract and become familiar with all details. Visit the Site and determine all factors affecting this section of the Work and include all costs for same in Bid Opportunity.

1.4 VOLTAGE RATINGS

- .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.

1.5 PERMITS, FEES AND INSPECTION

- .1 Submit to Electrical Inspection Department and Supply Authority necessary number of Drawings and Specifications for examination and approval prior to commencement of Work.
- .2 Pay all associated fees for inspection of the Work by authorities having jurisdiction.
- .3 Notify Contract Administrator of changes required by Electrical Inspection Department prior to making changes. Changes and alterations required by authorized inspector of any authority having jurisdiction to be carried out without additional cost to The City.
- .4 Furnish Certificates of Acceptance from authorities having jurisdiction on completion of Work to Contract Administrator. Copies to be included in Maintenance Manuals.

1.6 MATERIALS AND EQUIPMENT

- .1 Provide Materials and equipment in accordance with Div. 16.
- .2 Equipment and Material to be CSA certified or certified by an equivalent recognized certifying agency to meet Canadian Standards. Electrical equipment consisting of individual certified components must also have a CSA or equivalent certification for the entire assembly. Where there is no alternative to supplying equipment which is certified, obtain special approval from local Electrical Inspection Department or authority having jurisdiction.
- .3 Factory assemble control panels and component assemblies.
- .4 Any Material or equipment ordered or installed without the Contract Administrator's prior approval shall, if so directed by the Contract Administrator, be removed and replaced with approved Material or equipment without a change in the Contract price.

1.7 RESPONSIBILITY

- .1 Be responsible for any damage caused the City, or their Contractors due to improperly carrying out this Work.
- .2 Work shall be arranged in co-operation with other divisions of this Specification in such a manner that it doesn't interfere with the progress of the project. In areas where ducts or pipes must be installed along with conduit or cable, co-operate with other divisions so that the finished job will represent the most efficient use of the space.
- .3 In no case proceed with any Work in uncertainty. Obtain, from the Contract Administrator, any clarification necessary and thoroughly understand all portions of the Work to be performed.

1.8 ELECTRIC MOTORS, EQUIPMENT AND CONTROLS

- .1 Supplier and installer responsibility is indicated in Motor Schedule on electrical Drawings, or in this Specification and related mechanical responsibility is indicated in Mechanical Equipment Schedule on mechanical Drawings.
- .2 Refer to other Sections of this Specification and to Drawings for responsibility for control wiring and conduit.

1.9 FINISHES

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

1.10 WORKMANSHIP AND MATERIALS

- .1 The installation shall consist of Material and equipment specified unless as provided herein. Electrical equipment provided under this Contract shall be built in accordance with EEMAC standards and shall be C.S.A. certified (or certified by an equivalent recognized certifying agency to meet Canadian Standards) and/or locally approved. All equipment supplied under this Contract shall be new and the best of its respective kind and of uniform pattern throughout.
- .2 Any Material or equipment ordered or installed without the Contract Administrator's prior approval shall, if so directed by the Contract Administrator, be removed and replaced with approved Material or equipment without a change to the Contract.
- .3 Replace inferior Work if so ordered by Contract Administrator without a change to the Contract.
- .4 Retain same foreman or superintendent on the job until completed, unless otherwise directed by the Contract Administrator.
- .5 All tradesmen shall carry all tools on their person at all times. Any tool not in use shall be under lock and key in an area authorized by the building supervisor.

1.11 CLEANLINESS AND CLEANING

- .1 This division shall maintain a clean tidy job Site. All boxes, crates, and construction debris due to this portion of the Work shall be neatly piled outside the construction area and shall be removed at least weekly during the construction period. All construction areas shall be kept clear of debris.
- .2 Before the project will be accepted by The City, all electrical equipment shall be clean and free of dust, plaster, paint, etc. Any equipment which is scratched or damaged shall be refinished or replaced if so designated by the Contract Administrator.

1.12 MODIFICATIONS

- .1 Locations of all outlets are subject to modification by the Contract Administrator, who reserves the right to move these up to 3000 mm from the position shown, without change to the Contract price, provided notice is given before the related Work has commenced.

1.13 ENGINEERING OBSERVATIONS

- .1 Contractor's Work will be observed periodically by The City, and/or Contract Administrator or their representatives, solely for purpose of determining general quality of Work, and not for any other purpose. Guidance will be offered to Contractor in interpretation of plans and Specifications to assist him to carry out Work. Observation and directives given to Contractor does not relieve Contractor and his agents, servants and employees of their responsibility to erect and install Work in all its parts in a safe and Workmanlike manner, and in accordance with plans and Specifications, nor impose upon The City, and/or Contract Administrator or their representatives, any responsibility to supervise or oversee erection or installation of any Work.

1.14 IDENTIFICATION OF EQUIPMENT

- .1 Identify electrical equipment with nameplates and labels as follows and as indicated in other Specification sections.
- .2 Nameplates:
 - .1 Lamacoid 3mm thick plastic engraving sheet, shall be white with black letters or as directed, mechanically attached with self tapping screws. Nameplates for equipment fed from emergency power or from emergency UPS power (increase nameplate size as required to suit wording) shall be white with red letters.

NAMEPLATE SIZES

Size 1	10 x 50mm	1 line	3mm high letters
Size 2	12 x 70mm	1 lines	5mm high letters
Size 3	12 x 70mm	2 lines	3mm high letters
Size 4	20 x 90mm	1 line	8mm high letters
Size 5	20 x 90mm	2 lines	5mm high letters
Size 6	25 x 100mm	1 line	12mm high letters
Size 7	25 x 100mm	2 lines	6mm high letters

- .3 Labels:
 - .1 Embossed plastic labels with 6mm high letters unless specified otherwise.
- .4 Fabrication details of all nameplates labels and wording on nameplates and labels to be approved by Contract Administrator prior to manufacture.
- .5 Allow an average of twenty-five (25) letters per nameplate and label.
- .6 Room names and numbers used shall be actual room names and numbers that will be used on the project. Division 16 to co-ordinate and confirm with trades involved.
- .7 Identification to be English.
- .8 Co-ordinate names of equipment and systems with Division 15 to ensure that identical names are used.

- .9 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
- .10 Nameplates for disconnects, starters and contactors: Indicate equipment being controlled and voltage.
- .11 Nameplates for terminal cabinets and pull boxes: Indicate system and voltage.
- .12 Nameplates for control devices: indicate equipment controlled.
- .13 Adjacent to each breaker in CDP type panelboards, provide and mount lamacoid nameplates identifying the respective load and location.
- .14 To match existing where applicable.

1.15 WIRING IDENTIFICATION

- .1 Identify wiring with permanent indelible identifying markings on both ends of phase conductors of feeders (coloured plastic tapes) and branch circuit wiring (numbered wire markers). Conductor marker identification shall correspond with panel or terminal board directory information.
- .2 Maintain phase sequence and colour coding throughout.
- .3 Colour Code: To CSA C22.1.
- .4 Use colour coded wires in communication cables, matched throughout system. Colour coding used shall be documented by individual systems in Maintenance Manuals.
- .5 Insulated grounding conductors shall have a green finish and shall be used only as a grounding conductor.

1.16 CONDUIT, OUTLET BOXES AND CABLE IDENTIFICATION

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

	<u>Prime</u>	<u>Auxiliary</u>
Up to 250V (normal power)	yellow	
Up to 600V (normal power)	yellow	green
Up to 250V (emergency power)	yellow & red	
Up to 600V (emergency power)	yellow & red	green
Other communication systems	green	blue
Control	blue	
- .4 Other conduit systems as directed on Site; all conduit systems shall be identified.
- .5 Color outlet box covers to color designated and show circuit numbers in black felt marker on inside of covers.

1.17 WIRING TERMINATIONS

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

1.18 MANUFACTURERS AND CSA CERTIFICATION LABELS

- .1 Visible and legible after equipment is installed.

1.19 WARNING SIGNS

- .1 As specified and to meet requirements of Electrical Inspection Department and Contract Administrator.
- .2 Decal signs, minimum size 175 x 250mm.

1.20 LOCATION OF OUTLETS

- .1 Change location of outlets at no extra cost or credit, providing distance does not exceed 3000mm, and information is given before installation.

1.21 CONDUIT AND CABLE INSTALLATION

- .1 If plastic sleeves are used in fire rated walls or floors, remove before conduit installation.
- .2 Install cables, conduit and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to minimum.
- .3 Arrange for holes through exterior wall and roof to be flashed and made weatherproof.

1.22 FIELD QUALITY CONTROL

- .1 Conduct and pay for following tests:
 - .1 Circuits originating from branch distribution panels.
 - .2 Motors, heaters, and associated control equipment including sequenced operation of systems where applicable.
 - .3 Any other electrical systems.
- .2 Furnish manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to manufacturer's instructions.
- .3 All circuits shall be tested to ensure that the circuit numbers are correct and that the proper neutral conductors have been provided and installed.
- .4 Insulation resistance testing:
 - .1 Megger circuits, feeders and equipment up to 350V with a 500V instrument.
 - .2 Megger 350V - 600V circuits, feeders and equipment with a 1000V instrument.
 - .3 Check resistance to ground before energizing.
- .5 Advise Contract Administrator of dates and times for all testing with sufficient advance notice to allow Contract Administrator to make arrangements to attend.

- .6 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.
- .7 Submit test results for Contract Administrator's review.
- .8 Insert test results and supplier's certifications in Maintenance Manuals.

1.23 DRAWINGS

- .1 Carefully examine all Drawings and Specifications relating to all Work, and all electrical Work indicated thereon shall be considered as a part of the Work by this section unless indicated otherwise. Prior to the date of the last addendum report at once to the Contract Administrator, any defect, discrepancy, omission or interference affecting the Work of this section, or the guarantee of same.
- .2 Install all equipment as shown or as specified and in accordance with manufacturer's approved Shop Drawings.
- .3 The Drawings accompanying these Specifications are intended to show the general arrangement and extent of the Work to be carried out, but the exact location and arrangement of all parts shall be determined as the Work progresses. The location of equipment, outlets, etc., as given on the Drawings are approximately correct, but it shall be understood that they are subject to such modifications as may be found necessary or desirable at the time of installation. Such changes shall be implemented as directed by the Contract Administrator, without additional charge.
- .4 Where Drawings indicate the general location and route to be followed by conduit, cable, etc., these locations must be governed by job conditions. Where the required conduit, cable, or boxes are not shown on Drawings or only shown diagrammatically, they shall be installed to conserve maximum head room and interfere as little as possible with free use of space through which they pass. Maximum clearance above floor shall be maintained under all suspended conduit and equipment, unless otherwise shown on the Drawings, or approved by the Contract Administrator.
- .5 Submit a complete set of Drawings for the proposed installation to the Inspection Department having jurisdiction and receive written approval before installation or fabrication of any equipment. No extra compensation will be allowed for any changes or rearrangement of any electrical apparatus or Materials necessary due to failure to receive this approval.

1.24 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

- .1 Submit Shop Drawings, produce detailed data and samples in accordance with previous sections, as specified herein, and to Contract Administrator's satisfaction.
- .2 Shop Drawings submitted electronically (e.g. by email) shall comply with the following:
 - .1 Shop Drawings larger than 11 x 17 shall include a hard copy delivered separately by messenger the same day as the email copies.
 - .2 All necessary transmittals shall be included with the email submission.
 - .3 Emailed Shop Drawings shall comply in all respects with this section of the Specifications.

- .3 Indicate details of construction, dimensions, capacities, weights and electrical performance characteristics of equipment or Material.
- .4 Where applicable, include actual wiring, single line and schematic diagrams. Include all technical data and full details of each component.
- .5 Include wiring Drawings or diagrams showing interconnection with Work of other sections.
- .6 Shop Drawings of all equipment must be submitted to the Contract Administrator for review in sufficient time to enable him to retain them for at least ten (10) Working days.
- .7 Each applicable device to be highlighted or identified with an arrow.
- .8 Each applicable device to be tagged (e.g. light fixture type, motor tag, etc.).
- .9 Division 16 shall check all Shop Drawings and make necessary changes, or cause the supplier to make necessary changes, prior to submission to the Contract Administrator. Shop Drawings will be reviewed by the Contract Administrator and if re-submission is required, Division 16 shall ensure that the supplier's Drawings have been changed to comply before returning them to the Contract Administrator for review again.
- .10 Review of the Shop Drawings by the Contract Administrator shall not relieve the Contractor from responsibility for errors and omissions therein.
- .11 Each Drawing submission to bear the following signed stamp, and shall 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:

- .12 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 Contract, unless specifically noted to the contrary.
- .13 Provide field dimensions required by electrical suppliers and Subcontractors. In cases where fabrication is required prior to field dimensions being available, check all related Drawings and obtain clarification from Contract Administrator if necessary.
- .14 Incomplete submissions will be returned for updating and re-submittal without Contract Administrator's review.

1.25 MOUNTING HEIGHTS

- .1 Mounting height of equipment is from finished floor to centre line 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 unless indicated otherwise.
 - .1 Thermostats: 1200mm.
 - .2 Manual starters: 1200mm.
 - .3 Heights as above or at bottom of nearest block or brick course except where required to comply with Manitoba Building Code, other applicable codes, authorities having jurisdiction, etc.
 - .4 Heights to match existing where applicable except where required to comply with Manitoba Building Code, other applicable codes, authorities having jurisdiction, etc.

1.26 TEMPORARY LIGHTING AND POWER

- .1 All temporary and construction lighting and power Work and costs for same are not included as part of the scope of the Work of this section. Refer to such clauses in other sections of the Specification.

1.27 RECORD DRAWINGS

- .1 Provide one set of Contract prints to form Record Drawings, marked clearly with all changes and deviations from piping and ductwork, including all Contract Changes.
- .2 Update Record Drawings on a regular basis to ensure they are accurate, and have available for reference and inspection at all times.

1.28 TESTING

- .1 Test all circuits and wires for continuity, insulation resistance and high impedance grounds. Those circuits which test non-continuous, with an insulation resistance less than 2 Megohms or with high impedance grounds shall be replaced.
- .2 All empty conduits shall be left with an insulated #14 AWG fish wire.
- .3 Keep a record of all final tests, bind, and turn over typewritten results to the Contract Administrator as a part of the maintenance manual. All final test values measured, date of each measurement, company name and signature of person making each measurement shall be neatly recorded. After all tests have been successfully completed, each test report shall contain a summary which clearly states that all results were satisfactory.
- .4 Upon completion of the Work and adjustments of all equipment, all systems shall be tested in the presence of the Contract Administrator to demonstrate that all equipment furnished and installed or connected as a part of this section of the Contract shall function electrically in the required manner as determined by the Contract Administrator.

- .5 All circuits shall be tested to ensure that the circuit numbers are correct and that the proper neutral conductors have been provided and installed.

1.29 CUTTING AND PATCHING

- .1 Cutting, patching and repairs to existing surfaces required as a result of the removal and/or relocation of existing equipment and piping, and/or installation of new equipment and piping in existing building(s) to be included by Div. 16 - Electrical in Bid Opportunity price. Division 16 - Electrical to employ and pay appropriate Sub-contractor whose Work is involved, for carrying out Work described above.
- .2 Division 16 shall mark all openings required for conduits, cables, ducts, and the like.

1.30 FIREPROOFING

- .1 Where cables or conduits pass through floors, block or concrete walls and fire rated walls, seal openings with 3 M Brand 7900 Series Fire Barrier System, to maintain fire rating.
- .2 Fireproofing of electrical cables, conduits, trays, etc. passing through fire barriers shall conform to local codes and inspection authorities.

1.31 ACCESS DOORS

- .1 Provide and install access doors where electrical equipment requiring access is built-in. Access doors to be 2.5mm (12 ga.) steel, approximately 300mm x 300mm (12" x 12") minimum or as approved, finished prime coat only, with concealed hinges, anchor straps, plaster lock and without screws, all equal to Milcor manufacturer. All locks to be flush type, screwdriver operated. Where it is necessary for persons to enter through door, doors to be at least 600mm x 600mm.
- .2 In applied tile or exposed glazed or unglazed structural tile, access doors shall take the tile and be sized and located to suit tile patterns. In masonry walls access doors to be sized and located to suit masonry unit sizes. In removable acoustic tile ceilings, no access doors are required.
- .3 Access doors located in fire rated ceilings or walls shall be approved fire rated doors and frames.

1.32 PROTECTION

- .1 Protect exposed live equipment during construction for personnel safety.
- .2 Shield and mark live parts "LIVE 120 VOLTS", or with an appropriate voltage in English.

1.33 SCHEDULING OF WORK

- .1 Existing buildings will remain in use during construction. Arrange Work so that interruption of services is kept to a minimum. Obtain permission from The City prior to cutting into electrical services. Where deemed necessary by Contract Administrator, temporary electrical shall be installed and/or Work shall be carried out at night and on weekends.

- .2 Contractor to maintain continuous and adequate all existing electrical systems and other services during entire time of this Contract. Provide temporary conduit, wire, equipment, etc. where necessary to meet this requirement.

1.34 EXAMINATION OF DOCUMENTS AND SITE

- .1 Carefully examine all plans and Specifications pertaining to this Contract and become familiar with all details. Visit the Site and determine all factors affecting this section of the Work; include all costs for same in Bid Opportunity.

1.35 DEMOLITION OF EXISTING ELECTRICAL

- .1 Remove all unnecessary existing electrical equipment, wiring, etc., in those portions of the existing building which are being remodelled or demolished. All devices/fixtures, etc. are not necessarily shown on the plans. The City shall select from the Materials and/or equipment remaining that which he wishes to retain, and the remainder shall be removed from the Site. Any electrical equipment in remodelled sections or in structures removed or altered, adjacent to new Work, necessary for the operation of existing building, shall be relocated as necessary. All existing equipment re-used shall be made good and guaranteed. Power interruptions to be kept to a minimum and shall be at a time suitable to the building occupant.
- .2 Drawings do not show all electrical requiring removal to accommodate renovations. Division 16 shall visit Site, refer to Electrical Drawings and include all costs for demolition.
- .3 Refer to Specification Section 16195 - Work in Existing Building.

1.36 SPARE PARTS

- .1 The Contractor shall submit 15 days after Bid Opportunity a list of spare parts that the Contractor considers essential/important/useful to the operation of the systems described herein. This list shall be in addition to any spares/consumables called for in the Contract Documents and those which are required up to practical completion and hand over.
- .2 Each spare part listed shall include the manufacturer's/ supplier's price including all mark-ups, delivery and packaging. The prices shall remain valid for 12 months following handover of the project.
- .3 These spare parts may or may not be ordered during the Contract period. The Contractor shall only include these items in the Contract sum if specifically instructed to do so.
- .4 Any spare parts listed shall be completely interchangeable with those specified in the Contract Documents and included in the Works.
- .5 Any spares ordered shall be delivered to the specified client's representative complete with all documents/instructions.

1.37 CO-ORDINATION STUDY

- .1 Submit a complete Short Circuit and Time-Current Coordination Study for the breakers and fuses provided under this contract as well as for the existing upstream breakers and fuses affecting the distributions in this contract. If any existing breakers must be adjusted

for proper coordination, other breakers affected must be included in the study and adjusted as required for proper coordination. Hydro protective devices to be included in the study.

- .1 For the new distributions include all existing upstream overcurrent protection up to and including the (eg. main breaker in the normal main distributions and up to and including the main breaker in the emergency main distributions).
- .2 Drawings of existing distributions are not available. Visit site to obtain information.
- .3 Curves shall be plotted on a standard log-log scale as time versus current values on a common 600 Volt base. It shall be the responsibility of the Division 16 contractor to provide time-current curves of all breakers, fuses, etc.
- .4 The study shall:
 - .1 Select settings and characteristics for the protective devices in order to achieve maximum selectivity between devices during fault conditions (ie. the device nearest the fault will operate first, thus minimizing the interruption) and to provide proper protection for all distribution equipment, transformers, cable, etc.
 - .2 Determine the fault currents at critical points in the power system under the worst case conditions in order to ensure the adequacy of the electrical equipment and protective devices. Motor contribution is to be taken into account.
 - .3 Include all breakers in CDP type panelboards. Breaker settings shall be listed in the study for all breakers with adjustable trips.
- .5 In addition to the curves for the protective devices, each drawing shall show and include proper protection and coordination for:
 - .1 Transformer inrush points.
 - .2 Transformer full load currents.
 - .3 Transformer damage curves (single phase and three phase).
 - .4 Cable damage curves.
 - .5 The largest motor or motors likely to present coordination problems.
- .6 All required breaker settings shall be listed in table form including breaker details such as breaker type, trip rating, etc. All breakers with adjustable trips shall be included in this list.
- .7 Maximum available short circuit currents shall be listed for each bus. This listing shall also include the interrupting rating of the protective devices actually supplied in the contract.
- .8 In all cases use actual values for transformer impedance, cable types, cable sizes, cable lengths, available utility fault current, etc.
- .9 Identification names and numbers for breakers and distribution in the study shall match the identification shown on the contract documents.
- .10 The short circuit and coordination study shall be done by a Professional Engineer licensed in the Province of Manitoba and the study shall be signed and sealed by the Professional Engineer.
- .11 Ground fault curves shall be plotted on the same drawings as overcurrent curves to ensure proper coordination.
- .12 Where there is a generator set, the study shall include the generator breakers.

- .13 Where there is equipment such as power factor correction panels with incoming breakers include these breakers in the study.
- .14 As a minimum, the study shall be bound in a 3-ring loose leaf binder and shall include:
 - .1 A title sheet listing the study name, project name, project number, date, engineering company that prepared the study (including address and phone number), the engineers seal and signature, etc.
 - .2 Table of Contents.
 - .3 Purpose of the study.
 - .4 The criteria for determining proper selective coordination, protection, adequacy, etc. (eg. describe when coordination is achieved, minimum/maximum tripping times and current values, separation between curves, safety margins, damage curves, etc.).
 - .5 Summary stating that proper selective coordination, proper protection, adequacy of the equipment for the maximum available short circuit currents, etc. was achieved and listing any areas of compromise, potential problems, marginal adequacies, etc.
 - .6 Drawings of the breaker curves showing proper selective coordination, protection, adequacies, etc. On each drawing, include a single line diagram of the distribution for the curves shown on the drawing, breaker settings, etc.
 - .7 Maximum available short circuit currents at each bus.
- .15 The study shall be started immediately on award of contract and shall be submitted as a shop drawing for review in advance of distribution shop drawings. A minimum of 6 copies shall be submitted.
- .16 In cases such as primary breaker protection for transformers provide breakers with fully adjustable solid state trips (fully adjustable LSI setting) for transformers 45 kVa and larger in order to allow proper coordination. Costs for this shall be included in the Bid price.
- .17 All breakers shall be set per the curves in the coordination study.
- .18 The Short Circuit and Time-Current Coordination Study (revised to as-built conditions) shall be included in the Operating and Maintenance Manuals.
- .2 A certified testing agency normally engaged in field service equipment testing shall be engaged and shall test all the circuit breaker settings for coordination verification as follows (to include new and existing breakers that require adjustment of settings):
 - .1 Verification of coordination testing shall consist of:
 - .1 Testing of all circuit breaker solid state relays with the breaker manufacturer's test kit to verify at least 3 points on each time-current characteristic. One point shall be tested at the breakpoint of the characteristic at the high end and another point shall be tested at the breakpoint of the characteristic at the low end. The other points shall be tested along the straight line of the characteristic.
 - .2 Ductor (contact resistance) testing and meggar (insulation) testing of all breakers including moulded case breakers in CDP type panels, air circuit breakers, other breakers with solid state trips, high voltage breakers, etc.
 - .2 The report shall be bound in a 3-ring loose leaf binder, similar to the Short Circuit and Time-Coordination Study, with title sheet, table of contents, purpose,

test criteria, test equipment used, summary and test data. The test data shall list all devices in table form with both the actual tested values and the required values listed. All test values shall fall within +/- 10% of the required values. Necessary corrective action shall be taken to correct any problems and then re-tested until the equipment passes all required tests. Compare test results to the time current coordination study and confirm that the curves as actually tested provide the required coordination. After all tests and analysis has been completed successfully, the summary in the final report shall clearly state that all equipment has successfully passed all tests and is in good operating condition. The test report shall be certified by the testing agency and shall be signed and sealed by a Professional Engineer responsible for the testing. A minimum of 6 copies shall be submitted.

.3 The breaker co-ordination test report shall be included in the Operating and Maintenance Manuals.

.3 Acceptable Supplier of Service:

- .1 Meg-A-Ron Engineering
- .2 J.R. Stephenson Mfg. Ltd.
- .3 Siemens
- .4 Schneider
- .5 Cutler Hammer

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements

1.2 LOCATION OF CONDUIT

- .1 Drawings do not indicate all conduit runs. Those indicated are in diagrammatic form only.
- .2 Produce layout sketches of conduit runs through mechanical and electrical service areas in order to pre-avoid any conflict with other construction elements and to determine the most efficient route to run conduit.

Part 2 Products

2.1 CONDUITS

- .1 Rigid galvanized steel threaded conduit.
- .2 Electrical metallic tubing (EMT): with couplings. Minimum size shall be 19mm.
- .3 Flexible metal conduit and liquid-tight flexible metal conduit.

2.2 CONDUIT FASTENINGS

- .1 One hole steel straps to secure surface conduits 50 mm and smaller. Two hole steel straps for conduits larger than 50 mm.
- .2 Beam clamps to secure conduits to exposed steel Work.
- .3 U channel type supports for two or more conduits at 1500 mm oc. (Surface mounted or suspended).
- .4 Six mm dia. galv. threaded rods to support suspended channels.

2.3 CONDUIT FITTINGS

- .1 Fittings for raceways: to CSA C22.2 No. 18.
- .2 Fittings: manufactured for use with conduit specified. Coating: same as conduit.
- .3 Factory "ells" where 90 deg. bends are required for 25 mm and larger conduits.
- .4 Steel set screw connectors and couplings. Insulated throat liners on connectors.
- .5 Raintight connectors and fittings c/w O-rings for use on weatherproof or sprinklerproof enclosures. Raintight couplings to be used for surface conduit installations exposed to moisture or sprinkler heads.

2.4 EXPANSION FITTINGS FOR RIGID CONDUIT

- .1 Weatherproof expansion fittings with internal bonding assembly suitable for 100 or 200 mm linear expansion.
- .2 Watertight expansion fittings with integral bonding jumper suitable for linear expansion and 19 mm deflection in all directions.
- .3 Weatherproof expansion fittings for linear expansion at entry to panel.

2.5 FISH CORD

- .1 Polypropylene c/w 3m spare length at each conduit end.

2.6 DUCT WATER SEALING

- .1 Floor and Wall Sleeve Seals: Where conduits penetrate through concrete floor or through wall below grade, provide LINK-SEAL sleeve seals.
- .2 Where conduits penetrate existing concrete floor or wall, anchor/water stop plate not required. Install LINK-SEAL sleeve seals only.
- .3 After installation of conduit and Link-Seal, Contractor shall apply waterproofing Material grout on outside of floor or wall around seal.
- .4 Complete installation to be per manufacturer's recommendations.

Part 3 Execution

3.1 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 Use rigid galvanized steel threaded conduit where specified.
- .4 Use electrical metallic tubing (EMT) except where specified otherwise.
- .5 Use flexible metal conduit for connection to motors in dry areas, and equipment subject to vibration or movement. Provide a separate insulated grounding conductor within flexible conduit.
- .6 Use liquid tight flexible metal conduit for connection to motors or vibrating equipment in damp, wet or corrosive locations.
- .7 Conduit stubs from floor slabs where exposed to damage to be rigid galv. steel.
- .8 The conduit sizes as shown or indicated are the minimum acceptable and shall not be reduced without the approval of the Contract Administrator.

- .9 Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter.
- .10 Mechanically bend steel conduit over 19 mm dia.
- .11 Field threads on rigid conduit must be of sufficient length to draw conduits up tight.
- .12 Install fish cord in empty conduits.
- .13 Where conduits become blocked, remove and replace blocked section. Do not use liquids to clean out conduits.
- .14 Dry conduits out before installing wire.
- .15 Conduit to be sized as per Canadian Electrical Code or as shown on Drawings. Note that the sizes of branch circuit conductors scheduled and/or specified on the Drawings are minimum sizes and must be increased as required to suit length of run and voltage drop in accordance with Canadian Electrical Code. Where conductor sizes are increased to suit voltage drop requirements, increase the conduit size to suit.
- .16 Running threads will not be permitted; proper couplings shall be used.
- .17 No circuits fed from emergency or essential power sources shall be run in the same conduit as other systems.
- .18 Provide separate conduit system for emergency distribution.
- .19 All conduit runs passing across expansion joints of the building shall be installed utilizing approved expansion fittings, and bonding devices.
- .20 Refer to 16010 for identification requirements.

3.2 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 150 mm parallel to steam or hot water lines with minimum of 75 mm at crossovers.
- .7 No power driven pins (Ramset) shall be utilized to secure any portion of the conduit.

3.3 CONCEALED CONDUITS

- .1 Do not install horizontal runs in masonry walls.

- .2 Do not install conduits in terrazzo or concrete toppings.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements
- .2 Section 16111 Conduits, Conduit Fastenings and Conduit Fittings
- .3 Section 16191 Fastenings and Support

Part 2 Products

2.1 MATERIALS

- .1 Conductors in Conduit:
 - .1 Type: RW90
 - .2 Conductors:
 - .1 Solid Copper #10 AWG and smaller.
 - .2 Stranded Copper #8 AWG and larger.
 - .3 Sized as indicated (Minimum # 12 AWG).
 - .3 Insulation: cross link polyethylene (RW90), 90 deg. C.
 - .4 Configuration: Single conductor.
 - .5 Voltage Rating: Minimum 600V.
 - .6 Certification: CSA C22.22 No. 38 or latest revision.
- .2 Armored Cable (TECK):
 - .1 Type: TECK
 - .2 Conductors:
 - .1 Solid Copper #10 AWG and smaller.
 - .2 Stranded Copper #8 AWG and larger.
 - .3 Sized as indicated (Minimum # 12 AWG).
 - .3 Insulation: cross link polyethylene (RW90), 90 deg. C.
 - .4 Configuration: Multi-conductor, as required, c/w a separate bare CU ground wire.
 - .5 Colour Code: Black, red, blue and white in 4/C cable. Cables of more than 4/C to be number coded.
 - .6 Voltage Rating: 1KV, 5KV, or 15KV as indicated.
 - .7 Inner Jacket:
 - .1 Black polyvinyl chloride (PVC)
 - .2 Low Flame Spread (LFS)
 - .3 Low Gas Emission (LGE)
 - .8 Armor: Inter-locked aluminum
 - .9 Outer Jacket:
 - .1 Black polyvinyl chloride (PVC), -40 deg. C

- .2 Low Flame Spread (LFS)
- .3 Low Gas Emission (LGE)
- .10 Flame Rating: FT4
- .11 Certification: CSA C22.22 No. 131 or latest revision.
- .3 Low Voltage Control Cables:
 - .1 Type: LVT
 - .2 Conductor: Solid Copper #18 AWG
 - .3 Insulation: Thermoplastic, colour coded
 - .4 Configuration: single, two conductor - parallel, three or more conductors twisted
 - .5 Voltage Rating: 30V
 - .6 Outer Jacket: thermoplastic
 - .7 Certification: CSA C22.22 No. 35
 - .8 Flame Rating: FT4
- .4 Variable Frequency Drive Power Cables
 - .1 For output wiring to the motor from the VFD.
 - .2 Use cable specifically designed for Variable Frequency Drives.
 - .1 Teck Drive RX cable as manufactured by Alcatel.
 - .2 PVC jacket rated at FT4.
 - .3 Continuous corrugated impervious aluminum shield.
 - .4 CSA approved to standard C22.2 No. 123.
 - .5 Teck Drive RX cables are to be installed in connectors specifically made for use with the Drive RX cables.
 - .6 Terminate the Drive RX cable grounds as per the cable manufacturer's instructions, using ground bushings as directed. The ground connections are to be made at the ground points indicated by the VFD manufacturer. Coordinate with Division 15.
 - .7 Installed as per manufacturer's instructions.
 - .3 For input wiring to the VFD must be separated from the output wiring from the VFD by a minimum of 300mm.

Part 3 Execution

3.1 GENERAL

- .1 To Minimize Voltage Drop on 120 Volt, 15 Amp Branch Circuits:
 - .1 All branch circuits shall be minimum #10 AWG for all circuits longer than 21 metres and shall be minimum #8 for all circuits longer than 35 metres.
 - .2 All branch circuit wiring and conduit shall be installed to minimize voltage drop. Install additional conduit runs as required to take the most direct and shortest route to outlets.

3.2 INSTALLATION IN RACEWAYS

- .1 Install wiring as follows:

- .1 In conduit systems in accordance with Section 16111.
- .2 Ensure conduits are dry and free of debris before pulling cables.
- .3 Colour coding and identification as per this section.
- .4 Wires in outlet, junction and switch boxes, not having a connection within box shall not be spliced, but shall continue unbroken through the box.

3.3 INSTALLATION IN EQUIPMENT

- .1 Group and lace-in neatly wire and cable installed in switchboards, panelboards, cabinets, wireways and other such enclosures.

3.4 TERMINATIONS

- .1 Terminate wires and cables with appropriate connectors in an approved manner.
- .2 Compression adapters intended to terminate larger feeders on small lugs are not acceptable. All lugs, including breaker lugs, are to be sized to accommodate the cable being terminated.

3.5 IDENTIFICATION

- .1 Wire in conduit #2 AWG and smaller shall have solid coloured insulation, color coded as listed below.
- .2 Wire in conduit 1/0 AWG and larger and single conductor cables for normal power feeders shall be identified at each outlet box and termination with a 150 mm band of coloured vinyl tape of the appropriate colour. Emergency power feeders shall be provided with an additional 75 mm band of red vinyl tape installed adjacent to the 150 mm band of the coloured phase identification tape, as listed below. Neutral and ground conductors shall be identified. Paint or other means of colouring the insulation shall not be used.
- .3 Color code wire in conduit and single conductor cables as follows:
Phase A - red
Phase B - black
Phase C - blue
Neutral - white
Ground - green
- .4 Maintain phase sequence and colour coding throughout project.
- .5 Use colour coded wires in communication cables, matched throughout system.
- .6 Identify control conductors in motor control equipment, contactors, etc. with mylar/cloth wire markers.
- .7 Refer to 16010 for additional requirements.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements
- .2 Section 16111 Conduits, Conduit Fastenings and Conduit Fittings
- .3 Section 16191 Fastenings & Supports

1.2 LOCATION

- .1 Locate splitters, junction and pull boxes as indicated or as needed for each system.

Part 2 Products

2.1 SPLITTERS

- .1 Sheet metal enclosure, welded corners and formed hinged cover suitable for locking in closed position. Sprinklerproof
- .2 Main and branch lugs to match required size and number of incoming and outgoing conductors as indicated.
- .3 Minimum three spare terminals on each set of lugs in splitters.
- .4 Explosion proof in hazardous areas to suit the hazardous classification.
- .5 Weatherproof where installed outdoors.
- .6 Enclosures in other areas to suit environment.

2.2 JUNCTION AND PULL BOXES

- .1 Welded steel construction with screw-on flat covers for surface mounting.
- .2 Covers with 25 mm minimum extension all around, for flush-mounted pull and junction boxes.
- .3 Cast type with gasketed covers where exposed to weather.
- .4 Explosion proof in hazardous areas to suit the hazardous classification.

2.3 CABINETS

- .1 Type E: sheet steel, hinged door and return flange overlapping sides, handle, lock and catch, for surface mounting.
- .2 Type T: sheet steel cabinet, with hinged door, latch, lock, 2 keys, containing 19 mm G1S fir plywood backboard. Cabinets to be flush or surface mounted as indicated.

- .3 Provide other systems cabinets as specified and located on Drawings.

Part 3 Execution

3.1 SPLITTER INSTALLATION

- .1 Install splitters and mount plumb, true and square to the building lines.
- .2 Extend splitters full length of equipment arrangement except where indicated otherwise.

3.2 JUNCTION, PULL BOXES AND CABINETS INSTALLATION

- .1 Install pull boxes in inconspicuous but accessible locations.
- .2 Mount cabinets with top not higher than 2 m above finished floor.
- .3 Install terminal block as indicated.
- .4 Install pull boxes so as not to exceed 30 m of conduit run between pull boxes.
- .5 Install junction and pull boxes clear of all mechanical ductwork and piping.

3.3 IDENTIFICATION

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
- .2 Identify splitters with size 7 nameplates.
- .3 Identify junction and pull boxes with size 3 nameplates.
- .4 Identify cabinets with size 5 nameplates.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements
- .2 Section 16111 Conduits, Conduit Fastenings and Conduit Fittings

Part 2 Products

2.1 OUTLET AND CONDUIT BOXES GENERAL

- .1 Size boxes in accordance with CSA C22.1.
- .2 Sectional boxes shall not be used.
- .3 Gang boxes where wiring devices are grouped.
- .4 Blank cover plates for boxes without wiring devices.
- .5 Combination boxes with barriers where outlets for more than one system are grouped.
- .6 In moist or dusty areas, gasketed watertight or dust tight boxes and covers shall be provided.

2.2 SHEET STEEL OUTLET BOXES

- .1 Electro-galvanized steel device boxes for flush installation in drywall and minimum size 102mm square outlet boxes with extension and square cornered tile covers as required.
- .2 Electro-galvanized steel utility boxes for outlets connected to surface-mounted EMT conduit, sized as required for the installation.

2.3 CONDUIT BOXES

- .1 Cast FS or FD ferrous alloy boxes with factory-threaded hubs and mounting feet for surface wiring of switches and receptacle where exposed to moisture.

2.4 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 32 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 For flush installations mount outlets flush with finished wall using plaster rings to permit wall finish to come within 6 mm of opening.
- .3 Provide correct size of openings in boxes for conduit, mineral insulated and armoured cable connections. Reducing washers are not allowed.
- .4 Boxes to be mounted plumb and square with building lines.
- .5 Install pull boxes, or fittings, in conduit runs where more than four bends are necessary.
- .6 Install pull boxes where run exceeds 23.0 (75 feet) in length.
- .7 All junction, outlets and pull boxes shall be so installed that they are always readily accessible.
- .8 No power driven pins (Ramset) shall be utilized to secure boxes without specific approval from Contract Administrator.
- .9 All concealed junction boxes, conduit fittings, etc. to be c/w galv. steel covers, secured with two bolts.

END OF SECTION

Part 1 General

1.1 REFERENCES

- .1 CSA C22.2No.65 Wire Connectors.
- .2 EEMAC 1Y-2, Bushing Stud Connectors and Aluminum Adapters (1200 Ampere Maximum Rating).

Part 2 Products

2.1 MATERIALS

- .1 Pressure type wire connectors: with current carrying parts of copper sized to fit copper conductors as required.
- .2 Fixture type splicing connectors: with current carrying parts of copper sized to fit copper conductors 10 AWG or less.
- .3 Clamps or connectors for armoured cable, aluminum sheathed cable, flexible conduit, as required.

Part 3 Execution

3.1 INSTALLATION

- .1 Remove insulation carefully from ends of conductors and:
 - .1 Install pressure type wire connectors and tighten.
 - .2 Install mechanical pressure type connectors and tighten screws with appropriate compression tool recommended by manufacturer. Installation shall meet secureness tests in accordance with CSA C22.2 No.65.
 - .3 Install fixture type connectors and tighten. Replace insulating cap.
 - .4 Install bushing stud connectors in accordance with EEMAC 1Y-2.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements
- .2 Section 16111 Conduits, Conduit Fastenings and Conduit Fittings
- .3 Section 16122 Wires and Cables

Part 2 Product

2.1 SUPPORT CHANNELS

- .1 U shape, size 41 x 41 mm, 2.5 mm thick, surface mounted, suspended or set in poured concrete walls and ceilings or as required.
 - .1 Manufacturers: B-Line, Burndy, Electrovert, Unistrut, Pilgrim, Pursley.

Part 3 Execution

3.1 INSTALLATION

- .1 Secure equipment to solid masonry, tile and plaster surfaces with steel anchors.
- .2 Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.
- .3 Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
- .4 Fasten exposed conduit or cables to building construction or support system using straps.
 - .1 One-hole malleable iron straps to secure surface conduits and cables 50 mm and smaller.
 - .2 Two-hole steel straps for conduits and cables larger than 50 mm.
 - .3 Beam clamps to secure conduit to exposed steel Work.
- .5 Suspended support systems.
 - .1 Support individual cable or conduit runs with 6 mm dia threaded rods and spring clips.
 - .2 Support 2 or more cables or conduits on channels supported by 6 mm dia threaded rod hangers where direct fastening to building construction is impractical.
- .6 For surface mounting of two or more conduits use channels at 1500 mm oc spacing.
- .7 Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.

- .8 Ensure adequate support for raceways and cables dropped vertically to equipment where there is no wall support.
- .9 Do not use wire lashing or perforated strap to support or secure raceways or cables.
- .10 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of Contract Administrator.
- .11 Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer's installation recommendations.
- .12 Threaded rod to be minimum 6 mm diam. galv. or nickel plated. Black steel rod is not acceptable.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Division 15000 Mechanical Specifications
- .2 Section 16010 Electrical General Requirements
- .3 Section 16111 Conduits, Conduit Fastenings and Conduit Fittings
- .4 Section 16122 Wires and Cables
- .5 Section 16132 Outlet Boxes, Conduit Boxes and Fittings
- .6 Section 16440 Disconnect Switches - Fused and Non-Fused up to 1000V
- .7 Section 16811 Motor Starters to 600V

1.2 SYSTEM DESCRIPTION

- .1 Provide complete electrical power and control connections for mechanical equipment, except as noted herein.

Part 2 Products

2.1 MATERIALS

- .1 Include motor starters, disconnects, conduit, wire, fittings, interlocks, outlet boxes, junction boxes, and all associated equipment required to provide power wiring for mechanical equipment, unless otherwise indicated.
- .2 Include pushbutton stations, motor protective switches, interlocks, conduit, wire, devices and fittings required to provide control wiring for mechanical equipment except for temperature/humidity control systems.
- .3 Unless otherwise noted, motors and control devices shall be supplied by Div. 15. Motor horsepower ratings shall be as shown in the Div. 15 Specifications. Motor voltage and phase ratings shall be as shown on the Div. 16 Drawings.

2.2 EXTERIOR EQUIPMENT

- .1 All equipment mounted on the exterior of the building shall be weatherproof.

Part 3 Execution

3.1 POWER WIRING

- .1 Install power feeders, starters, disconnects and associated equipment and make connections to all mechanical equipment.

- .2 Install branch circuit wiring for mechanical systems control panels, time clocks and control transformers. Control panels for equipment on emergency power to be connected to emergency branch circuits.
- .3 Install main power feeders to starter/control panels furnished by Div. 15. Install branch circuit wiring for motors, electric coils, etc.

3.2 CONTROLS

- .1 Install all electrical controls except controls supplied under Division 15, unless otherwise noted herein. Controls which have both electrical and mechanical connections shall be installed by the trade supplying the control.
- .2 Section 15900 shall supply and install all conduit, wire, devices and fittings required to wire and connect control systems specified in 15900. Control wiring shall be installed in conduit.
- .3 Wire and connect electrical interlocks for starters supplied by Div. 16.
- .4 Wire and connect thermistor control devices, built-in to large motors, to motor starters as per wiring diagrams provided by Div. 15.

3.3 COORDINATION

- .1 Refer to mechanical Drawings for the exact location of motor control devices, and other mechanical equipment requiring an electrical connection.
- .2 Obtain full information from Div. 15, regarding wiring, controls, overload heaters, equipment ratings and overcurrent protection. Notify the Div. 15 Subcontractor, at once, if any information provided is incorrect or unsatisfactory.
- .3 Coordinate control wiring requirements with Div. 15 and provide all control wiring and connections as required to make the control systems operate as specified.
- .4 Refer to Div. 15 Specifications for any further electrical requirements.

3.4 SHOP DRAWING REVIEW

- .1 Review Div. 15 equipment Shop Drawings and adjust breaker/feeder sizes as required.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements
- .2 Section 16111 Conduits, Conduit Fastenings and Conduit Fittings
- .3 Section 16131 Splitters, Junction, Pull Boxes and Cabinets
- .4 Section 16132 Outlet Boxes, Conduit Boxes and Fittings
- .5 Section 16191 Fastenings and Supports

1.2 COORDINATION

- .1 The building shall remain open and in normal operation during the construction period.
- .2 Where existing services such as electrical power, fire alarm system, sound system, etc. are required to be disrupted and/or shut down, coordinate the shut-downs with The City and carry out the Work at a time and in a manner acceptable to them. Carefully schedule all disruption and/or shut-downs and ensure that the duration of same is kept to the absolute minimum. Submit for approval a written, concise schedule of each disruption at least 120 hours in advance of performing Work and obtain The City's written consent prior to implementing.
- .3 Should any temporary connections be required to maintain services 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 system be damaged, make full repairs without extra cost, and to the satisfaction of The City and Contract Administrator.
- .4 If existing equipment shown on Drawings is defective it shall be brought to the Contract Administrator and The City's attention prior to Work completion.

1.3 EXISTING DEVICES IN NEW CONSTRUCTION

- .1 Existing junction boxes in walls and ceiling spaces required to maintain existing circuits shall remain accessible.
- .2 Where services are concealed within walls, floors or ceilings and cannot be visually identified, Contractor shall provide electronic scanning devices or other approved means to locate and identify concealed services prior to drilling.

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 circuit breakers, starters, panelboards, etc. required to be tied in to existing systems shall match the existing devices.
- .3 New wiring required to interconnect new devices to existing systems shall be provided to suit the manufacturers requirements and instructions.

Part 3 Execution

3.1 INSTALLATION

- .1 Install boxes, conduit and wiring through existing areas as required for the new installation.
- .2 Add modules, switches, etc. in existing control panels, as required, to extend existing systems to new or renovated areas.
- .3 Patch and repair walls and ceilings in existing areas that have been damaged or cut open due to the new electrical installation.
- .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 WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements
- .2 Section 15400 Plumbing

1.2 PRODUCT DATA

- .1 Submit product data in accordance with Section 16010.

Part 2 Products

2.1 ELECTRIC HEATING CABLE - EXTERNAL TYPE

- .1 Supply all electric heating cable as shown on plan or as specified.

Part 3 Execution

3.1 INSTALLATION

- .1 Externally Installed Heat Trace Cable
 - .1 Install all electric heating cable where shown on plans or as specified. Distribute length evenly over a 10 foot section of pipe. Provide straps as required.
 - .2 Installations to be as recommended by the cable manufacturer. Provide a letter from the cable manufacturer confirming that all cables are installed as recommended.

END OF SECTION

Part 1 General

1.1 PRODUCT DATA

- .1 Submit product data in accordance with Section 16010.

Part 2 Products

2.1 DISCONNECT SWITCHES

- .1 Fusible and non-fusible disconnect switch in CSA Enclosure and size as indicated. To suit the environment (i.e. weatherproof, watertight, dust-tight, general purpose, etc.)
- .2 Provision for padlocking in on-off switch position by three locks.
- .3 Mechanically interlocked door to prevent opening when handle in ON position.
- .4 Fuses: size as indicated, to Section 16478 - Fuses - Low Voltage.
- .5 Fuseholders: suitable without adaptors, for type and size of fuse indicated.
- .6 Quick-make, quick-break action, heavy duty industrial grade.
- .7 ON-OFF switch position indication on switch enclosure cover.
- .8 Disconnects used for service entrances shall be approved service entrance switches.
- .9 Disconnects for two speed motors to be six pole. Refer to motor schedule and Drawings for two speed motors and provide a six pole disconnect switch for each two speed motor.
- .10 Disconnect switches located at motors connected to variable frequency drives are to be provided with one Form 'C' electrical contact to interlock from the disconnect to the VFD. The interlock is to operate prior to the main power contacts opening to the motor.

2.2 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
- .2 Indicate name of load controlled and voltage on size 6 nameplate.

Part 3 Execution

3.1 INSTALLATION

- .1 Install disconnect switches complete with fuses as indicated.
- .2 Install additional brackets, supports, etc. required for mounting the disconnect switches.

- .3 Install six pole disconnects at all two speed motors.
- .4 Provide conduit and wire to interlock between VFD and motor disconnect to power down VFD when motor disconnect is operated.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements
- .2 Section 16122 Wires and Cables

1.2 REFERENCES

- .1 Ground equipment to: CSA C22.2 No. 41.
- .2 Copper grounding conductors to: CSA G7.1.

Part 2 Products

2.1 EQUIPMENT

- .1 Grounding conductors system, circuit and equipment, grounding to be bare (or green insulated if indicated/required) stranded copper sized in accordance with the Canadian Electrical Code.
- .2 System and circuit, equipment, grounding conductors, bare stranded copper, tinned, soft annealed, size as indicated.
- .3 Insulated grounding conductors: green, type RW-90.
- .4 Non-corroding accessories necessary for grounding system, type, size, Material as indicated, including but not necessarily limited to:
 - .1 Grounding and bonding bushings.
 - .2 Grounding or bonding clamps. All grounding and bonding clamps shall be brass where attached to copper pipes. Clamps for other applications shall be of a type and Material that will minimize deterioration from galvanic action due to dissimilar metals.
 - .3 Bolted type conductor connectors.
 - .4 Thermit welded type conductor connectors.
 - .5 Bonding jumpers, straps.
 - .6 Pressure wire connectors.

Part 3 Execution

3.1 INSTALLATION GENERAL

- .1 Install complete permanent, continuous, system and circuit, equipment, grounding systems including, conductors, connectors, accessories, as indicated, to conform to requirements of local authority having jurisdiction over installation.
- .2 Install connectors in accordance with manufacturer's instructions.
- .3 Protect exposed grounding conductors from mechanical injury.
- .4 Use mechanical connectors for grounding connections to equipment provided with lugs. Soldered joints not permitted.
- .5 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.

- .6 Bond single conductor, metallic armoured cables to cabinet at supply end, and provide non-metallic entry plate at load end.
- .7 All conduit runs containing feeders and branch circuits shall be complete with an insulated green ground wire bonded to all outlet boxes, junction boxes, pull boxes, equipment enclosures, etc. The conduit system shall be continuous but shall not be relied on to serve as the equipment grounding means. Ground conductors shall be sized according to the Canadian Electrical Code, but shall be minimum #12 AWG. All locknuts and couplings shall be securely tightened. All flexible conduit shall include an insulated ground wire and shall be properly grounded through an approved fitting. A separate ground conductor shall be installed in all fibre, PVC or plastic duct runs and shall be connected to maintain the grounding of the system.

3.2 SYSTEM AND CIRCUIT GROUNDING

- .1 Install system and circuit grounding connections to neutral points of 600V and 208 V system.

3.3 EQUIPMENT GROUNDING

- .1 Install grounding connections to typical equipment included in, but not necessarily limited to following list. Service equipment, transformers, frames of motors, motor control centres, starters, control panels, panels.

3.4 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 16010.
- .2 Perform tests before energizing electrical system.
- .3 Disconnect ground fault indicator, if provided, during tests.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements

1.2 PRODUCT DATA

- .1 Submit product data in accordance with Section 16010.
- .2 Include time-current coordination characteristic curves for breakers.

Part 2 Products

2.1 BREAKERS GENERAL

- .1 Moulded case circuit breakers: 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 deg. C ambient.
- .3 Common-trip breakers: with single handle for multi-pole applications.
- .4 Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting. Trip settings on breakers with adjustable trips to range from 5-10 times current rating.
- .5 Circuit breakers with interchangeable trips as indicated.
- .6 Minimum Interrupting Ratings (RMS Symmetrical) unless otherwise indicated:
 - .1 120/208 Volts - 10,000 Amps
 - .2 347/600 Volts - 14,000 Amps

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.

2.3 SOLID STATE TRIP BREAKERS

- .1 Moulded case circuit breaker to operate by means of a solid-state trip unit with associated current monitors and self-powered shunt trip to provide inverse time current trip under overload condition, and long time, short time, instantaneous and ground fault tripping.
 - .1 Each breaker shall have the following independent and fully adjustable curve shaping characteristics:
 - .1 Adjustable long time pickup
 - .2 Adjustable long time delay
 - .3 Adjustable short time pickup
 - .4 Adjustable short time delay with selective curve shaping
 - .5 Adjustable instantaneous pickup
 - .6 Adjustable ground fault pickup
 - .7 Adjustable ground fault delay with selective curve shaping

2.4 MANUFACTURERS

- .1 To match existing.

Part 3 Execution

3.1 INSTALLATION

- .1 Install circuit breakers as indicated.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Section 16010 Electrical General Requirements

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section 16010.
- .2 Submit fuse performance data characteristics for each fuse type and size above 30 A. Performance data to include: average melting time-current characteristics, I_t(for fuse coordination), and peak let-through current.

1.3 MAINTENANCE MATERIALS

- .1 Provide maintenance materials in accordance with Section 16010.
- .2 Three spare fuses of each type and size installed above 600 A.
- .3 Six spare fuses of each type and size installed up to and including 600 A.

1.4 DELIVERY AND STORAGE

- .1 Ship fuses in original containers.
- .2 Do not ship fuses installed in switchboard.

Part 2 Products

2.1 FUSES GENERAL

- .1 Plug and cartridge fuses: to CSA C22.2 No. 59.
- .2 Fuse type references L1, L2, J1 etc. have been adopted for use in this specification.
- .3 Fuses: product of one manufacturer.

2.2 FUSE TYPES

- .1 HRC-L fuses (formerly Class L), motor loads:
 - .1 Type L1, time delay, capable of carrying 500% of its rated current for 10 s minimum.
- .2 HRCI-J fuses (formerly Class J), Panel loads:
 - .1 Type J1, time delay, capable of carrying 500% of its rated current for 10 s minimum.

Part 3 Execution

3.1 INSTALLATION

- .1 Install fuses in mounting devices immediately before energizing circuit.
- .2 Ensure correct fuses fitted to physically matched mounting devices.
- .3 Ensure correct fuses fitted to assigned electrical circuit.

END OF SECTION

Part 1 General

1.1 RELATED WORK SPECIFIED ELSEWHERE

- .1 Electrical General Requirements Section 16010

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with Section 01300 - Submittals.

Part 2 Products

2.1 MATERIALS

- .1 Components comprising ground fault protective system to be of same manufacturer.

2.2 BREAKER TYPE GROUND FAULT INTERRUPTER

- .1 Single or Two pole ground fault circuit interrupter for 15 to 40A, 120/240V, 1 phase circuit c/w test and reset facilities.

2.3 GROUND FAULT PROTECTOR UNIT

- .1 Self-contained with 15 A or 20 A, 120 V circuit interrupter and duplex receptacle complete with:
 - .1 Solid state ground sensing device.
 - .2 Facility for testing and reset.
 - .3 Flush mounted with stainless steel face plate.

Part 3 Execution

3.1 INSTALLATION

- .1 Do not ground neutral on load side of ground fault relay.
- .2 Pass phase conductors including neutral through zero sequence transformers.
- .3 Connect supply and load wiring to equipment in accordance with manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

- .1 Perform tests in accordance with Section 16010 - Electrical - General Requirements.
- .2 Submit report of tests to Consultant and a certificate that system as installed meets criteria specified herein. Include copies of report in maintenance manuals.
- .3 Demonstrate simulated ground fault tests.

END OF SECTION

Part 2 Products

2.1 MATERIALS

- .1 Starters: EEMAC E14-1.
 - .1 Half size starters not acceptable.
 - .2 Provide NEMA rated starters only; IEC rated starters are not acceptable.

2.2 MANUAL MOTOR STARTERS

- .1 Single and Three phase manual motor starters of size, type, rating, and enclosure type as indicated, with components as follows:
 - .1 Switching mechanism, quick make and break.
 - .2 Overload heaters, manual reset, trip indicating handle.
- .2 Accessories:
 - .1 Toggle switch labelled as indicated.
 - .2 Indicating light: type and colour as indicated.
 - .3 Locking tab to permit padlocking in "ON" or "OFF" position.
 - .4 Flush mounted type in public areas or as indicated.

2.3 FULL VOLTAGE MAGNETIC STARTERS

- .1 Magnetic of size, type, rating and enclosure type as indicated with components as follows:
 - .1 Contactor solenoid operated, rapid action type.
 - .2 Motor overload protective device in each phase, manually reset from outside enclosure.
 - .3 Power and control terminals.
 - .4 Wiring and schematic diagram inside starter enclosure in visible location.
 - .5 Identify each wire and terminal for external connections, within starter, with permanent number marking identical to diagram.
 - .6 Control transformer.
 - .7 Starters to be two speed where required; type to match requirement of motor provided by Division 15.
- .2 Accessories:
 - .1 Pushbuttons and Selector switches: labelled as indicated.
 - .2 Indicating lights: type and color as indicated.
 - .3 2-N/O and 2-N/C spare auxiliary contacts unless otherwise indicated.
 - .4 HOA selector switch.
 - .5 Two speed starters shall have individual Red run pilot lights for LOW and HIGH speed run indication.
 - .6 An adjustable 20 sec. - 3 min. time delay relay (set at 30 sec.) shall be installed in two speed starters. It shall function only during the transition from HIGH SPEED

to LOW SPEED where the motor will be in a de-energized state for a period of 30 seconds after initiation of this switching.

2.4 CONTROL TRANSFORMER

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

2.5 FINISHES

- .1 Apply finishes to enclosure in accordance with Section 16010 - Electrical - General Provisions.

2.6 EQUIPMENT IDENTIFICATION

- .1 Provide equipment identification in accordance with Section 16010 - Electrical - General Provisions.
- .2 Manual starter designation label, white plate, black letters, size 1, engraved as indicated.
- .3 Magnetic starter designation label, white plate, black letters, size 4 engraved as indicated.

2.7 MANUFACTURERS

- .1 Acceptable manufacturers: to match existing.
- .2 Manufacturer shall provide his industrial quality product line; commercial quality starters are not acceptable.

Part 3 Execution

3.1 INSTALLATION

- .1 Install starters, connect power and control as indicated.
- .2 Ensure correct fuses and overload devices elements installed.
- .3 All starters for two speed motors to be provided with six pole disconnect switches and wired with six conductors. Refer to motor schedule and Drawings for two speed motors.

3.2 TESTS

- .1 Perform tests in accordance with Section 16010 - Electrical - General Requirements and manufacturer's instructions.

- .2 Operate switches, contactors to verify correct functioning.
- .3 Perform starting and stopping sequences of contactors and relays.
- .4 Check that sequence controls, interlocking with other separate related starters, equipment, control devices, operate as indicated.
- .5 Ensure motor rotation corresponds with the direction required by the driven equipment.

END OF SECTION

MOTOR No.	NAME	LOCATION	H.P. (kW)	VOLTS	STARTER & ACC.				CIRCUIT	STARTER LOCATION	FEEDER	REMARKS
					MAN	MAG	PL	HOA				
CH-1	Chiller	Machine Rm	238 FLA	600/3ø					BSMT. 600V	SEE MECHANICAL DRAWING	SEE DRAWING	CONTROLS BY DIV. 15 302 AMP MINIMUM CIRCUIT AMPACITY 421 AMP MAXIMUM O/C PROTECTION
CT-1	Cooling Tower	Roof	15 HP	600/3ø					MECH. RM. MCC	SEE MECHANICAL DRAWING	SEE DRAWING	CONTROLS BY DIV. 15
AHU-1	Air Handling Unit	Machine Rm	2 HP	600/3ø		✓	✓	✓	MECH. RM. 600V	AT UNIT	SEE DRAWING	CONTROLS BY DIV. 15
EF-1	Exhaust Fan	Machine Rm	1.5 HP	600/3ø		✓	✓	✓	MECH. RM. 600V	AT UNIT	SEE DRAWING	CONTROLS BY DIV. 15