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## **ELECTRICAL GENERAL REQUIREMENTS**

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### **1. GENERAL**

#### **1.1 Work Included**

- .1 Complete and operational electrical system as required by the Drawings and as herein specified.

#### **1.2 Related Work**

- .1 General Requirements: Division 1
- .2 Site Work: Division 2
- .3 Concrete: Division 3
- .4 Process: Division 11
- .5 Mechanical: Division 15

#### **1.3 Drawings and Specifications**

- .1 The General Conditions, Supplementary Conditions, and Division 1 are a part of this Specification and shall apply to this Division.
- .2 The intent of the Drawings and Specifications is to include all labour, products, and services necessary for complete Work, tested and ready for operation.
- .3 Symbols used to represent various electrical devices often occupy more space on the Drawing than the actual device does when installed. In such instances, do not scale locations of devices from electrical symbols. Install these devices with primary regard for usage of wall space, convenience of operation and grouping of devices.
- .4 These Specifications and the Drawings and Specifications of all other Divisions shall be considered as an integral part of the accompanying Drawings. Any item or subject omitted from either the Specifications or the Drawings but which is mentioned or reasonably specified in and by the others, shall be considered as properly and sufficiently specified and shall be provided.
- .5 Provide all minor items and Work not shown or specified but which are reasonably necessary to complete the Work.
- .6 If discrepancies or omissions in the Drawings or Specifications are found, or if the intent or meaning is not clear, advise the Contract Administrator for clarification before submitting Bid.
- .7 Responsibility to determine which Division provides various products and Work rests with the Contractor. Additional compensation will not be considered because of differences in interpretation of Specifications.

## ELECTRICAL GENERAL REQUIREMENTS

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### 1.4 Quality Assurances

- .1 Codes, Rules, Permits and Fees
  - .1 Comply with all laws, ordinances, rules, regulations, codes, and orders of all authorities having jurisdiction relating to this Work.
  - .2 Comply with all rules of the Canadian Electrical Code, CSA Standard C22.1 and the applicable building codes. Do overhead lines in accordance with CAN/CSA-C22.3 No.1 and underground systems in accordance with CAN/CSA-C22.3 No.7 except where specified otherwise.
  - .3 Quality of Work specified and/or shown on the Drawings shall not be reduced by the foregoing requirements.
  - .4 Immediately after award of Contract and prior to installation, verify location, arrangement and point of attachment for service and service entrance equipment with supply authority and inspection departments. Failure to do so will render this Division responsible for any corrections necessary without additional compensation.
  - .5 Give all required notices, submit Drawings, obtain all permits, licences and certificates and pay all fees required for this Work.
  - .6 Furnish a Certificate of Final Inspection and approvals from inspection authority to the Contract Administrator.
- .2 Standard of Workmanship:
  - .1 Execute all Work in a competent manner and to present an acceptable appearance when completed.
  - .2 Employ a competent supervisor and a sufficient number of licensed tradesmen to complete the Work in the required time.
  - .3 Arrange and install products to fit properly into designated building spaces.
  - .4 Unless otherwise specified or shown, install products in accordance with recommendations and ratings of manufacturers.

### 1.5 Submittals

- .1 Within 30 days of award of Contract, the Contractor shall submit a completed equipment procurement schedule which lists the manufacturer and model of equipment, indicating the projected ordering, Shop Drawing submittal date and delivery dates of all products to meet the required construction schedule.
- .2 Submit samples as required where specified in Division 16.

## ELECTRICAL GENERAL REQUIREMENTS

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- .3 Prior to delivery of any products to jobsite and sufficiently in advance of requirements to allow ample time for checking, submit Shop Drawings for review as specified in Division 1. Submit Shop Drawings for all equipment as required in each Section of this Specification.
- .4 Prior to submitting the Shop Drawings to the Contract Administrator, the Contractor shall review the Shop Drawings to determine that the equipment complies with the requirements of the Specifications and Drawings.
- .5 The term "Shop Drawing" means drawings, diagrams, illustrations, schedules, performance characteristics, brochures and other data, which are to be provided by the Contractor to illustrate details of a portion of the Work.

Indicate materials, methods of construction and attachment of support wiring, diagrams, connections, recommended installation details, explanatory notes and other information necessary for completion of Work. Where equipment is connected to other equipment, indicate that such items have been coordinated, regardless of the section under which the adjacent items will be supplied and installed. Indicate cross references to Design Drawings and Specifications.

Adjustments made on Shop Drawings by the Contract Administrator are not intended to change the contract price. If adjustments affect the value of the Work state such in writing to the Contract Administrator prior to proceeding with the Work.

- .6 Manufacture of products shall conform to revised Shop Drawings.
- .7 Keep one (1) complete set of Shop Drawings at jobsite during construction.

### **1.6 As-Constructed Drawings**

- .1 The Contractor shall keep one (1) complete set of white prints at the Site office, including all addenda, change orders, Site instructions, clarifications, and revisions for the purpose of As-Constructed Drawings. As the Work on-site proceeds, the Contractor shall clearly record in Red Pencil all as-built conditions, which deviate from the original Contract Documents. As-Constructed Drawings to include circuiting of all devices, conduit and feeder runs (complete with conductor size and number) and locations of all electrical equipment.
- .2 Prior to Substantial Performance, the Contractor shall obtain CAD files of all electrical Drawings, using AutoCAD Release 2000i, and use the services of a competent CAD operator to transfer all as-constructed information, including: Change Orders, Clarifications, Revisions, Site Instructions and Shop Drawings. Upon completion, the Contractor shall certify, in writing, that the As-Constructed Drawings are complete and that they accurately indicate all electrical services, including exposed as well as concealed items.
- .3 On completion of the Work, two weeks prior to final inspection, submit As-Constructed Drawings to Contract Administrator for review.
- .4 Within one month after return of As-Constructed Drawings by the Contract Administrator, obtain and pay for a complete set of original reproducible sepias. Transfer all changes from As-Constructed Drawings to electronic Drawings (AutoCAD) and certify accuracy. Deliver electronic Drawings to the Contract Administrator.

## ELECTRICAL GENERAL REQUIREMENTS

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### 1.7 Operation and Maintenance Manuals

- .1 All maintenance manual data shall be submitted in an electronic format in accordance with the requirements of Division 1.
- .2 Within thirty days prior to Substantial Performance, the Contractor shall submit a draft copy of the proposed contents of each maintenance manual to the Contract Administrator for review. Once the draft copy is approved, the Contractor will supply four (4) copies in electronic format in accordance with the requirements of Division 1 Final copies of manuals to be received by Contract Administrator not less than seven days prior to Substantial Performance.
- .3 Each section of the manual shall contain the following information:
  - .1 Systems Descriptions. A brief synopsis of each system typed and inserted at the beginning of each section. Include sketches and diagrams where appropriate.
  - .2 Descriptive and technical data.
  - .3 Maintenance and operating instructions for all electrical equipment and controls. (These operating instructions need not be manufacturer's data but may be typewritten instructions in simple language to guide the City of Winnipeg (City) in the proper operation and maintenance of his installation.)
  - .4 Lubricating and servicing intervals recommended.
  - .5 A copy of all wiring diagrams complete with wire coding.
  - .6 List of spare parts of all electrical equipment complete with names and addresses of sales, service representatives and suppliers.
  - .7 Copy of test data.
  - .8 A motor list showing each motor number, name, horsepower, full load amps, overload settings, nameplate, current rating, heater size and type, and current being drawn, on the form specified in Section 16970.
  - .9 Include type and accuracy of instruments used to obtain test data.
  - .10 Copy of final inspection certificate.
  - .11 Copy of the purchase order, showing equipment make and model numbers issued to the manufacturer complete with all addenda. All cost details may be hidden.
  - .12 Copy of all warranty certificates.
  - .13 Set of final reviewed Shop Drawings.

## **ELECTRICAL GENERAL REQUIREMENTS**

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- .14 Names, addresses, phone numbers and facsimile numbers of Contractor, Contract Administrators, sub-contractors and suppliers used on the Work together with a Specification reference of the portion of the Work they undertook.

### **1.8 Product Handling**

- .1 Use all means necessary to protect the products of this Division before, during and after installation and to protect products and installed Work of all other trades.
- .2 Immediately make good any damage by repair or replacement at no additional cost to the City and to the approval of the Contract Administrator.
- .3 Remove advertising labels from all electrical equipment. Do not remove identification of certification labels.
- .4 Remove dirt, rubbish, grease, etc. resulting from this Work from all surfaces, including the inside of all cabinets, equipment enclosures, panelboard tubs, etc.

### **1.9 Guarantee**

- .1 Furnish a written guarantee to the City prior to final contract payment, which will be in effect for one year from the date of final acceptance of the complete Work. Replace or repair at no cost to the City any defective material or workmanship except where, in the opinion of the Contract Administrator, such defects are due to the misuse or neglect by the City.
- .2 This general guarantee shall not act as a waiver of any specified or special equipment guarantees, which cover a greater length of time.

### **1.10 Progress Claims**

- .1 Within thirty days after award of Contract, a breakdown of material and equipment items including labour and expense components shall be compiled on the consultant format. Subsequent request for payment shall be documented accordingly.

## **2. PRODUCTS**

### **2.1 Selected Products and Equivalent**

- .1 Products and materials provided shall be new and free from all defects. Defective products or materials will be rejected, regardless of previous inspections. The Contractor shall be responsible to remove and replace defective products at their expense, and shall be responsible for any resulting delays and associated expenses, which result from defective products being rejected. Related materials shall be of the same manufacturer throughout the project.
- .2 Products and materials referred to in the Specifications by trade names, manufacturer's name and catalogue reference are those, which shall be used as the basis for the Bid.

## **ELECTRICAL GENERAL REQUIREMENTS**

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- .3 The design has been based on the use of the specified product.

### **2.2 Quality of Products**

- .1 All products provided shall be CSA approved, UL approved where applicable, and new, unless otherwise specified.
- .2 If products specified are not CSA approved, obtain special approval from the local regulatory authority. Pay all applicable charges levied and make all modifications required for approval.
- .3 Products provided, if not specified, shall be new, of a quality best suited to the purpose required and their use subject to approval by the Contract Administrator.

### **2.3 Uniformity of Manufacture**

- .1 Unless otherwise specifically called for in the Specifications, uniformity of manufacture shall be maintained for similar products throughout the Work.

### **2.4 Product Finishes**

- .1 Finish all cabinets, panelboards, switchboards, equipment cabinets, cable trays, etc. in ANSI 61 grey enamel unless otherwise specified.
- .2 Apply primer on all items, which are to be finished on the job.
- .3 Touch up all damaged painted finishes with matching lacquer, or, if required by the Contract Administrator, completely repaint damaged surface.

### **2.5 Use of Products during Construction**

- .1 Any equipment used for temporary or construction purposes shall be approved by the Construction Manager and in accordance with the General Conditions, "Use of Premises." Clean and restore to "as new" condition all equipment prior to the time of Substantial Completion.
- .2 The warranty period shall not begin until the date of Substantial Performance of the Work.

### **2.6 Non-Specific Date/Time Compliance**

- .1 All equipment, hardware, software and firmware (for the purposes of this clause, the "Product") delivered or deliverables resulting from any services provided are fully Date Compliant and the product will not adversely or materially effect the daily business operations as a result of a date related computer problem (for the purposes of this clause, the "Warranty"). Date Compliant means that the product accurately and correctly processes and stores date/time data (including, but not limited to, calculating, comparing, displaying, recording and sequencing operations) including year, century and leap year calculations.
- .2 Provide documentary proof of Date Compliance prior to Substantial Completion listing all equipment and certifying their compliance.



## **ELECTRICAL GENERAL REQUIREMENTS**

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- .3 Notwithstanding any other remedy available under this agreement or at law for breach of the warranty, any product that is not Date Compliant shall, within 24 hours of receipt of notice of the breach, be repaired or replaced at the Contractor's sole cost and expense, including parts, labour, transportation and insurance, so as to correct any failure to meet the warranty.

### **3. EXECUTION**

#### **3.1 Site Examination**

- .1 Examine the Site of Work and become familiar with all features and characteristics affecting this Work before submitting Bid.
- .2 No additional compensation will be given for extra Work due to existing conditions which such examination should have disclosed.
- .3 Report to the Contract Administrator any unsatisfactory conditions which may adversely affect the proper completion of this Work.

#### **3.2 Location of Outlets and Luminaires**

- .1 Electrical Drawings are, unless otherwise indicated, drawn to scale and approximate distances and dimensions may be obtained by scaling. Figured dimensions shall govern over scaled dimensions. Where exact dimensions and details are required, refer to architectural and structural Drawings.
- .2 Outlet and equipment locations shown on the Drawings are approximate. Locations may be revised up to 3 m to suit construction and equipment arrangements without additional cost to the City, provided that the Contractor is notified prior to the installation of the outlets, or equipment.
- .3 Maintain luminaire locations wherever possible. Notify the Contract Administrator of conflicts with other services.
- .4 Unless otherwise specified or shown, install products in accordance with recommendations and ratings of manufacturers.

#### **3.3 Separation of Services**

- .1 Maintain separation between electrical wiring system and building piping, ductwork, etc. so that wiring system is isolated (except at approved connections to such systems) to prevent galvanic corrosion.
- .2 In particular, contact between dissimilar metals, such as copper and aluminum, in damp or wet locations is not permitted.
- .3 Do not support wiring from pipes, ductwork, etc. Hangers for suspended ceilings shall not be used for the support of wiring.

**ELECTRICAL GENERAL REQUIREMENTS**

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**3.4 Equipment Identification**

- .1 3 mm thick plastic lamacoid name plates, black face, white core, mechanically attached with self tapping screws, to be attached to the front face of the following equipment:

**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

- .1 Distribution Centres (indicate designation, bus capacity, voltage)
- .2 MCCs (designation, voltage)
- .3 Starters, contactors, disconnects (designation, voltage, load controlled)
- .4 Panelboard (designation, voltage, bus capacity)
- .5 Automatic transfer switch (designation, voltage, rating)
- .6 Terminal cabinets and pull boxes (system, voltage)
- .7 Transformers (designation, capacity, primary and secondary voltage)
- .2 Color code exposed conduits (including conduits above T-bar ceilings), junction and pull boxes, and metallic sheathed cables with paint or plastic tape (25 mm wide band) at 15 m intervals. Color coding to be as follows:

<b>SYSTEM</b>	<b>MAJOR BAND</b>	<b>MAJOR BAND</b>
High Voltage	Yellow	Purple
347/600 V Normal	Dk. Blue	
120/208 V Normal	Lt. Blue	
UPS System	Lt. Blue	White
Fire Alarm System	Red	
Communication Circuits	Black	Yellow

- .3 Provide neatly typed circuit directories in panelboards to indicate the area or equipment controlled by each branch circuit.
- .4 All conductors shall be identifiable by coloured insulation and permanent markers at every terminal and accessible points throughout its entire run.

## **ELECTRICAL GENERAL REQUIREMENTS**

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### Conductors:

Equipment Grounding – Green  
Neutral Conductor – White

#### 347/600 Volt System

Phase A – Orange  
Phase B – Brown  
Phase C – Yellow

#### 120/208 Volt System

Phase A – Red  
Phase B – Black  
Phase C – Blue

### **3.5 Wiring to Equipment Supplied by Others**

- .1 Equipment supplied by the City or under other Divisions will be moved to the installation Site by others. However, the electrical connection to the equipment shall be done by this Division.

### **3.6 Testing**

- .1 Refer to Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems.

### **3.7 Single Line Diagram**

- .1 Provide and mount a framed As-Constructed single line diagram to be located adjacent to the main electrical equipment. Use a clear plexiglass cover. The diagram shall be 914 mm x 600 mm minimum, CAD produced drawing.

### **3.8 Instructions to City's Personnel**

- .1 Refer to Section 16990 - Electrical Equipment and Systems Demonstration and Instruction.

### **3.9 Access Panels**

- .1 Where electrical equipment, junction boxes, remote ballasts or the like are concealed, access panels shall be supplied. Panels shall be of adequate size for servicing of the electrical Work and complete with necessary frames and hinged doors held closed with captive fasteners. Coordinate type and size of panels with the Contract Administrator.
- .2 In removable ceiling areas, provide markers on ceiling tile to locate equipment requiring access. Markers shall be of a type approved by the Contract Administrator.

### **3.10 Mounting Heights**

- .1 Unless a conflict exists, use the following as mounting heights from finished floors to centre of device.

## **ELECTRICAL GENERAL REQUIREMENTS**

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Thermostats	1400 mm
Panelboards, starters, and disconnects (to top of cover)	2000 mm
End of line resistors	1800 mm
Receptacles	1400 mm
Light Switches	1400 mm
Fire Alarm Manual Stations	1400 mm
Fire Alarm Bells	2100 mm
Telephone outlet	1400 mm

### **3.11 Sealing of Wall and Floor Openings**

- .1 All conduit and cable entries through outside walls of buildings, through partition walls separating electrical rooms from other areas, through fire separations, and through floors above grade shall be sealed to prevent passage of moisture, dust, gasses, flame, or to maintain pressurization.
- .2 Openings shall be sealed when all wiring entries shown on the Drawings have been completed.
- .3 Sealing material shall be fire resistant and shall not contain any compounds, which will chemically affect the wiring jacket or insulating material. Cable penetrations through fire separations to be sealed.

### **3.12 Housekeeping Pads**

- .1 All floor-mounted electrical equipment installed by this Division shall be mounted on concrete housekeeping pads that, unless otherwise noted, shall be the responsibility of the Contractor.
- .2 The Contractor shall determine the extent of the housekeeping pads required and supply all information and details as to size and locations to the Contract Administrator within 30 days after the award of Contract.

### **3.13 Sleeves**

- .1 Provide sleeves of galvanized steel pipe with machine cut ends of ample size to accommodate conduits passing through walls, partitions, ceilings, floors, etc.
- .2 For wall, partitions and ceilings the ends shall be flush with the finish on both sides but for floors they shall extend 100 mm above finished floor level.
- .3 The space between the sleeve and the conduit shall be filled with Dow Corning silicone room temperature vulcanizing (RTV) foam for fire stop and caulked around the top and bottom with approved permanently resilient, non-flammable and weatherproof silicone base compound. Ensure that the seal is compatible with the floor and ceiling finishes.
- .4 Locate and position sleeves exactly prior to construction of walls, floors.
- .5 Failure to comply with the above requirements shall be remedied at this Division's expense.

## **ELECTRICAL GENERAL REQUIREMENTS**

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### **3.14 Temporary Lighting and Power**

- .1 Provide grounded extension cords and temporary lights as required for electrical Work.
- .2 Coordinate with General Contractor for obtaining temporary power service.
- .3 If City's operations will be affected by any power outage required for this Work, give adequate notice to the City and do not interrupt power until approval has been obtained.
- .4 Give adequate notice to Contractor of any power outage required for this Work. Schedule outages to provide least interference with other Work.

### **3.15 Insulation Resistance Testing**

- .1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.
- .2 Megger 350 to 600 V circuits, feeders and equipment with a 1000 V instrument.
- .3 Check resistance to ground before energizing.
- .4 Carry out tests in presence of the Contract Administrator.
- .5 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.
- .6 Submit test results for the Contract Administrator's review.

### **3.16 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 (maximum deviation of 15 percent).
- .2 Measure phase voltages at loads and adjust transformer taps to within 2 percent of rated voltage of equipment.
- .3 Submit, at completion of Work, report listing phase and neutral currents on panelboards, dry-core transformers and motor control centres, operating under normal load. State hour and date on which each load was measured, and voltage at time of test.

**END OF SECTION**

## SCOPE OF ELECTRICAL WORK

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### 1. GENERAL

- .1 Supply and install all material, equipment, wiring and labour necessary for the installation of the systems detailed on the Drawings in accordance with the latest edition of the Canadian Electrical Code.

### 2. WORK INCLUDED

#### 2.1 Related Work

- .1 The Administrative Sections under Division 0 (Bidding and Contract Requirements) and 1 (General Requirements) shall be considered to be part of these Specifications.

#### 2.2 General Requirements

- .1 General clean-up
- .2 All inspection and obtaining all permits, licenses required by various Inspection Agencies and local regulations related to Electrical Trade.
- .3 Scaffolding
- .4 Shop Drawings
- .5 Project Record Documents (As-constructed Drawings) where specified
- .6 Operating and Maintenance (O&M) Data, where specified

#### 2.3 Specific Requirements Included But Not Limited to Scope of Work

- .1 Secondary Electrical Room
  - .1 Modifications to LBT17:
    - .1 Remove existing 5 kV cable, connected to switch unit presently feeding Cryogenic Oxygen Plant. Coil existing cable in tray below existing switch for future use. Maintain and protect the existing cable lugs and stress cones.
    - .2 Provide new 5 kV feeder from existing switch LBT17 to feed new transformer at Nitrogen Removal facility. Cable shall be installed in existing tray in floor below Switch LBT17, install through south wall and install in PVC duct bank to Nitrogen Removal Facility transformer.
    - .3 This contractor shall replace the existing LBT17 fuse from a 200E to a 300E fuse. Provide a new 300E fuse. Existing 200E fuse shall be removed and turned over to the Contract Administrator.

### SCOPE OF ELECTRICAL WORK

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- .2 Provide a redundant 5 kV cable from Secondary Electrical Room to redundant transformer at Nitrogen Removal Facility. Provide lugs and stress cone to allow quick connection to switch gear. Provide a minimum of 15 m of cable in tray below Secondary Electrical Room Switch LBT17.
- .3 Provide a PVC direct buried PVC duct bank from the Secondary Electrical Room to the transformers at Nitrogen Removal Facility as indicated on the Drawings and hereafter specified.
- .4 Provide two (2) 1.5 MVA Pad Mount Oil Filled Transformers, TC-1 and TC-2, at Nitrogen Removal Facility and terminate 5 kV cables from Secondary Electrical Room to primary side of transformers. Primary voltage shall be 4160 and secondary shall be 347/600 V 3-phase/ 4 wire. Transformers shall be located on concrete pad of suitable size for the two transformers.
- .5 Provide 2000 A bus duct from each transformer to the Main Distribution, CMD-1 and CMD-2. Bus duct shall be suitable to exit out the top of the transformers and enter into the top of each of the two (2) distributions. Refer to Drawings and Specification for details.
- .6 Provide 600 A 3-phase 3 wire 2000 A distributions to services the Nitrogen Facility. Distribution shall be split with two (2) main breakers, one (1) tie breaker and distribution breakers as identified on the Drawings and hereafter specified.
- .7 Provide surged protection on each side of the main distribution and indicated on the Drawings and hereafter specified.
- .8 Provide 600 V and 120/208 V panels and indicated on the Drawings and hereafter specified. Panels shall be complete with breakers as indicated on the panel legends.
- .9 Provide 600-120/208V 3-phase 4wire dry type transformers with kVA sized as indicated on the Drawings and hereafter specified.
- .10 Provide wiring and connections to VFD units that will be supplied under Division 11 and Division 15. All filters (both line and load) shall be installed by this Contractor and be supplied with each VFD to match the VFD and associated motor.
- .11 Provide split wired Motor Control Center (1C and 2C) complete with split bus and tie molded case breaker. MCC bus to be sized as indicated on the drawings and hereafter specified. Provide starters as indicated on the MCC Schedule.
- .12 Provide disconnect wiring and connection to all motors and power related equipment as indicated on the Drawings and specified hereafter. All exterior disconnect switched shall be weatherproof.
- .13 Provide all lighting, lighting controls and general power as indicated on the Drawings and specified hereafter.

## SCOPE OF ELECTRICAL WORK

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- .14 Provide welding outlets, to accommodate City of Winnipeg portable welders, as indicated on the Drawings and hereafter specified. New welding outlets shall be suitable to match existing plant welders.
- .15 Provide all cabling required making a complete and operational facility. Provide raceway systems to allow complete installation for all cables. Refer to Cable Schedule and Raceway Schedule In the Specification.
- .16 Provide a complete Fire Alarm System as specified herein and indicated on the Drawings. System shall be connected to the Main Administration Building Server Room. Provide copper wire connection with the ability to be upgraded to fiber cable. Final connections shall be determined on-site. Fire Alarm Panel shall be complete fiber cable adapters.
- .17 Provide a Security System consisting of door switches and motion detectors. Signal from these devices to be terminated in the Nitrogen Removal Control Panel and be extended to Administration Building Server Room. Final connection location shall be determined on site.
- .18 Provide a CCTV System complete with cameras, transmission coax cable and power supplies as require for a complete system. Camera coax cables shall be terminated in the Nitrogen Removal Control Panel and extended to the Administration Building Server Room. Final connection in Server Room shall be determined on-site.
- .19 Refer to Division 17 and provide all wiring associated with control devices as indicated in this Specification and indicated on the Drawings.
- .20 Provide complete primary and secondary grounding as herein specified and indicated on the Drawings. All ground shall comply with the Canadian Electrical Code and local amendments to this code.

### 2.4 Additional Requirements

- .1 Provision of all necessary testing, detailed wiring continuity checks, wiring completion checks, installation integrity checks, functional equipment operation checks and written system verification reports to provide a complete system that is ready for commissioning and startup (refer also to Section 16980).
- .2 Provision of commissioning and startup of all systems included in the Scope of Work.

### 2.5 Materials

- .1 Bus systems including all forms of buses integral with the electrical power system, together with their associated insulation, supports, bus ducts and protective devices.
- .2 Conductors, including all types of wires, conductors, cables, which form an integral part of the electrical power system.
- .3 Cables and bus support systems which are intended to enclose or support all forms of electrical conductors used for any purpose covered by this scope. This includes cable trays,



## SCOPE OF ELECTRICAL WORK

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raceways and all forms of rigid, flexible, metallic and non-metallic conduit, and including conduit for communication systems or others, which may be installed at a later date, or buried conduit for wiring work by others, only when such buried conduit is indicated in the Contract Documents.

- .4 Control panels associated with any electrical equipment covered under this Section of Work unless otherwise noted.
- .5 Circuit breakers of all types and for all applications associated with electrical equipment, which receives its power supply from the main, auxiliary or emergency (including battery) system.
- .6 Grounding systems, as required by the Canadian Electrical Code, or as otherwise specified in the Bid Documents.
- .7 Control and instrumentation systems - electrical or electronic including high frequency, ultra high frequency and microwave control and instrumentation systems, with auxiliary equipment and components, unless specified otherwise.
- .8 Transformers of various types, dry, encapsulated etc., and for all applications, except control transformers supplied with Mechanical Equipment included in Division 15.
- .9 Electronic data processing and transmission systems, including auxiliary equipment, interface and components.

### **3. WORK EXCLUDED**

#### **3.1 Specific Exclusions**

- .1 Supply of VFDs associated with Process equipment specified in Division 11.
- .2 Supply of VFDs associated with Mechanical (HVAC) equipment in Division 15.

#### **3.2 Other Work Excluded**

- .1 Special starters, including multi-speed switches, which are associated with packaged units not detailed in the Electrical Specifications.
- .2 Perforations through roofing materials for electrical servicing or attachments (Division 7)
- .3 Painting (on-site), except touch-up of electrical equipment (Division 9)
- .4 Ducted fans (Division 15)
- .5 Ducted heaters (Division 15)
- .6 Pneumatic tube systems (Division 15)

## SCOPE OF ELECTRICAL WORK

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- .7 Control transformers supplied with Mechanical Equipment (Division 15)
- .8 All control wiring between equipment supplied by Division 15 HVAC system will be performed by Division 17.

### 4. UNITS OF MEASUREMENT

#### 4.1 General

- .1 The Contract Documents have been prepared using the modified International System (SI) units of metric measurement. Whenever appropriate, available metric products shall be used unless otherwise specified herein.
- .2 Only metres (m) and millimetres (mm) are used. Generally, metres are used for measurements of 10 m or more, and millimetres for measurements less than 10 m.
- .3 All measurements on Drawings are in millimetres unless otherwise indicated.

#### 4.2 Conversions

- .1 The following three (3) conversion methods were used in product and location dimensions:
  - .1 Hard Conversion: industry available products which are manufactured in metric measurements.
  - .2 Soft Conversion: products which are still manufactured in Imperial units and are converted in Specifications using arithmetic conversion factors.
  - .3 Rationalized Conversion: dimensions which are soft converted and rounded off for ease of measurements.
- .2 In cases where measurements may be open for interpretation, dual dimensions have been incorporated until hard conversions can be used exclusively.

### 5. DEFINITIONS

#### 5.1 General

- .1 All terminologies, abbreviations, and acronyms used in this Document are as listed in the various Standards, Codes, Rules, and Bulletins used herein.

**SCOPE OF ELECTRICAL WORK**

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**6. CODES**

**6.1 General**

- .1 All Codes, Standards, Rules, Regulations, Bulletins, By-laws etc., shall be those that are currently enforced in the locality of jobsite, unless otherwise specified herein.

**END OF SECTION**

## **INSTALLATION OF CABLES IN TRENCHES AND IN DUCTS**

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### **1. GENERAL**

#### **1.1 Related Work**

- .1 Excavation and Backfilling: Division 2

### **2. PRODUCTS**

#### **2.1 Cable Protection**

- .1 Provide 600 x 600 x 50 concrete patio blocks above directed buried duct banks. Patio blocks to be colored RED for identification.

#### **2.2 Markers**

- .1 Concrete type cable markers: 600 x 600 x 100 mm with words "cable", "joint" or "conduit" impressed in top surface, with arrows to indicate change in direction of cable and duct runs.

### **3. EXECUTION**

#### **3.1 Direct Burial of Cables**

- .1 After sand bed specified in Division 2 is in place, lay cables maintaining 75 mm clearance from each side of trench to nearest cable. Do not pull cable into trench.
- .2 Provide offsets for thermal action and minor earth movements. Offset cables 150 mm for each 60 m run, maintaining minimum cable separation and bending radius requirements.
- .3 Make termination and splice only as indicated leaving 0.6 m of surplus cable in each direction.
  - .1 Make splices and terminations in accordance with manufacturer's instructions using approved splicing kits.
- .4 Underground cable splices not acceptable.
- .5 Minimum permitted radius at cable bends for rubber, plastic or lead covered cables, 8 times diameter of cable; for metallic armoured cables, 12 times diameter of cables or in accordance with manufacturer's instructions.
- .6 Maintain 75 mm minimum separation between cables of different circuits. Maintain 300 mm horizontal separation between low and high voltage cables. When low voltage cables cross high voltage cables maintain 300 mm vertical separation with low voltage cables in upper position. At crossover, maintain 75 mm minimum vertical separation between low voltage cables and 150 mm between high voltage cables. Maintain 300 mm minimum lateral and vertical separation for fire alarm and control, cables when crossing other cables, with fire alarm and control cables in upper position. Install treated planks on lower cables 0.6 m in each direction at crossings.

## **INSTALLATION OF CABLES IN TRENCHES AND IN DUCTS**

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- .7 After sand protective cover specified in Division 2 is in place, install continuous row of concrete patio as indicated to cover length of run.

### **3.2 Cable Installation in Ducts**

- .1 Install cables as indicated in ducts.
- .2 Do not pull spliced cables inside ducts.
- .3 Install multiple cables in duct simultaneously.
- .4 CSA-approved lubricants of type compatible with cable jacket to reduce pulling tension.
- .5 To facilitate matching of colour coded multiconductor control cables reel off in same direction during installation.
- .6 Before pulling cable into ducts and until cables properly terminated, seal ends of lead covered cable with wiping solder; seal ends of non-leaded cables with moisture seal tape.
- .7 After installation of cables, seal duct ends with duct sealing compound.

### **3.3 Markers**

- .1 Mark cable every 30 m along cable or duct runs and changes in direction or as indicated on the Drawings.
- .2 Where markers are removed to permit installation of additional cables, reinstall existing markers.
- .3 Install concrete patio type markers.
- .4 Lay concrete markers flat and centered over cable with top flush with finish grade.

### **3.4 Field Quality Control**

- .1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems.
- .2 Perform tests using qualified personnel. Provide necessary instruments and equipment.
- .3 Check phase rotation and identify each phase conductor of each feeder.
- .4 Check each feeder for continuity, short circuits and grounds. Ensure resistance to ground of circuits is not less than 50 megohms.
- .5 Pre-acceptance test.
  - .1 After installing cable but before splicing and terminating, perform insulation resistance test with 5000 V megger on each phase conductor.

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**INSTALLATION OF CABLES IN TRENCHES AND IN DUCTS**

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- .2 Check insulation resistance after each splice and/or termination to ensure that cable system is ready for acceptance testing.
- .6 Acceptance Tests
  - .1 Ensure that terminations and accessory equipment are disconnected.
  - .2 Ground shields, ground wires, metallic armour and conductors not under test.
  - .3 High Potential (Hipot) Testing.
    - .1 Conduct Hipot testing at 200 percent of original factory test voltage in accordance with manufacturer's or IPCEA recommendations.
  - .4 Leakage Current Testing.
    - .1 Raise voltage in steps from zero to maximum values as specified by IPCEA manufacturer for type of cable being tested.
    - .2 Hold maximum voltage for specified time period by IPCEA or manufacturer.
    - .3 Record leakage current at each step.
  - .5 Provide Contract Administrator with list of test results showing location at which each test was made, circuit tested and result of each test.
  - .6 Remove and replace entire length of cable if cable fails to meet any of test criteria.

**END OF SECTION**

**DIRECT BURIED UNDERGROUND CABLE DUCTS**

---

**1. GENERAL**

**1.1 Work Included**

- .1 Provide complete system of underground ducts, fittings and turn-ups for the installation indicated on the Drawings.

**1.2 Related Work**

- .1 Excavation and backfilling: Division 2
- .2 Concrete Work: Division 3
- .3 Plumbing and Drainage: Division 3

**2. PRODUCTS**

**2.1 Rigid PVC Duct**

- .1 Duct: rigid non-metallic conduit of unplasticized polyvinyl chloride type DB-2 heavy wall for direct burial without concrete encasement, conforming to CSA Standard B196.1, manufactured by Canron Plastics Ltd. Nominal length 6 m  $\pm$ 12 mm with minimum wall thickness at any point of 3.0 mm.
- .2 Accessories: bell ends, couplings, reducers, plugs, caps, adaptors, bends, and other fittings of same materials as duct. Use solvent weld compound as recommended by manufacturer. Horizontal, vertical and foundation spacers as manufactured by Pilgrim Products Ltd.
- .3 Expansion joints every 100 m and as required.

**2.2 Cable Pulling Equipment**

- .1 6 mm stranded nylon pull rope tensile strength 5 kN.

**2.3 Duct Spacers**

- .1 Plastic spacers to suit installation shown, manufactured by Pilgrim Products Ltd.

**2.4 Markers**

- .1 Concrete type cable markers: As indicated, with words; "cable", "joint" or "conduit" impressed in top surface, with arrows to indicate change in direction of duct runs.

**3. EXECUTION**

- .1 Install underground ducts for wiring systems as shown on the Drawings and as per Manufacturer's instructions.

**DIRECT BURIED UNDERGROUND CABLE DUCTS**

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- .2 Clean inside of duct before laying.
- .3 Provide a separate green insulated copper ground wire in all ducts, even if not shown. Use Canadian Electrical Code to size ground wire.
- .4 Furnish minimum of 85 percent of total footage of each size in standard lengths of 6 m or 3 m. Remainder of each size may be furnished in random lengths, but not less than 1.5 m.
- .5 Arrange ducts in horizontal layers separated by plastic spacers to provide horizontal and vertical spacing between duct centres, as shown on Drawings. Stack spacers vertically above each other and install in at least two groups per 3 m length of duct.
- .6 Support duct bank on plastic foundation spacers on same centre lines as tier separators. Foundation spacers to maintain at least 75 mm clearance between ducts and trench bottom or mud mat. Ensure full, even support every 1.5 m throughout duct length.
- .7 Make joints with tapered couplings to provide a secure watertight connection. At locations where coupling is loosely fitted to produce a slight change of direction of the duct run, thoroughly waterproof joint with a coating of solvent compound. Stagger all joints to provide 200 mm vertical and horizontal clearance between adjacent couplings. Where needed, use bender to provide bends of radius required.
- .8 Make bell and spigot joints. Drive ducts together as recommended by manufacturer to produce a solid watertight connection. Stagger all joints to provide 200 mm vertical and horizontal clearance between adjacent couplings. Where needed, use manufactured bends to provide bends of radius required.
- .9 Use adaptors and connect duct to a 90 degree rigid, heavy-wall, steel conduit bend where conduit rises above ground.
- .10 Terminate ducts with standard bell ends where ducts enter manholes, cable pits, junction boxes and building interiors.
- .11 Pull through each duct wooden mandrel not less than 300 mm long and of diameter 6 mm less than the internal diameter of duct, following by stiff bristle brush to remove sand, earth and other foreign matter. Pull stiff bristle brush through each duct immediately before pulling in cables.
- .12 In each duct install pull rope continuous throughout each duct run with 3 m spare rope at each end.
- .13 Plug ends of unused spare ducts with plugs of same material as ducts.
- .14 Seal all joints in ducts with solvent cement.
- .15 Install marker as required.
- .16 Ensure lines and levels for underground ducts are set to obtain proper drainage, coverage, separation, etc. Ensure such conditions are met prior to proceeding with the Work.



**DIRECT BURIED UNDERGROUND CABLE DUCTS**

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- .17 Construct duct runs to provide at least 750 mm from top of concrete encasement to finished surface above. Grade duct runs between manholes, vaults, cable pits and buildings to ensure proper drainage. Minimum slope shall be 75 mm per 30 m. Provide grades and slopes shown on Drawings. Depths of cover shown on electrical Drawings are minimum; greater depths may result from grading of ducts.
- .18 Install ducts in accordance with additional requirements of utility or service company having jurisdiction.
- .19 For each duct run, install a 2/0 bare copper ground wire in sand. Connect to main ground bus.

**END OF SECTION**

**CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS**

---

**1. GENERAL**

**1.1 Work Included**

- .1 Provide a complete system of conduit and fittings for installation of wiring.

**2. PRODUCTS**

**2.1 Rigid Steel Conduit**

- .1 Galvanized with threaded joints and connections.
- .2 Connections in dry locations: steel or malleable iron locknuts inside and outside enclosures. Insulated bushings Thomas & Betts Series 222 or approved alternate.
- .3 Connectors subjected to moisture interior and exterior: liquid and dust tight with insulated throat, Thomas & Betts "Bullet Hub" 370 Series or approved alternate.
- .4 Fittings: cast metal "Condulet" as manufactured by Crouse-Hinds Canada Ltd. including gasketed covers in damp locations.
- .5 Expansion joints: cast metal Crouse-Hinds type XJ or approved alternate.

**2.2 Flexible Conduit**

- .1 Connectors: Slip-proof, insulated throat or non-metallic bushings, steel, Thomas & Betts Ltd. "Tite-Bite", Series 300.

**2.3 Liquid-Tight Flexible Conduit**

- .1 Conduit: Flexible metal conduit with liquid-tight PVC jacket. Industrial Wire & Cable "Liquiseal".
- .2 Connectors: Captive sealing jacket and ground cone insulated throat, steel (Thomas & Betts Ltd. "Super-Tight", Series 6000).

**3. EXECUTION**

**3.1 Rigid Steel Conduit**

- .1 Use as raceways for following applications:
  - .1 In all areas exposed to weather.
  - .2 In all areas where Teck cable is not used.

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**CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS**

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- .3 For all fire alarm circuits and related wiring.
- .4 For all lighting and receptacle power distribution.
- .5 For all computer communication wiring.

**3.2 Flexible Conduit**

- .1 Use as raceways for following applications:
  - .1 Connections to motors in dry locations.
  - .2 Flexible connections to luminaries.
- .2 Provide a separate insulated ground wire in all flexible conduits.

**3.3 Liquid-Tight Flexible Conduit**

- .1 Use as raceways for following applications:
  - .1 At all motors, pipe mounted control devices, and other devices subject to movement or water.
  - .2 At all motors provide a short length before connecting to the motor terminal box. Minimum length shall be 450 mm plus four (4) times the conduit diameter.
  - .3 Provide a separate ground wire within flexible conduit, bonded to motor frames and system ground.

**3.4 Workmanship**

- .1 Install all conduit and wiring concealed, unless otherwise shown on the Drawings. Do not recess conduit in columns, except as noted, without permission.
- .2 Where conduit is run exposed, run parallel to building lines. Where conduits are grouped (two (2) or more), space evenly, make bends concentric and mount on Unistrut racks.
- .3 Lay out conduit to avoid interference with other Work. Maintain a minimum clearance of 150 mm from steam or hot water piping, vents, etc.
- .4 Organize conduit in slabs to minimize crossovers.
- .5 Where conduits or ducts enter or exit concrete structures below grade provide 16 mm x 1500 mm steel reinforcing dowels to prevent shearing. Extend dowel 1000 mm beyond concrete and band conduit to dowel. The first 3 m length of conduit extending from the structure to be Polykin wrapped rigid steel.

**CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS**

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- .6 Where steel conduit is required to be bent, do not heat, and do not bend conduit in such a way as to reduce pipe cross Section area at any point. Radii of bends shall be as per Canadian Electrical Code.
- .7 For all runs of conduits, do not include more than equivalent of four quarter bends. Provide conduit fittings, pullboxes and junction boxes where necessary. Pulling elbows shall not be used except by special permission.
- .8 Where possible, install conduits so that they are not trapped, cap turned up conduits to prevent the entrance of dirt or moisture during construction. Swab out conduit and thoroughly clean internally before wires and cables are pulled.
- .9 Take extreme care in reaming ends of all conduit to ensure a smooth interior finish that will not damage the insulation of the wires.
- .10 Use insulated non-metallic bushings on all conduit terminations.
- .11 Ensure electrical continuity in all conduit systems.
- .12 All conduit shown exposed in finished areas is to be free of unnecessary labels and trade marks.
- .13 Install a 90 lb. test line in all conduits left empty by this Contractor including those which others will pull cables, wires, etc.
- .14 Conduits and ducts crossing building expansion joints shall have conduit expansion fittings to suit the type of conduit used, and shall be Crouse-Hinds, Sceptre, or approved fitting.
- .15 Seal conduits with duct seal where conduits are run between heated and unheated areas. Where conduits, cables, or cable trays pierce fire separations, seal openings with Dow Corning 3-6548 sealant or approved equal.
- .16 Where conduits pass through walls, they shall be grouped and installed through openings. After all conduits shown on the Drawings are installed, wall openings shall be closed with material compatible with the wall construction. Review size and quantity of conduit sleeves with the Contract Administrator.
- .17 Where Drawings show conduit designations, these conduits shall be identified at each point of termination with Thomas & Betts "Ty-Rap" No. TY532M labels.
- .18 Where conduit finish is damaged, repair or replace.
- .19 Use "Condulet" fittings for power and telephone type conduit terminations in lieu of boxes where support is not provided.
- .20 All branch circuit wiring, home-runs, communication and data to be minimum 20 mm diameter unless otherwise stated.

**CONDUITS, CONDUIT FASTENINGS AND CONDUIT FITTINGS**

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- .21 Provide necessary flashing and pitch pockets, making watertight joints where conduits pass through roof or watertight membranes.
- .22 Where panel board branch circuit conduits are amalgamated, size shall not exceed 25 mm diameter.

**END OF SECTION**

## **CABLETROUGHHS**

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### **1. GENERAL**

#### **1.1 Description**

- .1 Provide a complete system of cabletroughs as shown on the Drawings.
- .2 Coordinate the location of the support channels so as not to interfere with other services.

#### **1.2 Related Work**

- .1 Wire and Cables 0 – 1000 V: Section 16122
- .2 Fastenings and Supports: Section 16191

#### **1.3 Shop Drawings and Product Data**

- .1 Submit Shop Drawings and product data in accordance with Section 16010 - Electrical General Requirements.
- .2 Indicate various types of cabletroughs with terminology used in Part 2.

### **2. PRODUCTS**

#### **2.1 Cabletrough**

- .1 Cabletroughs and fittings: to EEMAC F5-1
- .2 Ventilated type, Class C1 to CSA C22.2 No.126
- .3 Ladder tray, 150 mm rung space, class C1 to CSA C22.2 No. 126
- .4 Aluminum tray 150, 300, 450 or 600 mm wide as required with depth of 75 mm.
- .5 Horizontal elbows, end plates, drop outs, vertical risers and drops, tees, wyes, expansion joints, reducers and other fittings where required. Radii on fittings: 600 mm minimum.
- .6 Barriers where different voltage systems or electrical systems are in the same cabletrough, or as indicated.
- .7 Approved materials: Pilgrim, Enduro, Canstrut, Pursley, Newton Instrument Co., or approved equal.

#### **2.2 Supports**

- .1 Provide hardened steel (HS) rod hangers, rod hanger clamps and accessories as required.
- .2 Provide U-channel support structures for cabletroughs supported from floor.

## **CABLETROUGHES**

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- .3 Approved materials: same as cabletrough

### **3. EXECUTION**

#### **3.1 Installation**

- .1 Install complete cabletrough system. Provide concrete curbs around openings passing through floors.
- .2 Support cabletrough on both sides at 1500 mm on-centre spacing.
- .3 Provide additional support system for cabletroughs as may be deemed necessary to provide a secure system.
- .4 Remove sharp burrs or projections to prevent damage to cables or injury to personnel.
- .5 Fire stop all penetrations of fire barriers.
- .6 Install bare ground cable in all new trough system and bond to trough as required by the Canadian Electrical Code.

#### **3.2 Cables in Cabletrough**

- .1 Install cables individually.
- .2 Lay cables into cabletrough. Use rollers when necessary to pull cables.
- .3 Secure cables in cabletrough at 5 m centers, with nylon ties.
- .4 Identify cables every 30 m with nameplates in accordance with Section 16010 - Electrical General Requirements.
- .5 Mark power and communication runs in accordance with colour coding outlined in Section 16010 - Electrical General Requirements.

**END OF SECTION**

## BUSWAYS

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### 1. GENERAL

#### 1.1 Description

- .1 Provide a complete system of busways as shown on the Drawings.
- .2 Coordinate the location of the support channels so as not to interfere with other services.

#### 1.2 Shop Drawings and Product Data

- .1 Submit Shop Drawings and product data in accordance with Section 16010 - Electrical General Requirements.
- .2 Indicate in detail exact routing of busways throughout building and in relation to column lines and structural slabs and walls. Provide drop test results for each size of busway.

### 2. PRODUCTS

#### 2.1 General

- .1 Feeder and plug-in type busways to be complete system of shop fabricated interconnecting busways as indicated on Drawings. Fabricate busways in 3048 mm lengths or in shorter lengths to suit field conditions or duct fittings.
- .2 100 percent neutral for Distribution Bus.
- .3 Totally enclosed (interior) and totally enclosed weatherproof (exterior) in CSA Enclosure 3 housing.
- .4 Line to line voltage drop not exceeding 1.5 V per 30 m at rated current with distributed load at any system power factor.
- .5 Internal fire barriers at floor/wall penetrations complete with flanges.

#### 2.2 Bus

- .1 Copper, sized for the ratings indicated, silver flashed at all joints, connections fitting locations. Wrap with two (2) layers of camished cambric tape or equivalent insulation. Bus bars to be rated for 55°C rise over a maximum ambient of 40°C, but insulation be rated for 105°C.

#### 2.3 Ratings

- .1 Busways to be rated 600V, 3-phase, 3 conductors with neutral capacity indicated in Clause 2.1 and as indicated on the Drawings. Brace bus bars to withstand 100 kA symmetrical 3-phase, 60 Hz, short circuit at 600 V. Ampere ratings of busway to be as indicated on Drawings. If busway has different ampere rating when mounted vertically or horizontally,



## **BUSWAYS**

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use the lower rating and provide same duct and bus bar size for horizontal and vertical installation. Busway minimum ratings must equal ratings indicated. Select busway design to reduce electrical impedance. Voltage drops at 95 percent power factor to be in accordance with manufacturer's data sheets at the time of Bid.

### **2.4 Ground**

- .1 Provide a continuous ground in all feeder distribution busway sections to provide low impedance ground path.

### **2.5 Fire Barriers**

- .1 At all locations where busways pass through fire retarding walls or floors, provide approved fire barriers sealing busway penetrations. Use non-tracking fire barrier material that will not absorb moisture.

### **2.6 Fittings**

- .1 Provide complete system of fittings for busway installation, including:
  - .1 Transformer tap-offs
  - .2 Flanged throats for connection to switchboards and motor control centres
  - .3 Tee and angle fittings, tap-off boxes, end caps, elbows, reducers and offsets
  - .4 Special short busway lengths to suit field conditions
  - .5 Joint fittings, splice plates and coverplates
  - .6 End fittings
  - .7 Busway clamp hanger frames
  - .8 Expansion joints on vertical and horizontal busway runs at all locations to suit layout as recommended by manufacturer and where busway crosses building expansion joint.

### **2.7 Hangers and Supports**

- .1 Provide a complete system of hangers and supports, generally as indicated on Drawings or required for installation shown. Use busway clamp hanger frames to clamp to busway. Provide light field welded angle iron brackets to transfer weight of busway to building structure. Spacing of supports to be as shown on Drawings and as required by CSA Code. For vertical riser busways, provide brackets to transfer weight of busway to building structure at each support.

## BUSWAYS

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### 2.8 Finish

- .1 Clean and de-scale all metal parts. Apply a zinc-chromate prime coat and two (2) coats of spray enamel to exterior and interior surfaces as per Section 16010 - Electrical General Requirements. Use cadmium plated or corrosion resistant bolts for all bolted connections.

### 2.9 Main Service Feeder Busway

- .1 Provide low impedance feeder busway from transformer secondary throat connections to main secondary switchboard. Match busway flanges to transformer and switchboard flanges. Use two (2) bus bars per phase arranged in symmetrical pattern so that bars of opposite polarity are adjacent to each other.

### 2.10 Manufacturers

- .1 Eaton Cutler Hammer
- .2 Schneider Electric

## 3. EXECUTION

### 3.1 Installation

- .1 Before manufacture, field measure all critical and non-standard lengths of busway. Do not scale from Drawings. Install all off-sets, corners and elbows to suit job conditions.
- .2 Provide all necessary miscellaneous fittings space hangers and brackets. Provide a complete system of independent support for all busway runs. Connect from supports to busway clamp hanger fittings. Space hangers in accordance with manufacturer's recommendation, maximum spacing 3 m. Where hanging supports are not practical, floor mounted support systems shall be provide. These floor mount support systems shall not interfere with the operation or clearances required.
- .3 Torque bolts in accordance with manufacturer's recommendations. Record torques and advise Contract Administrator in writing. Re-torque all connections after no more than six months after energizing and report to Contract Administrator in writing.
- .4 Cover busway with plastic envelope until building is clean and bus ready to be meggered and energized.
- .5 Connect all busway sections in the presence of the Contract Administrator and have readings approved before energizing.
- .6 Provide lamicaid plate identification on outside of busway covers. Install identification plates wherever busways enter or leave an area, and at all tee fittings, but do not duplicate identification, if identification at one location is sufficient. Show busway designation, voltage, and source of feed.

**BUSWAYS**

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- .7 Provide one (1) torque wrench and head to match each type of bolt used and turn over to the City.
- .8 Locate expansion joints as shown on the Drawings.
- .9 Coordinate concrete curbed slots at all points the busways passed through floors.
- .10 Install all fire barriers where required.

**END OF SECTION**

## **WIREWAYS AND AUXILIARY GUTTERS**

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### **1. GENERAL**

#### **1.1 Description**

- .1 Supply and install wireways and auxiliary gutters and fittings as a means for flexible wiring system.
- .2 All wireways and gutters to be 2-piece with removable cover to provide access to wiring.
- .3 Wireways, auxiliary gutters and fittings are based on CSA CSS.2, No. 26.

#### **1.2 Submittals**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements.

### **2. PRODUCTS**

#### **2.1 Wireways**

- .1 Sheet steel with bolted cover to give uninterrupted access
- .2 Finish: based gray enamel
- .3 Elbows, tees, couplings, and hanger fittings manufactured as accessories to wireway supplied.

### **3. EXECUTION**

#### **3.1 Installation**

- .1 Install wireways and auxiliary gutters.
- .2 Keep number of elbows, offsets, and connections to minimum.
- .3 Install supports, elbows, tees, connectors, and fittings.
- .4 Install barriers to separate different voltages or to separate different systems.
- .5 Install gutter to full length of equipment.

**END OF SECTION**

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**HV POWER CABLES & 15 KV SHIELDED CABLE TERMINATIONS**

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**1. GENERAL**

**1.1 Description**

- .1 Complete supply, installation, and termination of power cables rated 15,000 V.

**1.2 Codes and Standards**

- .1 Insulated cables to CSA C22.2 No. 38, CSA C68.3 and ICEA 5-66-524

**2. PRODUCTS**

**2.1 Insulated Cables**

- .1 Three (3) conductors sized as indicated, copper stranded, with semi-conducting XLPE conductor shield.
- .2 Insulation of chemically cross linked, thermosetting polypropylene material, rated RW-90 or RWU-90, 100 kV B.I.L.
- .3 Insulation shielding of semi-conducting cross linked polyethylene over insulation and served wire or copper tape shield.
- .4 Cable jacket thermosetting low temperature black, with separator tape between shield and jacket.
- .5 Suitable for grounded neutral, 133 percent insulation level.
- .6 Short circuit rating 60 kA, 1 cycle; 14 kA, 30 cycle.
- .7 90°C normal, 130°C emergency rating, 250°C short circuit rating.

**2.2 Ground Conductor**

- .1 Minimum 2/0 AWG stranded soft drawn bare copper, 600 V, green insulation.
- .2 Alternatively, for multi-conductor cables, provide a stranded copper ground conductor, integral with the cable and sized according to Table 17 of the Canadian Electrical Code, Part I.

**2.3 Connectors**

- .1 Where not provided with equipment, supply suitable compression type connectors for use on copper conductors.

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**HV POWER CABLES & 15 KV SHIELDED CABLE TERMINATIONS**

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**2.4 Stress Cones**

- .1 Install stress cones on all 5 kV to 8 kV cable terminations

**3. EXECUTION**

**3.1 Insulated Cables**

- .1 Do not splice cables. A continuous length is required for all feeds.
- .2 Install in accordance with manufacturer's recommendations, observing requirements for minimum bending radius and pulling tensions.
- .3 Submit certified manufacturer's data sheets.

**3.2 Terminations**

- .1 Form stress relief cones in accordance with manufactures recommendations.
- .2 Install compression connectors using tools provided by the connector manufacturer in accordance with the manufacturer's recommendations.

**3.3 Tests**

- .1 The Electrical Contractor is to test cables prior to energization, as follows:
  - .1 Megger
  - .2 Hipot
  - .3 25 kV DC ICEA
  - .4 Radar scan shield test

**END OF SECTION**

**WIRES AND CABLES 0 - 1000 V**

---

**1. GENERAL**

**1.1 Work Included**

- .1 Provide a complete system of wiring, making all connections necessary for the installation shown on Drawings.

**1.2 References, Codes and Standards**

- .1 CSA C22.2 No. 0.3, Test Methods for Electrical Wires and Cables
- .2 Install and rate power cables in accordance with the Canadian Electrical Code requirements.

**1.3 Product Data**

- .1 Submit product data in accordance with Section 16010 - Electrical General Requirements.

**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 600 V insulation of chemically cross-linked thermosetting polyethylene (XLPE) material rated RW90.

**2.2 Teck Cable**

- .1 Conductors:
  - .1 Grounding conductor: copper
  - .2 Circuit conductors: copper, size as indicated
- .2 Insulation:
  - .1 Type: ethylene propylene rubber
  - .2 Chemically XLPE rated type RW90, 1000 V
- .3 Inner jacket: polyvinyl chloride material
- .4 Armour: interlocking aluminum
- .5 Overall covering: thermoplastic polyvinyl chloride material

## WIRES AND CABLES 0 - 1000 V

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### .6 Fastenings:

- .1 One-hole malleable iron 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 (2) or more cables at 1500 mm centers.
- .3 6 mm diameter threaded rods to support suspended channels.

### .7 Connectors:

- .1 Watertight, approved for TECK cable.

## 2.3 Control Cables

- .1 Single conductor wire to be 98 percent conductivity copper type TEW or TBS insulation rated at 600 V, solid or stranded conductor as required, size as noted on Drawings and specified herein, minimum #14 AWG with 90°C insulation and manufactured to CSA Specification C22.2, No. 38.
- .2 Cable for power and control shall be based on Teck 90 armoured cable, with stranded copper conductors, 90°C insulation, rated at 600 VAC, manufactured to CSA Specification C22.2, No. 131, integral copper ground wire, PVC inner jacket, aluminum interlocking armour, and PVC outer jacket having heat, flame, and moisture retardant properties. Flame retardancy of outer jacket to be rated in accordance with CSA Standard C22.2, No. 0.3. Conductor size shall be minimum #14 AWG or as noted on the Drawings.
- .3 Analog instrumentation cable shall use single or multiple pair, seven (7) strand copper conductor, individually twisted and shielded, individual tinned copper drain wire, complete electrical isolation between shields, overall multi-conductor cable shield with drain wire, XLPE inner jacket, interlocking aluminum armour, and FT4 flame retardant rated outer PVC jacket. Cable to be manufactured to CSA Specifications C22.2, No. 239 and CSA, No. 38 and shall be provided with a black, white, colour code and number code for each pair. Cable and conductor insulation to be rated for 105°C (dry) and 600 V. Conductor size shall be minimum #16 AWG or as noted on the Drawings. Standard of acceptance shall be Shawflex 69 series instrumentation and control cable.

## 3. EXECUTION

### 3.1 General

- .1 Minimum conductor size #12 AWG except for luminaire drops which can be #14 AWG if fed from 15 A circuits.
- .2 Minimum conductor size #14 AWG for all control cables.



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**WIRES AND CABLES 0 - 1000 V**

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**3.2 Installation of Building Wires**

- .1 Install wiring as follows:
  - .1 In conduit systems in accordance with Section 16111.
  - .2 In cabletroughs in accordance with Section 16114.
  - .3 In wire ways and auxiliary gutters in accordance with Section 16116.

**3.3 Installation of Teck Cable 0 - 1000 V**

- .1 Install cables.
- .2 Group cables wherever possible on channels.
- .3 Lay cable in cabletroughs in accordance with Section 16114.
- .4 Terminate cables in accordance with Section 16151 - Wire and Box Connectors - 0 - 1000 V.

**3.4 Installation of Control Cables**

- .1 Install control cables in conduit or cable troughs.
- .2 Ground control cable shield at one end only. Shields to be continuous over entire run.

**3.5 Workmanship**

- .1 Before pulling wire, ensure conduit is dry and clean. If moisture is present, thoroughly dry out conduits; vacuum if necessary. To facilitate pulling, recognized specially manufactured wire pulling lubricants may be used. Do not use grease. Employ suitable techniques to prevent damage to wire when ambient temperature is below the minimum permitted for each insulation type. Do not pull wires into incomplete conduit runs.
- .2 Installation to be free of opens and grounds. Before energization, measure insulation resistance and comply with the Canadian Electrical Code. Submit data sheet with values measured.
- .3 Do not Install any conductor smaller than #12 AWG, except where specifically indicated otherwise, i.e., for fire alarm system station circuits, P.A. wiring, etc.
- .4 Provide sizes of conductors as shown on Drawings. Voltage drop from lighting panels to farthest outlet must not exceed 2 percent at full load in any case. Advise Contract Administrator if problem is foreseen.
- .5 Exercise care in stripping insulation from wire. Do not nick conductors.

**WIRES AND CABLES 0 - 1000 V**

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**3.6 Identification, Coding and Balancing**

- .1 For branch circuit wiring, follow identification system shown on the Drawings and as specified in Section 16010 - Electrical General Requirements.
- .2 Connect single phase equipment to minimize imbalance on feeders. Adjust branch circuiting shown as required for optimum balancing. Record all changes on As-Constructed Drawings.
- .3 Colour code all feeders at all terminations, at all points where taps are made, and at all panelboards, switchboards, motor control centres, etc. Use two wraps of 3M #471 plastic film tape 48 mm wide.
- .4 Conductors sized No. 10 and smaller are required to be factory coloured, not taped on-site.
- .5 For direct current wiring use red for positive and black for negative.

**3.7 Testing**

- .1 All power and control wiring shall be tested for insulation resistance value with a 1000 V megger. Resistance values shall be as recommended by the cable manufacturer.
- .2 All wire test results shall be properly tabulated, signed, dated, and submitted to the Contract Administrator.

**END OF SECTION**

Power Cable List

CABLE NUMBER		CABLE TYPE	CABLE ROUTING	ORIGIN	DESTINATION	DESCRIPTION	REMARKS
CABLE SCHEDULE							
<b>POWER CABLES</b>							
P001	3/C #250MCM Teck Cable (8kV)	Direct Burried PVC Duct Bank	Sec. Elec. Rm. SW. LBT17	Transformer TC-1	8kV Teck Cable 100%		
P002	3/C #250MCM Teck Cable (8kV)	Direct Burried PVC Duct Bank	Sec. Elec. Rm. Cable Tray	Transformer TC-2	8kV Teck Cable 100%		
P003	2000 Amp Bus Duct 600V	Support Structure	Transformer TC-1		Suitable for exterior installation		
P004	2000 Amp Bus Duct 600V	Support Structure	Transformer TC-2		Suitable for exterior installation		
P005	2-3/C # 250MCM Teck Cable	Cable Tray	GMD-1	MCC-2	Teck Cable		
P006	2-3/C # 250MCM Teck Cable	Cable Tray	GMD-2	MCC-2C	Teck Cable		
P007	3/C #350MCM Teck Cable 100% GRD	Cable Tray	GMD-1	VFD Blower 1A	Inverter Rated Cable		
P007A	3/C #350MCM Teck Cable 100% GRD	Cable Tray	VFD Blower 1A		Inverter Rated Cable		
P008	3/C #350MCM Teck Cable 100% GRD	Cable Tray	GMD-1	VFD Blower 1B	Inverter Rated Cable		
P008A	3/C #350MCM Teck Cable 100% GRD	Cable Tray	VFD Blower 1B		Inverter Rated Cable		
P009	3/C #350MCM Teck Cable 100% GRD	Cable Tray	GMD-2	VFD Blower 2A	Inverter Rated Cable		
P009A	3/C #350MCM Teck Cable 100% GRD	Cable Tray	VFD Blower 2A		Inverter Rated Cable		
P010	3/C #350MCM Teck Cable 100% GRD	Cable Tray	GMD-2	VFD Blower 2B	Inverter Rated Cable		
P010A	3/C #350MCM Teck Cable 100% GRD	Cable Tray	VFD Blower 2B		Inverter Rated Cable		
P011	3/C # 30 Teck Cable	Cable Tray	MCC-1C	GDP - C100	Teck Cable		
P012	3/C # 250MCM Teck Cable	Cable Tray	MCC-2C	GDP - C200	Teck Cable		
P013	3/C # 350MCM Teck Cable	Cable Tray	MCC-1C	GDP - C400	Teck Cable		
P014	3/C # 2 Teck Cable	Cable Tray	CDP - C400	DCP - C300	Teck Cable		
P015	3/C # 6 Teck Cable	U-Channel Supports	GDP - C100	Transformer C100-CP-A	Teck Cable		
P016	3/C # 6 Teck Cable	U-Channel Supports	GDP - C200	Transformer C200-CP-B	Teck Cable		
P017	3/C # 6 Teck Cable	U-Channel Supports	CDP - C400	Transformer C400-CP-D	Teck Cable		
P018	3/C # 6 Teck Cable	U-Channel Supports	GDP - C200	Transformer C300-CP-C	Teck Cable		
P019	3/C # 6 Teck Cable	Cable Tray	GDP - C200	Transformer C200-CP-E	Teck Cable		
P020	3/C # 2 Teck Cable	Cable Tray	Transformer C100-CP-A	Panel CD-A	Teck Cable		
P021	3/C # 2 Teck Cable	Cable Tray	Transformer C200-CP-B	Panel CD-B	Teck Cable		
P022	3/C # 2 Teck Cable	Cable Tray	Transformer C400-CP-D	Panel CD-D	Teck Cable		
P023	3/C # 2 Teck Cable	Cable Tray	Transformer C300-CP-C	Panel CD-C	Teck Cable		
P024	3/C # 2 Teck Cable	Cable Tray	Transformer C200-CP-E	Panel CD-E	Teck Cable		
P025	3/C # 12 Teck Cable	Cable Tray	MCC-1C	Mixer 1A Disconnect	Teck Cable		
P026	3/C # 12 Teck Cable	Cable Tray	MCC-1C	Mixer 1B Disconnect	Teck Cable		
P027	3/C # 12 Teck Cable	Cable Tray	MCC-1C	Mixer 1C Disconnect	Teck Cable		
P028	3/C # 6 Teck Cable	Cable Tray	MCC-1C	WAS Pump 1 Disconnect	Teck Cable		
P029	3/C # 12 Teck Cable	Cable Tray	MCC-1C	Methanol Pump 1 Disconnect	Teck Cable		
P030	3/C # 12 Teck Cable	Cable Tray	MCC-2C	Mixer 2A Disconnect	Teck Cable		
P031	3/C # 12 Teck Cable	Cable Tray	MCC-2C	Mixer 2B Disconnect	Teck Cable		
P032	3/C # 12 Teck Cable	Cable Tray	MCC-2C	Mixer 2C Disconnect	Teck Cable		
P033	3/C # 6 Teck Cable	Cable Tray	MCC-2C	WAS Pump 1 Disconnect	Teck Cable		
P034	3/C # 12 Teck Cable	Cable Tray	MCC-2C	Methanol Pump 2 Disconnect	Teck Cable		
P035	3/C # 12 Teck Cable	Cable Tray	MCC-1C	Equilization tank Mixer 1	Teck Cable		
P036	3/C # 12 Teck Cable	Cable Tray	MCC-1C	Equilization tank Mixer 2	Teck Cable		
P037	3/C # 10 Teck Cable 100% GRD	Cable Tray	GDP - C100	VFD Blower Rm. Exh. C521-EF	Inverter Rated Cable		
P037A	3/C # 10 Teck Cable 100% GRD	Cable Tray	VFD Blower Rm. Exh. C521-EF	Exhaust Fan C521-EF	Inverter Rated Cable		
P038	3/C # 10 Teck Cable 100% GRD	Cable Tray	GDP - C200	VFD Blower Rm. Exh. C522-EF	Inverter Rated Cable		
P038A	3/C # 10 Teck Cable 100% GRD	Cable Tray	VFD Blower Rm. Exh. C522-EF	Exhaust Fan C522-EF	Inverter Rated Cable		
P039	3/C # 10 Teck Cable 100% GRD	Cable Tray	GDP - C100	VFD Blower Rm. Exh. C523-EF	Inverter Rated Cable		
P039A	3/C # 10 Teck Cable 100% GRD	Cable Tray	VFD Blower Rm. Exh. C523-EF	Exhaust Fan C523-EF	Inverter Rated Cable		
P040	3/C # 10 Teck Cable 100% GRD	Cable Tray	GDP - C100	VFD Blower Rm. Exh. C524-EF	Inverter Rated Cable		
P040A	3/C # 10 Teck Cable 100% GRD	Cable Tray	VFD Blower Rm. Exh. C524-EF	Exhaust Fan C524-EF	Inverter Rated Cable		
P041	3/C # 10 Teck Cable 100% GRD	Cable Tray	GDP - C100	VFD Blower Rm. Exh. C580-EF	Inverter Rated Cable		
P041A	3/C # 10 Teck Cable 100% GRD	Cable Tray	VFD Blower Rm. Exh. C580-EF	Exhaust Fan C580-EF	Inverter Rated Cable		
P042	3/C # 10 Teck Cable 100% GRD	Cable Tray	CDP - C400	VFD Blower Rm. Exh. C528-EF	Inverter Rated Cable		
P042A	3/C # 10 Teck Cable 100% GRD	Cable Tray	VFD Blower Rm. Exh. C528-EF	Exhaust Fan C528-EF	Inverter Rated Cable		
P043	2/C # 12 Teck Cable	Cable Tray	CP-A	Sample Room Vent C530	Teck Cable		
P044	3/C # 12 Teck Cable	Cable Tray	CP-A	Sample Room HVAC C552-CU	Teck Cable		

Power Cable List

CABLE SCHEDULE						
CABLE NUMBER	CABLE TYPE	CABLE ROUTING	ORIGIN	DESTINATION	DESCRIPTION	REMARKS
P045	3/C # 12 Teck Cable	Cable Tray	CDP-C100	Unit Heater C521-UH	Teck Cable	
P046	3/C # 12 Teck Cable	Cable Tray	CDP-C200	Unit Heater C522-UH	Teck Cable	
P047	3/C # 12 Teck Cable	Cable Tray	CDP-C200	Unit Heater C523-UH	Teck Cable	
P048	3/C # 12 Teck Cable	Cable Tray	CDP-C100	Unit Heater C524-UH	Teck Cable	
P049	3/C # 12 Teck Cable	Cable Tray	CDP-C400	Unit Heater C525-UH	Teck Cable	
P050	3/C # 12 Teck Cable	Cable Tray	CDP-C400	Unit Heater C526-UH	Teck Cable	
P051	3/C # 6 Teck Cable	Cable Tray	CP-A	Supply Fan C550-SF	Teck Cable	
P052	3/C # 10 Teck Cable	Cable Tray	CDP-200	Supply Fan C560-SF	Teck Cable	
P053	3/C # 6 Teck Cable 100% GRD	Cable Tray	CDP-100	VFD Equil. Pump C330-P	Inverter Rated Cable	
P053A	3/C # 6 Teck Cable 100% GRD	Cable Tray	VFD Equil. Pump C330-P	Equalization Pump C330-P	Inverter Rated Cable	
P054	3/C # 6 Teck Cable 100% GRD	Cable Tray	CDP-200	VFD Equil. Pump C340-P	Inverter Rated Cable	
P054A	3/C # 6 Teck Cable 100% GRD	Cable Tray	VFD Equil. Pump C340-P	Equalization Pump C340-P	Inverter Rated Cable	
P055	2/C # 12 Teck Cable	Cable Tray	CP-D	Equalization Sampling Pump	Teck Cable	
P056	4/C # 12 Teck Cable	Cable Tray	CP-D	Sampling Equipment	Teck Cable	
P057	3/C # 12 Teck Cable 100% GRD	Cable Tray	CDP-100	VFD Decanter C160	Teck Cable	
P057A	3/C # 12 Teck Cable 100% GRD	Cable Tray	VFD Decanter C160	Decanter C160	Inverter Rated Cable	
P058	3/C # 12 Teck Cable 100% GRD	Cable Tray	CDP-200	VFD Decanter C260	Inverter Rated Cable	
P058A	3/C # 12 Teck Cable 100% GRD	Cable Tray	VFD Decanter C260	Decanter C260	Inverter Rated Cable	
P059	3/C # 6 Teck Cable 100% GRD	Cable Tray	CDP-400	VFD Process Exh. Fan C510-EF	Inverter Rated Cable	
P059A	3/C # 6 Teck Cable 100% GRD	Cable Tray	VFD Process Exh. Fan C510-EF	Process Exhaust Fan C510-EF	Inverter Rated Cable	
P060	3/C # 4 Teck Cable 100% GRD	Cable Tray	CDP-400	VFD Soda Ash Blower C450-AB	Inverter Rated Cable	
P060A	3/C # 4 Teck Cable 100% GRD	Cable Tray	VFD Soda Ash Blower C450-AB	Soda Ash Blower C450-AB	Inverter Rated Cable	
P061	3/C # 12 Teck Cable	Cable Tray	CDP-C100	Weir Gate SBP 1 C010	Teck Cable	
P062	3/C # 12 Teck Cable	Cable Tray	CDP-C200	Weir Gate SBP 2 C020	Teck Cable	
P063	3/C # 12 Teck Cable	Cable Tray	CDP-100	Sump Pit C570-T Controller	Teck Cable	
P064	3/C # 12 Teck Cable	Cable Tray	CDP-200	Sump Pit C571-T Controller	Teck Cable	
P065	2/C # 12 Teck Cable	Cable Tray	CP-A	Sampling Pump C190-P	Teck Cable	
P066	2/C # 12 Teck Cable	Cable Tray	CP-B	Sampling Pump C290-P	Teck Cable	
P067	2/C # 10 Teck Cable	Cable Tray	CP-A	Chemical Analyzer C040	Teck Cable	
P068	2/C # 10 Teck Cable	Cable Tray	CP-A	Chemical Analyzer Comp.C040	Teck Cable	

**SPLITTERS, JUNCTION BOXES, PULL BOXES AND CABINETS**

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**1. GENERAL**

**1.1 Work Included**

- .1 Provide a complete system of splitters boxes and cabinets for the installation of wiring and equipment.

**1.2 Shop Drawings and Product Data**

- .1 Submit Shop Drawings and product data for cabinets in accordance with Section 16010 - Electrical General Requirements and Section 01300 - Submittals.

**2. PRODUCTS**

**2.1 Junction Boxes and Pull Boxes, Weatherproof**

- .1 Materials:
  - .1 Cast steel, Crouse Hinds, WBJ Series.

**2.2 Junction Boxes and Pull Boxes, Indoor Dry Locations**

- .1 Materials:
  - .1 Code gauge sheet steel, welded construction, phosphatized and factory paint finish.
- .2 Components:
  - .1 For flush mounting, covers to overlap box by 25 mm minimum all around with flush head cover retaining screws.
  - .2 Use rolled edges for surface boxes.
- .3 Junction boxes mounted in exterior walls shall be complete with box vapour barriers.

**2.3 Cabinets**

- .1 Materials:
  - .1 Cabinets: code gauge sheet steel, welded construction, phosphatized and factory paint finish, suitable for field painting.
  - .2 Locks: to match panelboards.

**SPLITTERS, JUNCTION BOXES, PULL BOXES AND CABINETS**

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.2 Components:

- .1 With hinged door and return flange overlapping sides, with handle, lock and catch for surface mounting, size as indicated or to suit.
- .2 Install a back mounting plate for DIN rail mounted terminal blocks. Plate to be painted white enamel.
- .3 Install metal divider in cabinets with more than one voltage.
- .4 Surface or flush with trim and hinged door, latch and lock and two keys, size as indicated or to suit. Keyed to match panelboard keys 19 mm.

**2.4 Splitters**

.1 Materials:

- .1 Code gauge sheet steel, welded construction, phosphatized and factory paint finish.

.2 Components:

- .1 Formed hinged cover suitable for locking in the closed position.
- .2 Main and branch lugs to match required size and number of incoming and outgoing conductors as indicated.
- .3 At least three (3) spare terminals on each set of lugs in splitters less than 400 A

**3. EXECUTION**

**3.1 Installation**

.1 Junction Boxes and Pull Boxes:

- .1 Supply all pull boxes and junction boxes shown on the Drawings or required for the installation.
- .2 Boxes installed in party walls to be offset by a minimum of one stud space.
- .3 Install in inconspicuous but accessible locations, above removable ceilings or in electrical rooms, utility rooms or storage areas.
- .4 Identify with system name and circuit designation as applicable.
- .5 Size in accordance with the Canadian Electrical Code, as a minimum.

**SPLITTERS, JUNCTION BOXES, PULL BOXES AND CABINETS**

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- .2 Cabinets:
  - .1 Mount cabinets with top not greater than 1980 mm above finished floor, coordinated with masonry, panelboards, fire hose cabinets and similar items.
  - .2 Install terminal block where indicated.
- .3 Splitters
  - .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.
- .4 Identification
  - .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.

**END OF SECTION**

## **OUTLET BOXES, CONDUIT BOXES AND FITTINGS**

---

### **1. GENERAL**

#### **1.1 Work Included**

- .1 Provide a complete system of boxes for the installation of wiring and equipment.

#### **1.2 References**

- .1 CSA C22.1-Canadian Electrical Codes, Part 1

### **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 for special devices.
- .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.

#### **2.2 Outlet Boxes for Metal Conduit**

- .1 Materials:
  - .1 Surface mounting exposed: cast ferrous for threaded conduit, with attached lugs, corrosion resistant two (2) coats finish.
- .2 Components:
  - .1 Ceiling outlets, surface mounting:
    - .1 Cast outlet boxes suitable for rigid conduit.
    - .2 Crouse Hinds VXF/VFT series.
  - .2 Wall outlets, surface, exposed mounting or used for outdoor outlets: One or more gang, Crouse-Hinds FS series or FD series, conduit.
  - .3 Covers: Unless wiring devices and plates are mounted, provide blank, round canopy covers to match boxes.



## **OUTLET BOXES, CONDUIT BOXES AND FITTINGS**

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### **2.3 Concrete Boxes**

- .1 Electro-galvanized sheet steel concrete type boxes for flush mount in concrete with matching extension and plaster rings as required.

### **2.4 Conduit Boxes**

- .1 Cast FS or FD feraloy boxes with factory-threaded hubs and mounting feet for surface wiring of switches and receptacle.

### **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 32 mm and pull boxes for larger conduits.
- .4 Double locknuts and insulated bushings on sheet metal boxes.

## **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 Provide correct size of openings in boxes for conduit, mineral insulated and armoured cable connections. Reducing washers are not allowed.
- .4 Install all outlets flush and surface mounted as required for the installation.
- .5 Surface mount above suspended ceilings, or in unfinished areas.
- .6 Adjust position of outlets in finished masonry walls to suit course lines. Coordinate cutting of masonry walls to achieve neat openings for all boxes.
- .7 Do not distort boxes during installation. If boxes are distorted, replace with new boxes.
- .8 Use plaster rings to correct depth. Use 30 mm on concrete block.
- .9 Do not use sectional boxes.
- .10 Provide boxes sized as required by the Canadian Electrical Code.

**OUTLET BOXES, CONDUIT BOXES AND FITTINGS**

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- .11 Install vapour barrier material to surround and seal all outlet boxes located on exterior walls of building. Maintain wall insulation.
- .12 Outlets installed in partition walls to be offset by a minimum of one stud space.
- .13 Primary bushings in termination box for cable connection.
- .14 Secondary bushings in termination box for bus duct connection.
- .15 Control junction box.
- .16 Stainless steel nameplate and connection diagram.

**END OF SECTION**

## **WIRING DEVICES**

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### **1. GENERAL**

#### **1.1 Work Included**

- .1 Provide and connect all wiring devices for the complete installation.

### **2. PRODUCTS**

#### **2.1 Manufacturer**

- .1 Wiring devices to be of one manufacture throughout project.
- .2 Manufacturers shall be Arrow-Hart, Crouse-Hinds, Hubbell, or Pass & Seymour.

#### **2.2 Devices**

- .1 The catalogue numbers shown below are for the particular manufacturer's series and all necessary suffixes shall be added for the requirements as stated. All devices shall be specification grade minimum and wherever possible shall be of the same manufacture.
- .2 Devices to be brown with stainless steel coverplates in all but mechanical areas unless noted otherwise. Use galvanized steel coverplates in mechanical areas and for surface mounted devices.

#### **2.3 Switches**

- .1 120-277 V, 20 A, single and double pole, three-way and four-way: as Hubbell No. 1221, 1222, 1223 and 1224.
- .2 For wet locations use the following switches: 20 A, 120 V single pole brown, side wired press-switch, as Hubbell No. 1281.
- .3 Manually - operated general purpose AC switches shall have the following features:
  - .1 Terminal holes approved by AWG # 10 wire.
  - .2 Silver alloy contacts.
  - .3 Urea or melamine molding for parts subject to carbon tracking.
  - .4 Suitable for back and/or side wiring.

## **WIRING DEVICES**

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### **2.4 Receptacles**

- .1 Duplex 15 A, 120 V, 3 wire, brown, U-ground, as Hubbell No. 5252, with the following features:
  - .1 Brown urea molded housing.
  - .2 Suitable for # 10 AWG for back and side wiring.
  - .3 Eight (8) back wired entrances, four (4) side wiring screws.
  - .4 Break-off links for use as split receptacles.
  - .5 Triple wipe contacts and riveted grounding contacts.
- .2 Duplex 15 A, 120 V, 3 wire, brown, U-ground ground fault receptacle, as Hubbell No. GF-5261.
- .3 Single 15 A, 120 V, 3 wire housekeeping receptacle with stainless steel plate engraved with Housekeeping, as Hubbell No. 5262.
- .4 Receptacles located in the wet areas and on the exterior of the building to be weatherproof construction.
- .5 Welding outlets to be 60A 600 V; Crouse-Hinds CAT. No. DBR56742. Contractor to confirm on-site receptacle to match existing welding outlet.
- .6 Provide coverplates for all wiring devices.
- .7 Use sheet steel utility box cover for wiring devices installed in surface mounted utility boxes.
- .8 Use stainless steel 1 mm thick coverplates on all wiring devices mounted in flush-mounted outlet boxes unless otherwise specified.
- .9 Weatherproof double lift spring-loaded cast aluminum coverplates, complete with gaskets for single receptacles or switches.
- .10 Weatherproof spring-loaded cast aluminum coverplates complete with gaskets for single receptacles or switches.
- .11 Use gasketed DS cast covers on FS and FD type boxes.

### **3. EXECUTION**

#### **3.1 Installation**

- .1 Install single throw switches with handle in the "UP" position when switch closed.

### **WIRING DEVICES**

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- .2 Install switches vertically in gang type outlet box when more than one switch is required in one location.
- .3 Mount switches on the latch side of the doorway as close as possible to door frame unless otherwise indicated on Drawings.
- .4 Install receptacles vertically in gang type outlet box when more than one (1) receptacle is required in one (1) location.
- .5 Protect cover plate finish with paper or plastic film until all painting and other Work is finished, and then remove paper.
- .6 Install suitable common coverplates where wiring devices are grouped. Do not distort plates by tightening screws excessively.
- .7 Do not use coverplates meant for flush outlet boxes on surface mounted boxes.
- .8 Wherever possible, mount equipment in a straight line at a uniform mounting height, coordinated with other equipment and materials.
- .9 Mounting dimensions are to the centre of the devices. Final instructions on mounting heights shall be given by the Contract Administrator's representative at the Site. The above shall be used as a guide, but shall be subject to final verification prior to installation.

**END OF SECTION**

**WIRE AND BOX CONNECTORS 0 - 1000 V**

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**1. GENERAL**

**1.1 Work Included**

- .1 Provide a complete system of wiring, making all connections necessary for the installation shown on Drawings.

**1.2 Special Codes**

- .1 Install and rate power cables in accordance with the Canadian Electrical Code requirements or in accordance with IPCEA requirements where permissible.

**1.3 References**

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

**2. PRODUCTS**

**2.1 Materials**

- .1 Pressure type wire connectors: with current carrying parts same material as conductors sized to fit the conductors as required.
- .2 Fixture type splicing connectors: with current carrying parts same material as conductors sized to fit the conductors 10 AWG or less.
- .3 Bushing stud connectors: to EEMAC 1Y-2 to consist of:
  - .1 Connector body and stud clamp for stranded copper conductors
  - .2 Clamp for stranded copper conductors
  - .3 Stud clamp bolts
  - .4 Bolts for copper bar

**2.2 Wire Connectors**

- .1 Use 3M "Scotchlock", self-insulated connectors for hand twist wire joints for lighting, small power, and control wiring.
- .2 Use Thomas & Betts (T & B) non-insulated ring type compression lugs for terminating #10 AWG and smaller motor connections. Tape with rubber and scotch tape. Lugs to accept ten 32 x 3/8 inch machine bolts.

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**WIRE AND BOX CONNECTORS 0 - 1000 V**

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- .3 Terminate conductors No. 8 AWG and larger with T & B Colour-Keyed compression connectors Series 54000 or on lugs provided with equipment.
- .4 T & B “KOPR-SHIELD” compound Series CP8 on all terminations for compression connectors.

**3. EXECUTION**

**3.1 Installation**

- .1 Remove insulation carefully from ends of conductors and:
  - .1 Apply coat of zinc joint compound on aluminum conductors prior to installation of connectors.
  - .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.

**3.2 Wire Connectors**

- .1 Select hand twist connectors for wire size and install tightly on conductors.
- .2 Brush “KOPR-SHIELD” compound on terminations for compression connectors as recommended by the manufacturer.
- .3 Install compression connectors using methods and tools recommended by manufacturer.
- .4 Do not install stranded conductors under screw terminals unless compression lugs are installed.

**END OF SECTION**

## CONNECTORS AND TERMINATIONS

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### 1. GENERAL

#### 1.1 Inspection

- .1 Obtain inspection certificate of compliance covering high voltage stress coning from Contract Administrator and include it with As-Built Drawings and maintenance manuals.

#### 1.2 Product Data

- .1 Submit product data sheets in accordance with Section 16010 - Electrical General Requirements.

### 2. PRODUCTS

#### 2.1 Connectors and Terminations

- .1 Copper long barrel compression connectors as required and sized for conductors.
- .2 Contact aid for aluminum cables where applicable.

### 3. EXECUTION

#### 3.1 Installation

- .1 Install stress cones, terminations, and splices in accordance with manufacturer's instructions.
- .2 Bond and ground as required.

**END OF SECTION**



## **FASTENINGS AND SUPPORTS**

---

### **1. GENERAL**

#### **1.1 Work Included**

- .1 Supply and install all hangers, supports and inserts for the installation shown on the Drawings and specified herein, as necessary to fasten electrical equipment securely to the building structure.

### **2. PRODUCT**

#### **2.1 Framing and Support System**

- .1 Materials:
  - .1 Intermediate duty supporting structures shall employ P1000 Unistrut or equal together with the manufacturers connecting components and fasteners for a complete system.
  - .2 Heavy duty supporting structures to be fabricated and welded from steel structural members and prime painted before installation.
- .2 Finishes:
  - .1 Outdoors, wet locations: hot dipped galvanized
  - .2 Indoors, dry locations: galvanized when available, prime painted if not available
  - .3 Nuts, bolts, machine screws: cadmium plated
- .3 Unistrut:
  - .1 Section P1000 or as required for load and span, with mounting screws, or approved. P1000 or equal is a minimum standard for supporting conduits 50 mm and larger.

#### **2.2 Concrete and Masonry Anchors**

- .1 Materials: hardened steel inserts, zinc plated for corrosion resistance. All anchor bolts must be galvanized.
- .2 Components: non-drilling anchors for use in predrilled holes, sized to safely support the applied load with a minimum safety factor of four (4).
- .3 Manufacturer: Hilti (Canada) Limited or approved equal.

#### **2.3 Non-Metallic Anchors**

- .1 Material: plastic anchors for sheet metal screws
- .2 Manufacturer: Fischer

## **FASTENINGS AND SUPPORTS**

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### **2.4 Conduit Supports**

- .1 General: malleable iron one-hole conduit straps where exposed to weather. Stamped steel two (2) hole straps indoors.
- .2 Structural Steel: Crouse-Hinds "Wedgetite" supports or equivalent manufactured by Appleton.
- .3 Masonry, concrete, stone, etc.: anchors
- .4 Title: toggle bolts
- .5 Metal studs, ceiling hangers, etc.: "Caddy-Clips"
- .6 Unistrut: Unistrut conduit clamps

### **2.5 Cable Supports and Clamps**

- .1 General: as per conduit supports, except that for single conductor cables, suitable non-ferrous, or approved stainless steel or aluminum clamps shall be used.

## **3. EXECUTION**

### **3.1 General**

- .1 Do not cut or drill beams, joists or structural steel unless written permission of the Contract Administrator is obtained.
- .2 Distance between conduit or cable supports not to exceed code requirements.
- .3 Supports to be suitable for the real loads imposed by equipment.
- .4 Supports to be securely fastened, free from vibration and excessive deflection or rotation. Maximum deflections are 4 mm over a 1 m span and 8 mm over a 2 m span.
- .5 Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer's installation recommendations.
- .6 Provide conduit rack with 25 percent spare capacity for multiple runs.
- .7 Provide channel support with fittings for vertical runs of conduit and cables.

### **3.2 Installation**

- .1 Secure equipment to solid masonry, tile and plaster surfaces with lead anchors or nylon shields.
- .2 Secure equipment to poured concrete with expandable inserts.
- .3 Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.

### **FASTENINGS AND SUPPORTS**

---

- .4 Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
- .5 Fasten exposed conduit or cables to building construction or support system using straps.
  - .1 One-hole malleable iron or steel straps to secure surface conduits and cables 50 mm and smaller.
  - .2 Two-hole steel straps for conduits and cables larger than 50 mm.
  - .3 Beam clamps to secure conduit to exposed steel Work.
- .6 Suspended support systems.
  - .1 Support individual cable or conduit runs with 6 mm diameter threaded rods and spring clips.
  - .2 Support two (2) or more cables or conduits on channels supported by 6 mm diameter threaded rod hangers where direct fastening to building construction is impractical.
- .7 Use plastic anchors for light loads only. Use metal anchors for all other loads.
- .8 Shot driven pins may only be used with written approval of the Contract Administrator.
- .9 Use round or pan head screws for fastening straps, boxes, etc.
- .10 Do not support heavy loads from the bottom chord of open web steel joists.
- .11 Support outlet boxes, junction boxes, panel tubs, etc., independent of conduits running to them. Support conduits within 600 mm of outlet boxes. Support surface mounted panel tubs with a minimum of four (4) 6 mm fasteners.
- .12 For surface mounting of two (2) or more conduits use channels at 1500 mm of spacing.
- .13 Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.
- .14 Ensure adequate support for raceways and cables dropped vertically to equipment where there is no wall support.
- .15 Do not use wire lashing or perforated strap to support or secure raceways or cables.
- .16 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of the Contract Administrator.

**END OF SECTION**

## **PAD MOUNT DISTRIBUTION TRANSFORMER**

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### **1. GENERAL**

#### **1.1 Related Work**

- .1 General Electrical Requirements: Section 16010
- .2 Busways: Section 16115
- .3 HV Power Cables and 15 kV Shielded Cable Terminations: Section 16120
- .4 Concrete pad or Pre-cast pad: Division 03
- .5 Installation of anchor devices, setting templates: Division 03

#### **1.2 References**

- .1 ANSI/IEEE 386, Separable Insulated Connector Systems for Power Distribution Systems above 600 V
- .2 CAN/CSA-C2, Single-Phase and Three Phase Distribution Transformers, Types ONAN and LNaN
- .3 CSA C227.4, Three-Phase Dead Front Pad-Mounted Distribution Transformers

#### **1.3 Source Quality Control**

- .1 Submit to Contract Administrator standard factory test certificates of each transformer and type test of each transformer with high voltage accessories in accordance with CSA C2.

#### **1.4 Shop Drawings**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements.
- .2 Indicate:
  - .1 Anchoring method and dimensioned foundation template
  - .2 Dimensioned cable and bus duct entry locations
  - .3 Dimensioned cable termination height
  - .4 Identified internal and external component layout on assembly Drawing
  - .5 Insulating liquid capacity

## **PAD MOUNT DISTRIBUTION TRANSFORMER**

---

### **1.5 Operation and Maintenance Data**

- .1 Provide operation and maintenance data for pad mounted distribution transformers for incorporation into manual specified in Section 16010 – Electrical General Requirements.
- .2 Include insulating liquid maintenance data.

### **1.6 Maintenance Materials**

- .1 Provide maintenance materials in accordance with Division 1
- .2 Provide spare parts and special tools as recommended by the manufacturer.

## **2. PRODUCTS**

### **2.1 Manufacturer**

- .1 Partner Technologies Incorporated
- .2 Carte International Inc.

### **2.2 Equipment**

- .1 Three phase dead front pad mounted distribution transformers: to CSA C227.4.
- .2 Oil filled pad mounted distribution transformers complete with primary cable compartments and top secondary busduct entry arrangement and accessories to form complete factory assembled, self contained, steel fabricated unit for mounting on concrete pad.
- .3 Separable insulated connectors.
- .4 Primary cable terminals with solderless connectors.
- .5 Low voltage terminals to accept bus duct connections.
- .6 Connectors for primary cables and secondary busduct.
- .7 Mechanical interlock to Section 16359 - Interlock Systems to prevent access to primary compartment unless primary supply is isolated at source. Separate padlocking for primary compartment door.
- .8 Stays to hold compartment doors in 110° open position.

### **2.3 Transformer Characteristics**

- .1 Transformer shall be K13 rated
- .2 Primary voltage: 4160V, 60 Hz, delta connected, 3-phase

## **PAD MOUNT DISTRIBUTION TRANSFORMER**

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- .3 Secondary voltage: 347/600 V, wye connected, 3-phase, 4 wire, neutral grounded.
- .4 Capacity: 1.5 MVA
- .5 Basic impulse level: 95 kV
- .6 Impedance: not less than 6.5 percent
- .7 NO loads and full loads not to exceed CSA C802.3-01 recommended kW rating
- .8 Voltage Taps four - 2.5 percent taps, 2-FCAN, 2-FCBN

### **2.4 Tap Changer**

- .1 Externally operated off-load tap changer, with provision for padlocking on 3-phase units.

### **2.5 Accessories**

- .1 Liquid temperature thermometer with two sets contacts
- .2 Liquid level gauge with two sets contacts
- .3 Pressure relief device
- .4 25 mm drain valve
- .5 25 mm filler plug

### **2.6 Grounding**

- .1 Connectors for grounding conductors size as indicated.

### **2.7 Finish**

- .1 Finish exterior of unit in accordance with Section 16010 - Electrical General Requirements.

### **2.8 Equipment Identification**

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
- .2 Transformers identification shall be TC-1 and TD-2
- .3 Nameplate showing information in accordance with CSA C2.

### **2.9 Warning Signs**

- .1 Provide warning signs in accordance with Section 16010 - Electrical General Requirements.

**PAD MOUNT DISTRIBUTION TRANSFORMER**

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**3. EXECUTION**

**3.1 Inspection**

- .1 Check factory made connections of transformer unit for mechanical security and electrical continuity.
- .2 Check transformer insulating liquid for correct quantity and specification according to manufacturer's instructions.

**3.2 Installation**

- .1 Ensure concrete pad is fully cured before transformer is installed.
- .2 Set and secure transformer unit in place, rigid, plumb and square.
- .3 Make connections.
- .4 Connect transformer unit ground bus to system ground.
- .5 Ensure care is taken to prevent contamination of liquid and components when field filling transformers. Supply test results if required.
- .6 Use only metal hose when field-filling transformer with oil: never, under any circumstances, use rubber hose.
- .7 Set taps to produce rated secondary voltage at no-load.

**3.3 Field Quality Control**

- .1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems.
- .2 Carry out following insulation tests using megger or other insulator tester with 20,000 megohm scale and resulting insulation resistance corrected to base of 20°C.
  - .1 High voltage to ground with secondary grounded for duration of test.
  - .2 Low voltage to ground with primary grounded for duration of test.
  - .3 High to low voltage
  - .4 Inspect primary and secondary connections for tightness and for signs of overheating
  - .5 Inspect and clean bushings and insulators
  - .6 Check oil level and temperature indicators
  - .7 Set transformer taps to rated voltage as specified

**PAD MOUNT DISTRIBUTION TRANSFORMER**

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- .8 Inspect for oil leaks and excessive rusting
- .9 Inspect oil level
- .10 Check fuses for correctness of type and size
- .11 Check for grounding and neutral continuity between primary and secondary circuits of transformer.

**END OF SECTION**



## **INTERLOCK SYSTEMS**

---

### **1. GENERAL**

#### **1.1 Shop Drawings and Product Data**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements.

### **2. PRODUCTS**

#### **2.1 Interlock Systems**

- .1 Kirk key interlocks, Type F for load interrupter switch and Type D for switchgear cubicle door to prevent:
  - .1 Opening cubicle door for access to fuses while load interrupter is in closed position.
  - .2 Closing load interrupter while cubicle door is open.
- .2 Key interlocks mounted in switchgear so that interlocks cannot be removed when operating switch or breaker is in closed position.

#### **2.2 Manufacturer**

- .1 Kirk Interlocks

### **3. EXECUTION**

- .1 Install interlocks on switch or breakers cubicle as indicated on Drawings.

**END OF SECTION**

## COORDINATION AND SHORT CIRCUIT STUDY

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### 1. GENERAL

#### 1.1 Description

- .1 Provide a coordination/protective study and short circuit study of all equipment specified herein and submit for review.
- .2 Include the following:
  - .1 5 kV cable thermal damage curves (8 kV rated)
  - .2 600 V air circuit breaker over current, overload, and ground fault devices.
  - .3 600 and 120/208 V panelboards and switchgear connecting feeder cables and bus duct.
  - .4 5 kV and 600 V transformer damage curves, magnetizing current for all transformers 150 kVA and larger.
  - .5 Lock rotor current, acceleration time and damage curve for motors 75 kW and larger.
  - .6 Any additional data necessary for successful completion of the coordination and short circuit study.
  - .7 Study shall be inclusive for new distribution equipment at the Nitrogen Removal Facility, existing 5 kV switch (LBT17) in Secondary Electrical Room and Existing 5 kV breakers at Grit Building Distribution (Breakers 52-F2 and 52-F5).
- .3 Data shall clearly state the operating time in cycles of each breaker and indicate whether the time current curves for relays are inclusive of breaker tripping times or otherwise.
- .4 Prepare a summation chart showing all ratings and settings with easy reference to the appropriate curve.
- .5 Symmetrical and asymmetrical fault current calculations shall be submitted to verify the correct choice of the protective elements of the system.
- .6 Prepare a systems single line diagram on which the resultant short circuit values, device numbers and equipment ratings are shown.
- .7 Include a list of recommended settings for each relay.

#### 1.2 Related Work

- .1 Pad Mount Distribution Transformer: Section 16323
- .2 Secondary Switchgear: Section 16426
- .3 Dry Type Transformers up to 600 V Primary: Section 16461

## **COORDINATION AND SHORT CIRCUIT STUDY**

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### **1.3 Qualifications**

- .1 This study shall be provided by the supplier of the main switchgear.
- .2 This study shall be performed by and bear the stamp of a Professional Engineer registered in the Province of Manitoba.

### **1.4 Submittals**

- .1 Submit the complete study for review prior to carrying out calibration and verification.
- .2 Submit typed results of coordination and short circuit study in maintenance manuals.

## **2. PRODUCTS**

### **2.1 Tripping Devices**

- .1 Relay style, CT ratios and fuse sizes have been selected on a preliminary basis for design purposes. Final selection shall be based on the results of this study and shall be included at no extra cost.

## **3. EXECUTION**

### **3.1 Data**

- .1 Provide the main switchboard supplier with all relevant data for equipment not provided by that supplier.

**END OF SECTION**

## **SECONDARY LIGHTNING ARRESTERS**

---

### **1. GENERAL**

#### **1.1 Shop Drawings and Product Data**

- .1 Submit Shop Drawings and product data in accordance with Section 16010 - Electrical General Requirements.

### **2. PRODUCTS**

#### **2.1 Equipment**

- .1 Arrester component parts: to CSA C233
- .2 Arrester characteristics:
  - .1 System voltage: 600 V
  - .2 Rated voltage of arrester: 550 V
  - .3 Indoor type

### **3. EXECUTION**

#### **3.1 Installation**

- .1 Install arresters and connect to secondary bus and ground bus.

**END OF SECTION**

## SECONDARY SWITCHGEAR

---

### **1. GENERAL**

#### **1.1 References**

- .1 EEMAC G8-3.3, Metal-Enclosed Interrupter Switchgear Assemblies

#### **1.2 Shop Drawings Product Data**

- .1 Submit Shop Drawings and product data in accordance with Section 16010 - Electrical General Requirements and Division 1.
- .2 Indicate on Shop Drawings:
  - .1 Floor anchoring method and foundation template.
  - .2 Dimensioned cable entry and exit locations.
  - .3 Dimensioned position and size of bus.
  - .4 Overall length, height and depth of complete switchgear.
  - .5 Dimensioned layout of internal and front panel mounted components.
- .3 Indicate on Product data:
  - .1 Time-current characteristic curves for air circuit breakers.

#### **1.3 Maintenance Data**

- .1 Provide maintenance data for secondary switchgear for incorporation into manual specified in Section 16010 - Electrical General Requirements.
- .2 Six (6) copies maintenance data for complete switchgear assembly including components.

#### **1.4 Maintenance Materials**

- .1 Provide maintenance materials in accordance with Division 1.

#### **1.5 Storage**

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

## SECONDARY SWITCHGEAR

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### 2. PRODUCTS

#### 2.1 Materials

- .1 Switchgear assembly: to EEMAC G8-3.3.

#### 2.2 Rating

- .1 Main switchgear: indoor 600 V, 2000 A, 3-phase, 4 wire, 60 Hz, minimum short circuit capacity 65 kA (rms symmetrical). Interrupting capacity rating to suit Coordination Study requirements.

#### 2.3 Secondary Switchgear

- .1 Secondary switchgear:
  - .1 Main Distribution: 600V, 2000A 3-phase, 3 wire
- .2 Secondary switchgears to consist of the following equipment:
  - .1 Metal enclosed drawout switchgear. Size of equipment shall be as indicated on the Drawings.
  - .2 TVSS surge protection – bus connect.
  - .3 Main breaker with digital overcurrent protection. Size of main breakers shall be as indicated on the Drawings.
- .3 Acceptable Manufacturers
  - .1 Eaton Cutler-Hammer Magnum DS series
  - .2 Schneider Electric

#### 2.4 Enclosure

- .1 Main incoming Section to contain:
  - .1 Power air circuit breaker sized as indicated.
  - .2 Microprocessor based trip unit including:
    - .1 Long Time Delay
    - .2 Short Time Delay
    - .3 Instantaneous Time Delay
    - .4 Ground Fault Protection

## SECONDARY SWITCHGEAR

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- .3 Microprocessor based digital monitoring and protective devices. Refer to Section 16435.
- .2 Distribution Sections to contain:
  - .1 Draw out air circuit breakers, sized as indicated.
  - .2 Copper bus, from main section to distribution Sections including vertical bussing.
  - .3 Microprocessor based tripping device.
- .3 Blanked off space for future units.
- .4 Metal enclosed, free standing, floor mounted, dead front, indoor CSA Enclosure one cubicle unit.
- .5 Ventilating louvres: vermin, insect proof
- .6 Access from front and rear
- .7 Steel channel sills for base mounting in single length common to multi-cubicle switchboard.
- .8 Provide bus duct entry hardware to accept the bus ducts for the incoming service feeders to each switchboard.
- .9 Provide "top-of-gear breaker lifter for removal and installation of circuit breakers.
- .10 Provide suitable quantity and size of lugs for cables as indicated on the Drawings.

### 2.5 Busbars

- .1 Main Distribution: 3-phase 100 percent capacity neutral busbars, continuous ground busbars, continuous current rating of 2000A self cooling, extending full width of cubicle, supported on insulators.
- .2 Main connections between bus and major switching components to have continuous current rating to match major switching components.
- .3 Busbars and main connections: 99.30 percent conductivity tin plated copper.
- .4 Silver surfaced joints, secured with non-corrosive bolts and Belleville washers.
- .5 Identify phases of busbars by suitable marking.
- .6 Lugs for each breaker suitable size for designated outgoing cables.
- .7 Busbar connectors, when switchboard shipped in more than one section.

## SECONDARY SWITCHGEAR

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### 2.6 Grounding

- .1 Copper ground bus not smaller than 50 x 6 mm extending full width of multi-cubicle switchboard and situated at bottom.
- .2 Lugs at each end for size of grounding cable required.

### 2.7 Power Circuit Breaker

- .1 Power circuit breakers: 600 V class, continuous current rating, and trip rating as indicated on Drawings, interrupting rating 65 kA. All breakers shall be 100 percent.
- .2 Drawout type breaker with dual magnetic direct-acting trips on each pole providing adjustable over-current and instantaneous protection:
  - .1 Delayed direct-acting trips with coil rating calibration range, for overcurrent conditions from 80 percent to 160 percent of coiled rating.
  - .2 Instantaneous trips with calibration from 500 percent to 1500 percent of ampere rating of breaker for short circuit protection.
  - .3 Normal stored energy, closing mechanism to provide quick make operation.
  - .4 Motor charged, stored energy, quick-make, closing mechanism with emergency manual spring charging handle and switch to isolate power supply to spring charging motor.
  - .5 On-off indicator and spring charging indicator.
  - .6 Breakers trip setting and fault interrupt rating capacity shall be according to Single Line Drawing and Coordination Study requirements.
  - .7 Breaker faceplate shall include color-coded visual indicators to indicate Contact stored energy status.
  - .8 Local control pushbuttons for "open" and "close".
- .3 Accessories:
  - .1 Microprocessor based trip unit including:
    - .1 Long time delay
    - .2 Short time delay
    - .3 Instantaneous time delay
    - .4 Ground fault protection
    - .5 Flux-transfer shunt trip



## SECONDARY SWITCHGEAR

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- .6 Acceptable Product: Eaton Cutler- Hammer Digitrip RMS 1150

### 2.8 Finishes

- .1 Apply finishes in accordance with Section 16010 - Electrical General Requirements.
  - .1 Cubicle exteriors gray
  - .2 Cubicle interiors white

### 2.9 Equipment Identification

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
- .2 Nameplates:
  - .1 White plate, black letters, size 7
  - .2 Complete switchgear labeled: "600 V"
  - .3 Main cubicle labeled: "Main Breaker"
  - .4 Distribution units labeled: "Feeder No. 1", "Feeder No. 2"

## 3. EXECUTION

### 3.1 Installation

- .1 Locate switchgear assembly as indicated and bolt to floor.
- .2 Connect main secondary power supply to main breaker or bus.
- .3 Connect load side of breakers in distribution cubicles to distribution feeders.
- .4 Check factory made connections for mechanical security and electrical continuity.
- .5 Run one (1) grounding conductor 4/0 AWG bare copper from ground bus to ground grid.
- .6 Check trip unit settings against co-ordination study to ensure proper working and protection of components.

**END OF SECTION**

## INSTRUMENT TRANSFORMERS

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### 1. GENERAL

#### 1.1 References

- .1 CAN3-C13, Instrument Transformers

#### 1.2 Product Data

- .1 Submit product data in accordance with Section 16010 - Electrical General Requirements.
- .2 Indicate dimensions and connection details.

### 2. PRODUCTS

#### 2.1 Potential Transformers

- .1 Potential Transformers: to CAN3-C13, dry type for indoor use, with following characteristics:
  - .1 Nominal Voltage Class: as indicated
  - .2 Rated Frequency: 60 Hz
  - .3 Basic Impulse Level: 10 kV
  - .4 Voltage Ratio: as required
  - .5 Accuracy Rating: 0.3B2.0
- .2 Potential Transformers fused with separate fuse block, fuses: as required.

#### 2.2 Current Transformers

- .1 Current Transformers: to CAN3-C13, dry type for indoor use with following characteristics:
  - .1 Nominal Voltage Class: as indicated
  - .2 Rated Frequency: 60 Hz
  - .3 Basic Impulse Level: 10 kV
  - .4 Metering Accuracy Ratio: 0.3B2.0
  - .5 Relay Accuracy Rating: 2.5H100
  - .6 Rated Primary and Secondary Current: as indicated
  - .7 Continuous-Current Rating Factor: 150 percent

## **INSTRUMENT TRANSFORMERS**

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- .8 Short-Time Mechanical Current Rating: 1.5 times primary rating
- .9 Short-Time Thermal Current Rating: 1.5 times primary rating
- .2 Positive action automatic short-circuiting device in secondary terminals.

### **2.3 Mounting Brackets**

- .1 Potential transformers with brackets as required.
- .2 Fabricate brackets and channels from electrogalvanized code gauge painted steel.

## **3. EXECUTION**

### **3.1 Installation**

- .1 Install instrument transformers and ensure accessibility.

**END OF SECTION**

**MICROPROCESSOR BASED METERING EQUIPMENT**

---

**1. GENERAL**

**1.1 Product Data**

- .1 Submit product data in accordance with Section 16010 – Electrical General Requirements.
- .2 Indicate dimensions and connection details.

**2. PRODUCTS**

**2.1 Microprocessor Based Metering Equipment**

- .1 Power System Analyzer and Meter.
  - .1 Where indicated on the drawing, provide a digital line Power Quality Meter and Analyzer device. The Analyzer and meter shall be UL, CSA, and CUL listed and meet ANSI C12.20 (0.5 percent) energy revenue metering accuracy standard.
  - .2 The metering equipment shall provide direct reading metered or calculated values of the items listed below and shall auto range between units, kilounits and megaunits for all metered values. The device shall be capable of displaying the frequency distribution in graphic form and shall be capable of displaying the Waveform in graphic form. The device shall be capable of displaying multiple parameters at once, including four (4) user-configurable custom screens, displaying any seven (7) of the parameters listed.
    - .1 AC current (amperes) in A, B, and C phase, 3-phase average, Neutral (N) and Ground (G) (provide neutral and ground current transformer). Accuracy  $\pm 0.2$  percent.
    - .2 AC voltage (volts) for A-B, B-C and C-A, phase average, A-N, B-N and C-N, average phase to N, and N to G. Accuracy  $\pm 0.2$  percent.
    - .3 Real Power (Watts), Reactive Power (vars), Apparent Power (VA), Real Energy (WH), Reactive Energy (VARH), Apparent Energy (VAH) for each phase and system. Accuracy  $\pm 0.4$  percent. Forward/Reverse indication shall be provided.
    - .4 Frequency (Hertz) Accuracy  $\pm 0.4$  percent.
    - .5 Demand values for System Current (Amperes), System Real Power (Watts), System Reactive Power (vars), and System Apparent Power (VA).
    - .6 Power Factor for both Displacement and Apparent.
    - .7 Percent Total Harmonic Distortion (THD) for all Currents and Voltages.
    - .8 K-Factor, Transformer Derating Factor, and Crest Factor.
  - .3 This device shall provide the following advanced analysis features:

**MICROPROCESSOR BASED METERING EQUIPMENT**

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- .1 Onboard logging capability, including the ability to log a total of 24 parameters with intervals ranging from 0.13 seconds (every 8 cycles) to twice a week (5,040 minutes). Four separate trends shall be available.
  - .2 Trend Analysis Screens displaying the minimum and maximum values for each metered value, with all parameters time stamped to 10 millisecond resolution.
  - .3 Time-of-use metering capability to store energy usage data for time-of-use revenue metering.
  - .4 Demand Analysis Screens displaying present demand and peak demands for phase currents and power. Peak demands shall display time and date stamped to within 10 millisecond resolution. Demand Window Selection for metered demand values shall be selectable as a fixed or sliding window, a synch, pulse initiation, or a communication system initiation.
  - .5 Harmonic Analysis Screens shall be capable of being function key triggered to capture a high-speed waveform of two (2) cycles of data sampled at 128 samples per cycle, simultaneously recording all currents and voltages. Data captured shall include the magnitude and the direction of the harmonic source from 1st through the 50th harmonic.
  - .6 Event/Alarm Analysis Screens shall display data recorded for up to ten (10) event/alarm conditions. For each event/alarm a description of the event/alarm, date, and time of event/alarm shall be recorded (10 mS resolution).
  - .7 The metering equipment shall be capable of transmitting all data at time of the event via Modbus communications to a personal computer for creating and displaying wave forms.
  - .8 The meter shall have the ability to store the last 504 meter events in non-volatile memory. Each event will be date and time stamped with 10 millisecond accuracy. The meter shall provide the ability to view the events via the local display or via Modbus communications.
  - .9 Event/Alarm Condition Levels shall be capable of being triggered by up to 7 of any of 61 conditions when the programmed threshold is exceeded. All shall have programmable time delays from 0.1 to 60 seconds except voltage disturbance, which shall be programmable from 0 to 3,600 cycles.
- .4 This metering equipment shall be capable of receiving the following inputs:
- .1 Instrument Transformers: Input ranges of this device shall accommodate external current transformers with ranges from 10,000/5 through 5/5 amperes. Provide external current transformers for each phase, neutral and ground circuit with rating as indicated on the drawing or sized for incoming service or associated feeder. The unit shall be capable of overranging up to eight (8) times nominal current rating. Provide fused external potential transformers for up to 500 kV.

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**MICROPROCESSOR BASED METERING EQUIPMENT**

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- .2 Control Power: the device shall also be capable of being supplied from a separate control power source with input range of 100 to 240 VAC.
- .3 Dry Contacts: three (3) dry discrete input contacts shall be capable of being monitored, which may be programmed by the user to perform any of the following functions. The status of the input contacts shall be locally displayable and accessible through the communications port.
  - .1 Trigger an Event/Alarm Analysis including Harmonic Analysis information for display on the device and information for Waveform Analysis and display at a personal computer.
  - .2 Act as a synchronizing pulse input to synchronize demand windows with a utility provided synchronizing pulse.
  - .3 Actuate a relay output.
  - .4 Reset a relay output, peak demand, Minimum/Maximum, or Event Analysis records.
- .5 Furnish Relay Output Contacts with four (4) Form C (NO/NC) relay output contacts which shall be capable of being independently programmed for the following functions:
  - .1 Act as a kWH, kVARH, or kVAH pulse initiator output.
  - .2 Actuate on one (1) or more Event/Alarm conditions, including discrete inputs and Communication Command signal.
- .6 Furnish one (1) 4 to 20 mA analog input and four (4) 4 to 20 mA outputs.
- .7 The device shall be fully programmable from the faceplate, including alarm relay and power quality (e.g., harmonic distortion) settings. Programming shall be password protected.
- .8 Analyzer shall be complete with Ethernet connection to communicate with the DCSA System.

**2.2 Medium Voltage Protective relays**

- .1 Relays for phase time overcurrent, instantaneous overcurrent and ground fault protection, ANSI 50/51, 50/51G, or 50/51N, shall be incorporated into a single device.
- .2 The relay shall be a solid-state microprocessor-based multifunctional type that operates from the 5 ampere secondary output of current transformers. The relay shall provide ANSI 50/51N protective functions for each of the 3 phases, and ANSI 50/51N or 50/51G ground fault protection functions as shown on the plans or as determined by the coordination study. The relay shall be true rms sensing of each phase and ground. Ground element shall be capable of being utilized in residual, zero sequence, ground source connection schemes, or deactivated.

**MICROPROCESSOR BASED METERING EQUIPMENT**

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- .3 The primary current transformer rating being used for phase and ground protection feeding the device shall be programmable for current transformers with primary current ratings from 5 through 5,000 amperes.
- .4 Both the phase and ground protection curves shall be independently field-selectable and programmable with or without load. Curves shall be selectable from the following:
  - .1 IEEE: Moderately inverse, very inverse, extremely inverse
  - .2 IEC: A, B, C or D
  - .3 Thermal: Flat,  $I_t$ ,  $I^2t$ ,  $I^4t$
  - .4 Thermal curves shall be similar to those on low voltage trip units for close coordination with downstream devices. Selectable short delay pickup and short delay time settings shall also be provided. The phase instantaneous overcurrent trip shall have field-programmable pickup points from 1.0 to 25 times current transformer primary rating or NONE. In addition, a field-selectable (ON or OFF) discriminator circuit shall be included such that when phase instantaneous overcurrent has been programmed to NONE, the discriminator circuit shall protect against currents exceeding 11 times current transformer primary rating, only when the breaker is being closed and shall be deactivated after approximately eight (8) cycles.
- .5 The relay shall be field-configurable to have either of the following function combinations assigned to its two type "a" contacts: 1) one contact assigned ANSI 51 phase and ANSI 51 ground and the other contact assigned ANSI 50 phase and ANSI 50 ground; 2) one contact assigned ANSI 51/50 phase and the other contact assigned 51/50 ground.
- .6 The relay shall have a built-in alphanumeric display capable of displaying the following information with metering accuracy of  $\pm 1$  percent of full scale ( $I_n$ ) from  $0.04 \times I_n$  to  $1 \times I_n$  and  $\pm 2$  percent of full scale ( $I_n$ ) from  $1 \times I_n$  to  $2 \times I_n$ :
  - .1 Individual phase currents
  - .2 Ground current
  - .3 Cause of trip
  - .4 Magnitude and phase of current causing trip
  - .5 Phase or ground indication
  - .6 Peak current demand for each phase and ground since last reset
  - .7 Current transformer primary rating
  - .8 Programmed phase and ground set points

**MICROPROCESSOR BASED METERING EQUIPMENT**

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- .7 Relay shall have the following features:
  - .1 Integral manual testing capability for both phase and ground protection function. Testing shall be selectable to either operate contact outputs or not operate output contacts.
  - .2 Continuous self-testing of internal circuitry.
  - .3 Unit failure alarm contact for customer use.
  - .4 Programmable lockout/self reset after trip function.
  - .5 Programmable set points for device curve selection.
  - .6 Programmable inputs, such as current transformer ratios.
  - .7 Access to program and test modes shall be via sealable hinged cover for security.
- .8 Relay shall be suitable for operating temperatures from -30°C to 55°C. Relay shall be suitable for operating with humidity from 0 to 95 percent relative humidity (non-condensing).
- .9 Relay shall have Ethernet communication capability. Relay shall be capable of the following over the communication network:
  - .1 Ability to transmit all information contained in the relay such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
- .10 Relay alarm and/or trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip upon detection of an overcurrent or fault condition based upon programmed settings. A “protection OFF” alarm shall be provided which is normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. Upon loss of power or relay failure, this alarm relay shall be de-energized providing a failsafe protection OFF alarm.
- .11 The relay shall be suitable for operating on control power with a nominal input voltage of 12 to 240 VAC 60 Hz. When AC control power schemes are shown on the drawings, in addition to control power transformer or remote control power shown or herein specified, dual-source power supply shall be included.
- .12 Provide a dual-source power supply (DSPS) for each relay when operated from standard 120 VAC, or, 50/60 Hz, auxiliary control power which is normally connected and available. The DSPS shall operate solely from the breaker main current transformers (CTs) during a fault condition, if the normally connected auxiliary AC voltage is not available. A battery or UPS as power shall not be required for reliable tripping under all fault conditions. The DSPS shall operate anytime there is a fault, even after an extended power outage. When the standard auxiliary power supply is not available, the DSPS shall provide enough power to operate the overcurrent relay in the tripped state with currents greater than 1.8 per unit rated secondary current, 9A with a single-phase current, 1.2 per unit secondary current or 6A with



### **MICROPROCESSOR BASED METERING EQUIPMENT**

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three-phase currents. There shall be no effect on the overcurrent relay trip time accuracy when the DSPS switches from normal AC voltage to fault-current power.

- .13 Provide the relay in a drawout case allowing for removal and replacement of the relay unit without disruption of the wiring. The drawout case shall have quick release operation with two-stage disconnect operation. The removal of the relay inner chassis shall disconnect the trip circuits and short the CT secondaries before the unit control power is disconnected. All voltage inputs, discrete inputs and contact outputs shall be disconnected while maintaining security against false tripping. Upon insertion of the relay inner chassis, the control power connections shall be made before the trip circuits are activated to provide additional security against false tripping. Drawout case terminals shall accommodate a bare wire connection, spade or ring terminals. A spare self-shortening contact on the terminal block shall be available to provide alarm indication and/or tripping of circuit breaker upon removal of the relay from the case.

#### **2.3 Acceptable Manufacturers**

- .1 Eaton Cutler-Hammer – Analyzer – IQ Analyer 6600 or approved equal.

### **3. EXECUTION**

#### **3.1 Installation**

- .1 Analyzer and protective relay shall be factory installed and connected in designated cubicles.

**END OF SECTION**

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**DISCONNECT SWITCHES FUSED AND NON-FUSED UP TO 600 V - PRIMARY**

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**1. GENERAL**

**1.1 Description**

- .1 Provide disconnect switches for 347/600 V and 120/208 V distribution as indicated on the Drawings, as manufactured by Eaton Cutler-Hammer or Schneider.

**2. PRODUCTS**

**2.1 Disconnect Switches**

- .1 Ratings: 600 V for 347/600 V distribution, 240 V for 120/208 V distribution. Unless otherwise shown, 3 pole for 3-phase, 3 wire distribution, 3 pole, and solid neutral for 3-phase 4 wire distribution. Ampere ratings as shown on the Drawings or to suit load requirements. For motors, use disconnects switches with HP ratings at least equal to motor HP.
- .2 Enclosures: CSA code gauge galvanized steel, hinged doors, external operating handles. Disconnect switches in dry locations shall be EEMAC-1 and EEMAC-3 where exposed to weather. Provide ON-OFF switch position indication on switch enclosure cover.
- .3 Finish: one (1) primer coat and one finish coat on all metal surfaces, colours as per Section 16010 - Electrical General Requirements.
- .4 Switch mechanisms: quick-make and quick-break action with self-wiping contacts, solderless pressure lug connectors. For switches 100 amperes and over, provide non-tracking arc shrouds. All switch poles to operate together from a common operating bar. Provide for padlocking disconnect switches in OFF position. Doors to be interlocked and complete with defeat mechanism, to prevent opening when handle in ON position.
- .5 Neutral Bars: where distribution system has grounded neutral conductor, provide neutral bar where required with ampere rating equal to switch rating, in enclosure. Provide ground bar for terminating ground conductors.
- .6 Fuse Holders: provide fuse holders (relocatable and suitable without adapters) on load side of switches, ampere rating equal to switch ratings, suitable for fuses specified.

**2.2 Fuses**

- .1 All fuses to be 100,000 A (minimum) interrupting capacity of the current limited type. In addition, fuses feeding motors to be of the time delay type. Provide one (1) full set of spare fuses, three (3) for each different ampere rating used, stored in suitable enclosure.

**DISCONNECT SWITCHES FUSED AND NON-FUSED UP TO 600 V - PRIMARY**

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**3. EXECUTION**

**3.1 Disconnect Switches**

- .1 Mounting: provide supports independent of conduits. Wall-mount where possible, otherwise provided Unistrut frame support. Where switches are grouped mount in uniform arrangement.
- .2 Wiring: connect line and load cable to all switches.
- .3 Fuse Rating: install so that rating is visible.
- .4 Identification: provide lamacoid plate in accordance with Section 16010 - Electrical General Requirements, on each switch showing voltage, source of supply and load being fed, for example:
  - .1 Door Controller
  - .2 120/208 V
  - .3 Fed from PPA
- .5 Nameplate: Size 3

**END OF SECTION**

## **GROUNDING - SECONDARY**

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### **1. GENERAL**

#### **1.1 Description**

- .1 Supply and install a complete secondary grounding system to include new equipment provided in this Contract. Securely and adequately ground all components of the electrical system in accordance with the requirements of all related sections in the latest Canadian Electrical Code, Local Building Code, and the local Electrical Inspection Branch.
- .2 The system is to consist of cables, supports, and all necessary materials and inter-connections to provide a complete system. Measured resistance to ground of the network shall not exceed 5 ohms.
- .3 All ground conductors shall be run in conduit.

#### **1.2 References**

- .1 ANSI/IEEE 837, Qualifying Permanent Connections Used in Substation Grounding
- .2 CSA Z32.1, Safety in Anaesthetizing Locations

### **2. PRODUCTS**

#### **2.1 Equipment**

- .1 Cables 2/0 and smaller to be connected to ground bars via Burndy Quiklug Type QA-2B connectors. Connections for cables larger than 3/0 shall be brazed.
- .2 All ground wires to be stranded copper TWH complete with a green jacket unless otherwise shown.
- .3 Uninsulated ground wires shall be bare stranded copper, soft annealed. Size as indicated.
- .4 Main Electrical Room: provide a copper ground bar complete with lugs suitable to terminate all ground cables. Ground bus shall be 12 mm thick, 100 mm high and 1,000 mm long. Bus shall be complete with pre-drilled holes suitable for lug mounting as required. Refer to Drawings for details.
- .5 Control Room: provide a copper ground bar complete with lugs suitable to terminate all ground cables. Ground bus shall be 12 mm thick, 100 mm high and 500 mm long. Bus shall be complete with pre-drilled holes suitable for lug mounting as required. Refer to Drawings for details.
- .6 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:
  - .1 Grounding and bonding bushings.

## **GROUNDING - SECONDARY**

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- .2 Protective type clamps
- .3 Bolted type conductor connectors
- .4 Bonding jumpers, straps
- .5 Pressure wire connectors

### **3. EXECUTION**

#### **3.1 General**

- .1 Install complete permanent, continuous grounding system, including conductors, accessories. Where EMT is used, run ground wire in conduit. All connectors shall be installed in accordance with manufacturers' requirements. All frames and metallic enclosures of all electrical equipment and electrically operated equipment shall be grounded through the conduit system or via a ground wire.
- .2 All transformers, switchgear, motor control centres, panelboards and splitters fed from the main distribution centre shall be grounded by grounding conductors sized in accordance with the Canadian Electrical Code. The ground wire shall be terminated at each end with an appropriate grounding lug which shall be connected to the equipment ground bus. Ground wire to be green TWH. Use mechanical connectors for grounding connections to equipment provided with lugs.
- .3 All sub panels such as lighting panels, local distribution panels, etc., shall be grounded with a green ground wire run back to the panel from which it is fed. The ground conductor shall be sized according to the Canadian Electrical Code.
- .4 All main distribution centres, motor control centres, switchgear, and all panels requiring equipment grounds shall contain a ground bus of adequate size, and tapped for lugs for the ground wire required.
- .5 All bolted connections must be accessible.
- .6 All motors shall be grounded by means of an adequately sized green ground wire contained within the feeder conduit.
- .7 Include a separate green ground wire in all power conduits including branch circuit wiring sized to Canadian Electrical Code.
- .8 Expansion joints and telescoping sections of raceways shall be bonded using jumper cables as per Canadian Electrical Code.
- .9 Use Burndy compression connectors or approved equal for all grounding splices and terminations unless otherwise shown on the Drawings. For bolted ground connections use Burndy "Durium" or approved equal hardware.

## **GROUNDING - SECONDARY**

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- .10 Connect all transformer neutrals to the main building ground wire, using compression terminations.
- .11 Install rigid conduit sleeves where ground wires pass through concrete slabs.
- .12 Conduit installed buried in earth or installed in or under grade floor slabs shall have separate ground wire installed, whether the conduits are metal or not.
- .13 Ground all utility services to the electrical system ground.
- .14 Protect exposed grounding conductors from mechanical injury.
- .15 Install bonding wire for flexible conduit, connected at one end to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.
- .16 Install flexible ground straps for bus duct enclosure joints, where such bonding is not inherently provided with equipment.
- .17 Soldered joints shall not be permitted.
- .18 Bond single conductor, metallic armoured cables to cabinet at supply end, and provide non-metallic entry plate at load end.
- .19 Install electrical room ground bus to wall as indicated, utilizing insulated off sets.

### **3.2 System and Circuit Grounding**

- .1 Install system and circuit grounding connections to neutral of secondary 600 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, switchgear, duct systems, frames of motors, motor control centres, starters, control panels distribution panels.

### **3.4 Field Quality Control**

- .1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems.
- .2 Perform ground continuity and resistance tests using method appropriate to Site conditions and to approval of Contract Administrator and local authority having jurisdiction over installation.
- .3 Perform tests before energizing electrical system.

**GROUNDING - SECONDARY**

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- .4 Disconnect ground fault indicator during tests.

**END OF SECTION**

**DRY TYPE TRANSFORMERS UP TO 600 V - PRIMARY**

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**1. GENERAL**

- .1 Provide enclosed dry type transformers 600 V primary to 120/208V.
- .2 Product Data – 3-phase, 4 Wire Secondary.
  - .1 Submit product data in accordance with Section 16010 - Electrical General Requirements.
- .3 Transformers to conform to CSA C57.12 and L2 standards, and are to be approved to CSA Code Part 2, Standard C22.2, No. 47 and CSA C9.

**2. PRODUCTS**

**2.1 Transformers**

- .1 General: dry type, air-cooled, self-ventilated. Enclosures to be EEMAC 1 type, code gauge steel, complete with ventilation openings, access panels, mounting brackets, and solderless primary and secondary cable connectors. Enclosures to have zinc chromate prime coat and enamel finish coat per Section 16010. Transformers to be single- or three-phase as noted on the Drawings.
- .2 Design
  - .1 Type: ANN
  - .2 3-phase, kVA as indicated on the Drawings, 600 V input, 120/208 V output, 60 Hz.
  - .3 Voltage primary taps: 2.5 percent full capacity above and below normal.
  - .4 Insulation: Class H
  - .5 Basic Impulse Level (BIL): 10 kV B.I.L.
  - .6 Hipot: 4 kV
  - .7 Average Sound Level: to meet the local municipal & building codes and meet at minimum the following criteria:
    - .1 45 dB maximum up to 45 kVA
    - .2 50 dB maximum up to 150 kVA
    - .3 55 dB maximum up to 300 kVA
    - .4 60 dB maximum above 500 kVA



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**DRY TYPE TRANSFORMERS UP TO 600 V - PRIMARY**

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- .8 Impedance at 170°C: 6.0 percent maximum up to 112.5 kVA; 5.5 percent maximum above 112.5 kVA.
- .9 Enclosure: EEMAC 1, removable metal front panel.
- .10 Mounting: up to 45 kVA suitable for wall or floor mounting and above 45 kVA suitable for floor mounting unless otherwise shown.
- .11 Finish: In accordance with Section 16010 - Electrical General Requirements.
- .12 Three Phase Windings: arrange with three primary windings connected in delta and three secondary windings connected in wye.
- .13 Max. Winding Temperature: 150°C rise with temperature continuous full load.
- .14 Max. Lead Connection: 55°C rise with temperature continuous full load.
- .15 Copper winding.

**2.2 Equipment Identification**

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
- .2 Label: Size 7

**2.3 Acceptable Manufacturers:**

- .1 Eaton Culter-Hammer
- .2 Schneider
- .3 Hammond Manufacturing
- .4 Delta Transformers
- .5 BEMAG Transformers

**3. EXECUTION**

**3.1 Installation**

- .1 Mount dry type transformers up to 45 kVA as indicated.
- .2 Mount dry type transformers above 45 kVA on floor.
- .3 Ensure adequate clearance around transformer for ventilation

**DRY TYPE TRANSFORMERS UP TO 600 V - PRIMARY**

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- .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 Mount transformers as indicated on Drawings and connect primary, secondary, neutral and ground conductors. Provide brackets and bolts for wall mounted transformers. Ensure all transformers have good ventilation.
- .9 Do not use permanent distribution system dry type transformers for temporary power distribution without permission from the Contract Administrator.
- .10 Mount transformers to reduce direct and transmitted noise. Mount core and coils of transformers on vibration and sound absorbing pads.
- .11 Record secondary voltage when transformers are carrying approximately 75 percent of full load. Adjust tap connections to give a continuous secondary voltage of 120 V phase to neutral. Set tap connections for above 120 V rather than below.
- .12 Connections to transformers shall be in flexible conduit and shall enter the enclosure below the coils.
- .13 Before energization, keep transformers or storage room enclosures above 10°C ambient.

**END OF SECTION**

## **PANELBOARDS - BREAKER TYPE**

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### **1. GENERAL**

#### **1.1 Shop Drawings**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements.
- .2 Drawings to include electrical detail of panel, branch breaker type, quantity, ampacity and enclosure dimension.

### **2. PRODUCTS**

#### **2.1 Panelboards**

- .1 Panelboards: product of one manufacturer.
  - .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.
- .2 Panelboards: bus and breakers rated for 250 V to be 14 KA, 600 V to be 18 KA (symmetrical interrupting capacity) or as indicated.
- .3 Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.
- .4 Panelboards: mains, number of circuits, and number and size of branch circuit breakers as indicated.
- .5 Two (2) 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 with concealed front bolts and hinges
- .9 Trim and door finish: baked grey enamel
- .10 TVSS surge protection – bus connected

#### **2.2 Breakers**

- .1 Breakers: refer to Section 16477 - Moulded Case Circuit Breakers
- .2 Breakers with thermal and magnetic tripping in panelboards except as indicated otherwise.

**PANELBOARDS - BREAKER TYPE**

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- .3 Main breaker: separately mounted on top or bottom of panel to suit cable entry. When mounted vertically, down position should open breaker.

**2.3 Equipment Identification**

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
- .2 Nameplate for each panelboard Size 4 engraved as indicated.
- .3 Nameplate for each circuit in distribution panelboards Size 2 engraved as indicated.
- .4 Complete circuit directory with typewritten legend showing location and load of each circuit.

**2.4 Acceptable Products**

- .1 Eaton Cutler-Hammer
- .2 Schneider Electric

**3. EXECUTION**

**3.1 Installation**

- .1 Locate panelboards as indicated and mount securely, plumb, true and square, to adjoining surfaces.
- .2 Mount panelboards to height specified in Section 16010 - Electrical General Requirements or as indicated.
- .3 Connect loads to circuits.
- .4 Connect neutral conductors to common neutral bus with respective neutral identified.

**END OF SECTION**

## MOULDED CASE CIRCUIT BREAKERS

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### 1. GENERAL

#### 1.1 Product Data

- .1 Submit product data in accordance with Section 16010 - Electrical General Requirements.
- .2 Include time-current characteristic curves for breakers with interrupting capacity of 22,000 A symmetrical (rms) and over at system voltage.

### 2. PRODUCTS

#### 2.1 Breakers General

- .1 Bolt-On Moulded Case Circuit Breaker: quick-make, quick-break type, for manual and automatic operation with temperature compensation for 40°C ambient.
- .2 Common-Trip Breakers: with single handle for multi-pole applications.
- .3 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 three (3) to eight (8) times current rating.
- .4 Circuit breakers with interchangeable trips as indicated.

#### 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 Magnetic Breakers

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

#### 2.4 Moulded Case Switch

- .1 Moulded case switch shall be complete with a high instantaneous magnetic fixed trip, factory set to trip at high fault currents.

#### 2.5 Optional Features

- .1 Include where indicated on Drawings:
  - .1 Shunt trip
  - .2 Auxiliary switch

## **MOULDED CASE CIRCUIT BREAKERS**

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- .3 Motor-operated mechanism complete with time delay unit
- .4 Under-voltage release
- .5 On-off locking device
- .6 Handle mechanism
- .7 Keyed interlocks
- .8 Non-auto

### **2.6 Enclosure for Individually Mounted Breakers or Moulded Case Switch**

- .1 Enclosure shall be CSA code gauge galvanized steel, hinged door, front mounted external operating handle, lockable in “off” position, EEMAC-1 unless shown otherwise. Use EEMAC-12, for industrial application, enclosure for wet environment or as shown “WP” on Drawings. Increase enclosure size above standard for large cables.
- .2 Where distribution system has grounded neutral conductor, provide neutral bar, with ampere rating equal to breaker/switch rating in enclosure.

## **3. EXECUTION**

### **3.1 Installation**

- .1 Install circuit breakers as indicated on Drawings and specified herein.
- .2 Install circuit breakers in panelboards to satisfy branch circuit requirements under the Scope of Work of this Contract.
- .3 Provide 15 percent spare quantity of circuit breakers in each panelboard.
- .4 Identification: Provide lamacoid plate on each breaker showing voltage, source of supply and load being fed - 120/208 V, 3-phase, 4W fed from LDP No.1 to Splitter Trough No. 1.

**END OF SECTION**



## POWER SURGE PROTECTORS

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### 2.3 Filtering

- .1 TVSS shall contain a high frequency extended range-tracking filter.
- .2 Noise attenuation  $\geq 45$  dB @ 100 kHz.

### 2.4 Panelboard Component (Integrated TVSS Panel)

- .1 Main Bus: the device shall have a copper, tin-plated main bus.
- .2 Circuit Breakers: are to be of the over centre toggle mechanism type which use bolt-on connectors to line side panelboard connectors.
- .3 Panelboard Enclosure: the panelboard shall be provided in an EEMAC-1 enclosure. The TVSS/filter status indicators shall be visible without the need to open the panelboard door. A lockable door shall be provided to limit access to authorized personnel only. Trim assembly shall be tamper proof. The trim (doors) shall be finished in grey ASA61 paint.
- .4 Neutral Bus: the unit shall be equipped with a copper 100 percent rated neutral bus suitable for use with non-linear loads, which shall include a sufficient quantity at solderless type lugs to service the total unit circuit capacity.
- .5 Wiring Gutters: the integrated TVSS filtering panel shall be equipped with a complete perimeter wiring gutter with a cross-sectional dimensions of not less than 12,200 mm<sup>2</sup>.
- .6 Safety and Insulated/Isolated Ground Bus: the integrated filter panel shall have a safety and insulated/isolated ground bus equipped with solderless type lugs of quantity to sufficiently service the circuit loads.

### 2.5 General Features

- .1 The integrated TVSS panel shall be factory installed and connected to the bus bar.
- .2 Connectors: terminals shall be provided for all the necessary input and output power and ground connections on the TVSS.
- .3 Enclosure: the specified system shall be provided in a heavy duty NEMA 12 dust tight enclosure with no ventilation openings for maintenance and branch panel applications. Indication of surge current module status shall be visible without opening the door.
- .4 Internal Connections: all surge current diversion connections shall be by way of low impedance wiring. Surge current diversion components shall be wired for reliable low impedance connections. No plug-in component modules, quick disconnect terminals or printed circuit boards shall be used in surge suppression paths.
- .5 Unit Status Indicators: red status indicators shall be provided on the hinged front cover to indicate unit phase status. The absence of the red light shall reliably indicate that one or more surge current diversion phases have failed and that service is needed to restore full operation.



## **POWER SURGE PROTECTORS**

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- .6 Fuses: the unit shall utilize internal fuses rated with a minimum interrupting capability of 200,000 A or greater.
- .7 Identification: the unit shall include manufacturer's nameplate, UL rating, and a CSA approval on the exterior enclosure.
- .8 Warranty: the manufacturer shall provide a five year warranty on the TVSS filter, a one year warranty on the panelboard and circuit breakers, and a one year warranty on individual equipment plug-in units. These warranties shall commence from date of shipment.
- .9 Testing: testing at each unit shall include assurance checks, "Hi-Pot" test at two (2) times rated voltage plus 1000 V per UL requirements, and operation and calibration tests.

### **2.6 Approved Manufacturers**

- .1 IT Innovative Technology Inc.
  - .1 Main panel application: PTE 300
  - .2 Branch panel application: PTE 300
- .2 Cutler Hammer
  - .1 Main panel applications: Model Visor Series
  - .2 Branch panel application: Model Visor Series
- .3 Tyco International Corporation.
  - .1 Main and branch panel applications: Model PTY-HE

## **3. EXECUTION**

### **3.1 Installation**

- .1 Install with manufacturer's recommended conductors tapped from the electrical service switchboard conductor system. Conductors are to be as short and as straight as possible. Input conductors to the TVSS shall be twisted together to reduce impedance during high frequency filtering.
- .2 An appropriately sized manual safety disconnect shall be installed before and in line with the TVSS from the electrical service for the purpose of electrically isolating the device from the system should service be required without interrupting the main service. Coordinate required disconnect ampacity with TVSS manufacturer.
- .3 The TVSS should be following the manufacturer's recommended practices as outlined in the manufacturer's installation and maintenance manual and in compliance with all applicable electrical codes.

**POWER SURGE PROTECTORS**

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- .4 Individual equipment protection devices shall be installed at the same voltage rating as the intended protected equipment and as close as possible to the intended protected equipment.

**END OF SECTION**

## CONTACTORS

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### 1. GENERAL

#### 1.1 Description

- .1 Supply and Install contactors as indicated on Drawings and specified herein to ensure a complete operational system.
- .2 This Specification covers contactors for voltages up to 600 V. Refer to Drawings for voltage, amperage, number of poles, and auxiliary contacts.

#### 1.2 Product Data

- .1 Submit product data in accordance with Section 16010 - Electrical General Requirements.

### 2. PRODUCTS

#### 2.1 Contactors

- .1 Contactors: to EEMAC No.1CS
- .2 Electrically held controlled by pilot devices as indicated and rated for type of load controlled. This rating shall be on the basis of incandescent or non-inductive loading for continuous operation. Half size contactors not accepted. All contactors shall have 120 V operating coils.
- .3 Breaker combination contactor as indicated.
- .4 Complete with two (2) normally open and two (2) normally closed auxiliary contacts unless indicated otherwise.
- .5 Mount in CSA Enclosure 1 unless otherwise indicated.
- .6 Include the following options in cover:
  - .1 Red indicating lamp
  - .2 Hand-Off-Auto selector switch
  - .3 On-Off selector switch
- .7 Control transformer: to Section 16825 - Control Devices, in contactor enclosure.

#### 2.2 Equipment Identification

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.

**CONTACTORS**

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- .2 Provide a Size 4 nameplate indicating name of load controlled.

**3. EXECUTION**

**3.1 Installation**

- .1 Install contactors and connect auxiliary control devices where indicated on Drawings and specified herein.
- .2 Contactors shall be mounted separately in suitable CEMA-1 enclosures.

**END OF SECTION**

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**GENERAL PROVISIONS FOR EXTERIOR AND INTERIOR LIGHTING**

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**1. GENERAL**

**1.1 Work Included**

- .1 Supply and install lighting fixtures complete with lamps, ballasts and all necessary fittings.

**1.2 Code Requirements**

- .1 Installation of lighting equipment to conform to Section 30, Canadian Electric Code, Part 1, and as amended or supplemented by provincial, municipal or other regulatory agencies having jurisdiction.

**1.3 Shop Drawings**

- .1 Submit a complete list of the types of lighting fixtures, lamps, ballasts and accessories with catalogue illustrations, data sheets, etc. for review. Bind in a suitable booklet and keep one copy of this booklet at the jobsite at all times.
- .2 Submit complete photometric data, based on actual fixtures proposed for project. Substantiate brightness and efficiency requirements. Photometric data must be produced by a recognized independent laboratory.

**1.4 Manufacturer's Operational Test**

- .1 Test fixtures for acceptance of lamp made to maximum tolerance as required in ANS standards.
- .2 Test fixtures with rated lamps for starting and operation.
- .3 Check wiring for agreement with design circuit.
- .4 Test for short circuits and improper grounds.
- .5 Test operation of fixture and lamp with ballast.

**1.5 Samples**

- .1 Provide samples of all fixtures, lamps, ballasts and accessories when requested.
- .2 If directed, set up these fixtures on or near Site, to show co-ordination of fit with ceiling and other equipment i.e., mechanical air diffuser assemblies, wiring channels, brackets, davits and standards. Retain fixture design, if approved, at the Site as a control standard. If submitted fixtures are disapproved, resubmit after revision for further field tests until approval is given.
- .3 Install one or more sample fixtures in a mock-up of specified ceiling. Pay all costs associated with Work of this trade in connection with construction of mock-up, installation and connection of fixtures, lamps, ballasts and accessories.

**GENERAL PROVISIONS FOR EXTERIOR AND INTERIOR LIGHTING**

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**1.6 Lamps Used for Temporary Lighting**

- .1 Fluorescent or mercury lamps may be used for temporary light and lamps used for this purpose will be accepted when the project or portions of the Work are turned over to the City. Spot relamp faulty or burned out lamps prior to this acceptance, without additional cost to the City.
- .2 Metal halide, sodium, incandescent and quartz lamps are not to be used for temporary lighting, unless all lamps so used are replaced with new lamps immediately prior to completion at no additional cost to the City.

**2. PRODUCTS**

- .1 All lighting units and associated equipment shall be Manitoba Hydro PowerSmart approved where applicable.
- .2 Provide, wherever possible, commercially available stock lighting fixtures meeting specified requirements and as shown on the Drawings.
- .3 Different fixtures may be supplied by different manufacturers. Similar fixtures shall be supplied by the same manufacturer.
- .4 Provide only lighting fixtures, which are structurally well designed and constructed, and which use new parts and materials of highest commercial grade available. Unless otherwise specifically noted, fixtures shall be of the quality stated in the manufacturer's catalogues and data sheets.
- .5 Refer to Luminaire Schedule on Drawings for details of fixtures and accessories.
- .6 Use self-aligning ball joint hangers for rod suspended fixtures.
- .7 Use cadmium plated chains for suspended fixtures in unfinished areas.

**3. EXECUTION**

**3.1 Installation**

- .1 Install fixtures in accordance with the manufacturer's requirements, code requirements, and as shown on the Drawings.
- .2 Confirm compatibility and interface of other materials with luminaire and ceiling systems. Examine the room finish schedule and reflected ceiling Drawings. Report discrepancies and defer ordering until clarified.
- .3 Supply plaster frames, trim rings and backboxes to other trades as the Work requires.

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**GENERAL PROVISIONS FOR EXTERIOR AND INTERIOR LIGHTING**

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- .4 Ground lighting equipment to metal raceway, armour of armoured cable, grounding conductor in non-metallic sheathed cable, or to a separate grounding conductor.
- .5 Coordinate with other trades to avoid conflicts between luminaires, supports, and fittings and mechanical and structural equipment.
- .6 Provide guards where fixtures are subject to mechanical damage as required by code or shown on the Drawings.

**3.2 Workmanship**

- .1 Completely clean all glassware, lamps, and hangers. Polish metal parts before completion.
- .2 Provide suitable extension couplings for row mounted fixtures.
- .3 Protect fixtures, hangers, supports, fastenings and accessory fittings at the Site prior to and during installation. Unless fixtures are erected immediately, after delivery to Site, deliver in original cartons or enclosed in air-tight plastic wrapping. Store in a dry and secure space on-site. Protect hangers, supports, fastenings and accessory fittings against corrosion. Take care during installation to ensure that insulation and corrosion protection is not damaged.
- .4 Fixtures which show evidence of corrosion, rough handling, scratching of finishes, etc. are to be replaced with new fixtures at no additional cost.
- .5 Install recessed fixtures to permit removal from below, for access to outlet or prewired fixture box.
- .6 Hang and mount fixtures to prevent distorting fixture frame, housing, sides or lens frame, and permit correct alignment of several fixtures in a row.
- .7 Support fixtures as shown on Drawings, level, plumb and true with structure and other equipment in horizontal or vertical position as intended. Install wall or side bracket mounted fixture housings rigidly and adjust to a neat flush fit with mounting surface.
- .8 Adjust length of hangers of suspended fixtures to hang fixture bodies level and in same horizontal plane, unless shown otherwise on Drawings.
- .9 Install ceiling canopies to cover suspension attachments and fit tightly to ceiling without restricting alignment of hanger.
- .10 For recessed fluorescent fixtures mounted in suspended ceiling with exposed tee bar grid system, support by the ceiling tee bar grid structure. Provide any additional support necessary for oversize fixtures, or to meet code requirements.
- .11 Metal inserts, expansion bolts or toggle bolts which do not carry wiring shall be accurately located in relation to outlet boxes, for perfect alignment and spacing of suspension stems or other hangers.

**GENERAL PROVISIONS FOR EXTERIOR AND INTERIOR LIGHTING**

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- .12 For remote mounted ballasts, supply mounting board and space ballasts in accordance with manufacturer's directions. Size wiring from ballasts to remote fixtures to meet manufacturer's requirements.
- .13 Remove any noisy ballasts from the fixtures and replace at no additional cost to the City prior to completion.

**END OF SECTION**



## **EXIT LIGHTS**

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### **1. GENERAL**

#### **1.1 Product Data**

- .1 Submit duct data in accordance with Section 16010 Electrical General Requirements.

#### **1.2 References**

- .1 CSA C860

### **2. PRODUCTS**

#### **2.1 Standard Units**

- .1 Housing: molded high impact thermo plastic
- .2 Face and back plates: molded high impact thermoplastic.
- .3 Lamps: LED-2W 120 V
- .4 Letters: 150 mm high x 19 mm, with 13 mm thick stroke, red on white glass, reading EXIT
- .5 Face plate to remain captive for relamping
- .6 Universal mounting

### **3. EXECUTION**

#### **3.1 Installation**

- .1 Install exit lights
- .2 Connect fixtures to exit light circuits
- .3 Connect emergency lamp sockets to emergency circuits
- .4 Ensure that exit light circuit breaker is locked in on position

**END OF SECTION**

## UNIT EQUIPMENT FOR EMERGENCY LIGHTING

---

### 1. GENERAL

#### 1.1 Work Included

- .1 Supply emergency lighting units complete with all accessories.

#### 1.2 Special Codes

- .1 Canadian Electric Code, Part 1, Section 46 "Emergency Systems, Unit Equipment and Exit Signs"
- .2 CSA Standard C22.2 No. 141 "Unit Equipment for Emergency Lighting"
- .3 Manitoba Building Code

#### 1.3 Product Data

- .1 Submit product data in accordance with Section 16010 - Electrical General Requirements.
- .2 Data to indicate system components, mounting method, source of power and special attachments.

#### 1.4 Warranty

- .1 For batteries, the 12 months warranty period prescribed in subsection GC 32.1 of General Conditions "C" is extended to 120 months, with a no-charge replacement during the first five years and a pro-rate charge on the second five years.

### 2. PRODUCTS

#### 2.1 General

- .1 Supply and Install battery power emergency lighting where shown on the Drawings. Lights are to switch "ON" automatically in the event of failure of normal power, and "OFF" on restoration of power. The batteries shall be automatically recharged from a 120 VAC supply.

#### 2.2 Equipment

- .1 Supply voltage: 120 V AC
- .2 Output voltage: 12 V DC
- .3 Operating time: 30 minutes
- .4 Charger: solid state, multi-rate, voltage/current regulated, inverse temperature compensated, short circuit protected with regulated output of  $\pm 0.01$  V for  $\pm 10$  percent input variations.

### **UNIT EQUIPMENT FOR EMERGENCY LIGHTING**

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- .5 Solid state transfer circuit.
- .6 Low voltage disconnect: solid state, modular, operates at 80 percent battery output voltage.
- .7 Signal lights: solid state, for 'AC Power ON' and 'High Charge'.
- .8 Lamp heads: integral on unit and remote, 345° horizontal and 180° vertical adjustment. Lamp type: tungsten, 12 W, minimum.
- .9 Cabinet: suitable for direct or shelf mounting to wall and complete with knockouts for conduit. Removable or hinged front panel for easy access to batteries.
- .10 Finish: Whist Metal
- .11 Auxiliary equipment:
  - .1 Ammeter
  - .2 Voltmeter
  - .3 Test switch
  - .4 Time delay relay
  - .5 Battery disconnect device
  - .6 AC input and DC output terminal blocks inside cabinet
  - .7 Shelf
  - .8 Cord and single twist-lock plug connection for AC
  - .9 RFI suppressors.

#### **2.3 Line Connection**

- .1 Each battery unit shall be equipped with AC line cord and plug.

#### **2.4 Units**

- .1 Units to contain solid state battery charger, transfer switch and batteries. Provide all relays, hardware and circuitry for operation specified. Units to have push-to-test switch, "ON" and "CHARGING" lights with extended lamp life.

#### **2.5 Batteries**

- .1 Unless specifically indicated provide batteries of sufficient watt-hour capacity to power the loads connected to each individual unit for 30 minutes, 12 V, long life, maintenance free, sealed lead acid batteries, contained within the units.

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**UNIT EQUIPMENT FOR EMERGENCY LIGHTING**

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**2.6 Wire Guard**

- .1 Where indicated provide substantial wire guards with chrome finish, for battery units and/or lamps.

**2.7 Wiring of Remote Heads**

- .1 Conduit: type Rigid Galvanized Steel, to Section 16111 - Conduits, Conduit Fastenings and Conduit Fittings.
- .2 Conductors: # 12 R90 (minimum) type to Section 16122 - Wires and Cables 0 - 1000 V, sized in accordance with manufacturer's recommendations.

**3. EXECUTION**

**3.1 Installation**

- .1 Mount battery units with the bottom of the enclosure not less than 2.2 m above the floor, where practicable.
- .2 Install duplex receptacle adjacent to unit and connect to 1-phase, 120 V unswitched area lighting circuit.
- .3 Where applicable wire from unit to exit lights.
- .4 Wiring from units to remote heads and/or exit lights shall be sized to prevent voltage drop of more than 5 percent.
- .5 All emergency heads shall be properly aimed.

**END OF SECTION**

## **FIRE ALARM SYSTEMS**

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### **1. GENERAL**

#### **1.1 Related Work**

- .1 Conduits, Conduit Fastenings and Conduit Fittings: Section 16111
- .2 Wires and Cables 0 - 1000 V: Section 16122
- .3 Instrumentation and Control: Division 17

#### **1.2 References**

- .1 CAN/ULC-S524, Installation of Fire Alarm Systems
- .2 ULC-S525, Audible Signal Appliances for Fire Alarm Systems
- .3 CAN/ULC-S526, Visual Signal Appliances, Fire Alarm
- .4 CAN/ULC-S527, Control Units, Fire Alarm
- .5 CAN/ULC-S528, Manual Pull Stations
- .6 CAN/ULC-S529, Smoke Detectors, Fire Alarm
- .7 CAN/ULC-S530, Heat Actuated Fire Detectors, Fire Alarm
- .8 CAN/ULC-S536, Inspection and Testing of Fire Alarm Systems
- .9 CAN/ULC-S537, Verification of Fire Alarm Systems
- .10 NBC, National Building Code of Canada
- .11 CSA C22.1 Section 32, Fire Alarm Systems and Fire Pumps
- .12 Local Building Code

#### **1.3 Description of System**

- .1 System includes:
  - .1 Control panel to carry out fire alarm and protection functions including receiving alarm signals, initiating general alarm, supervising system continuously, actuating zone annunciators, and initiating trouble signals.
  - .2 Trouble signal devices
  - .3 Power supply facilities

## **FIRE ALARM SYSTEMS**

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- .4 Manual alarm stations
- .5 Automatic alarm initiating devices
- .6 Audible signal devices
- .7 End-of-line devices
- .8 Annunciators
- .9 Visual alarm signal devices
- .10 Ancillary devices

### **1.4 Shop Drawings**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements.
- .2 Include:
  - .1 Layout of equipment
  - .2 Zoning
  - .3 Complete wiring diagram, including schematics of modules.

### **1.5 Operation and Maintenance Data**

- .1 Provide operation and maintenance data for Fire Alarm System for incorporation into manual specified in Section 16010 - Electrical General Requirements.
- .2 Include:
  - .1 Operation and maintenance instructions for complete fire alarm system to permit effective operation and maintenance.
  - .2 Technical data - illustrated parts lists with parts catalogue numbers.
  - .3 Copy of approved Shop Drawings.
  - .4 List of recommended spare parts for system.

### **1.6 Maintenance Materials**

- .1 Provide maintenance materials in accordance with Section 01300 - Submittals.

## **FIRE ALARM SYSTEMS**

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### **1.7 Maintenance**

- .1 Provide one year's free maintenance with two (2) inspections by manufacturer during warranty period. Inspection tests to conform to CAN/ULC-S536. Submit inspection report to the Contract Administrator.

### **1.8 Training**

- .1 Arrange and pay for two (2) on-site lectures and demonstrations by fire alarm equipment manufacturer to train operational personnel in use and maintenance of fire alarm system. Seminars will use actual demonstration.
- .2 A representative from the manufacturers shall attend the seminar.

## **2. PRODUCTS**

### **2.1 Materials**

- .1 Equipment and devices: ULC listed and labeled and supplied by single manufacturer.
- .2 Power supply: to CAN/ULC-S524
- .3 Audible signal devices: to ULC-S525
- .4 Visual signal devices: to CAN/ULC-S526
- .5 Control unit: to CAN/ULC-S527
- .6 Manual pull stations: to CAN/ULC-S528
- .7 Thermal detectors: to CAN/ULC-S530
- .8 Smoke detectors: to CAN/ULC-S529

### **2.2 System Operation**

- .1 Single stage operation. Operation of any alarm initiating device to:
  - .1 Cause audible signal devices to sound throughout building.
  - .2 Transmit signal to fire department via monitoring station.
  - .3 Cause zone of alarm device to be indicated on control panel.
  - .4 Cause air conditioning and ventilating fans to shut down or to function so as to provide required control of smoke movement.
  - .5 Cause fire doors and smoke control doors if normally held open, to close automatically.

## FIRE ALARM SYSTEMS

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### 2.3 Control Panel

- .1 Class B
- .2 Single stage operation
- .3 Zoned
- .4 Non-coded
- .5 Enclosure: CSA Enclosure 1, complete with lockable concealed hinged door, full viewing window, flush lock and two (2) keys. Enclosure to be suitable for surface wall mounting.
- .6 Supervised, modular design with plug-in modules:
  - .1 Alarm receiver with trouble and alarm indications, for class B initiating circuit.
  - .2 Spare zones: compatible with smoke detectors and open circuit devices.
  - .3 Space for future modules.
  - .4 Latching type supervisory receiver circuits. Discrete indication for both off-normal and trouble.
- .7 Components:
  - .1 Coded alarm receiver panel with trouble and alarm indications for class B initiating circuit.
  - .2 Single stage alarm pulse rate panels:
    - .1 Single stroke control type for output to signal control panel continuously.
  - .3 Audible signal control panel with two (2) control circuits complete with terminals for wiring and two (2) plug-in modules for dc signals up to 2.0 A load with trouble indication with class B connections.
  - .4 Common control and power units:
    - .1 Control panel containing following indications and controls:
      - .1 "Power on" LED (green) to monitor primary source of power to system.
      - .2 "Power trouble" indication
      - .3 "Ground trouble" indication
      - .4 "Remote annunciator trouble" indication



## **FIRE ALARM SYSTEMS**

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- .5 "System trouble" indication
- .6 "System trouble" buzzer and silence switch c/w trouble resound feature
- .7 System reset switch
- .8 "LED test" switch if applicable
- .9 "Alarm silence" switch to silence signals manually. If new alarm occurs after signals have been silenced, signals to resound.
- .10 "Signals silenced" indication.
- .2 Master power supply panel to provide 24 VDC to system from 120 VAC, 60 Hz input.
- .5 Auxiliary relays: plug-in type, dust cover, supervised against unauthorized removal by common trouble circuit.
  - .1 Contact terminal size: capable of accepting 22-12 AWG wire.
- .6 Fire Alarm shall be able to communicate with the DCS System via Ethernet connection port.

### **2.4 Power Supply**

- .1 120 VAC, 60 Hz input, 24 VDC output from rectifier to operate alarm and signal circuits. Power supply from 120 /208 V local power panel. Include surge protection on incoming power wiring.
- .2 Standby nickel cadmium battery unit with automatic battery charger to provide supervisory and trouble signal current for 24 hours, plus general alarm load for minimum of five minutes, complete with voltmeter and charging meter. Unit to be sized to carry the complete fire alarm system.

### **2.5 Manual Alarm Stations**

- .1 Manual alarm stations: pull lever, wall mounted surface type, non-coded single pole normally open contact for single stage bilingual signage.

### **2.6 Automatic Alarm Initiating Devices**

- .1 Heat detectors, fixed temperature, non-restorable, rated 88°C.
- .2 Smoke detector: ionization type air duct type with sampling tubes with protective housing.
  - .1 Twistlock plug-in type with fixed base

## **FIRE ALARM SYSTEMS**

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- .2 Wire-in base assembly with integral red alarm LED, and terminals for remote alarm LED.

### **2.7 Audible Signal Devices**

- .1 Bells: surface mounted, single stroke, polarized, 24 VDC, 250 mm.

### **2.8 End-of-Line Devices**

- .1 End-of-line devices to control supervisory current in alarm circuits, sized to ensure correct supervisory current for each circuit. Open, short or ground fault in any circuit will alter supervisory current in that circuit, producing audible and visible alarm at main control panel and remotely as indicated.

### **2.9 Ancillary Devices**

- .1 Remote relay unit to initiate fan shutdown.

## **3. EXECUTION**

### **3.1 Installation**

- .1 Install systems in accordance with CAN/ULC-S524 and TB OSH Chapter 3-4.
- .2 Install main control panel and connect to ac power supply.
- .3 Locate and Install manual alarm stations and connect to alarm circuit wiring.
- .4 Locate and Install detectors and connect to alarm circuit wiring. Do not mount detectors within 1 m of air outlets. Maintain at least 600 mm radius clear space on ceiling, below and around detectors. Locate duct type detectors in straight portions of ducts.
- .5 Connect alarm circuits to main control panel.
- .6 Locate and install audible signal devices and connect to signaling circuits.
- .7 Connect signaling circuits to main control panel.
- .8 Install end-of-line devices at end of alarm and signaling circuits, in a separate box not more than 1730 mm above finished floor.
- .9 Locate and Install remote relay units to control fan shut down.
- .10 Mount battery pack and charger in the control cabinet.
- .11 Connect remote fire alarm output to Local PLC Control Panel for alarm transmission to the Administration Building Server Room. Exact location shall be determined on-site.

## **FIRE ALARM SYSTEMS**

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### **3.2 Wiring**

- .1 Ensure conductors are routed in such a manner to provide required fire rating.
- .2 Signal circuits to be wired with a minimum 2-# 14 R90 per zone. In no case shall the voltage drop to any signal exceed 10 percent.
- .3 Alarm initiating devices to be wired with multi conductor # 18 R90 cables as required in accordance with the Canadian Electrical Code. Circuit resistance shall not exceed 50 ohms.
- .4 All wiring will be terminated into the terminal strips in the fire alarm cabinet with all wiring fully labeled. All cabling to be neat with cables bundled and wrapped inside the cabinets. No splicing will be allowed within the cabinets. A complete schedule of all wiring terminations will be mounted inside each control unit. A complete schematic with all devices, cable labeling information, destinations, etc. will be included with the Shop Drawings.

### **3.3 Field Quality Control**

- .1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and System and CAN/ULC-S537.
- .2 Fire alarm system:
  - .1 Test each device and alarm circuit to ensure manual stations, thermal and smoke detectors transmit alarm to control panel and actuate general alarm ancillary devices.
  - .2 Simulate grounds and breaks on alarm and signaling circuits to ensure proper operation of system.
  - .3 Class B circuits.
    - .1 Test each conductor on all circuits for capability of providing alarm signal on line side of single open-circuit fault condition imposed at electrically most remote device on circuit. Reset control unit after each alarm function and correct imposed fault after completion of each test.
    - .2 Test each conductor on all circuits for capability of providing alarm signal during ground-fault condition imposed at electrically most remote device on circuit. Reset control unit after each alarm function and correct imposed fault after completion of each test.

### **3.4 Verification and Certification**

- .1 The manufacturer shall make an inspection of the fire alarm equipment, including those components necessary to the direct operation of the system such as detectors and controls, whether or not manufactured by the manufacturer added under this Contract. The inspector shall comprise an examination of such equipment for the following.

## FIRE ALARM SYSTEMS

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- .1 That the type of equipment installed is that designated by the Specification.
  - .2 That the wiring connections to all equipment components show that the installer undertook to have observed ULC and CSA requirements.
  - .3 That equipment of the manufacturer's manufacture has been installed in accordance with the manufacturer's recommendations and that all signaling devices of whatever manufacture have been operated or tested to verify their operation.
  - .4 That the supervisory wiring of those items of equipment connected to a supervised circuit is operating and that the governmental regulations, if any, concerning such supervisory wiring have been met to the satisfaction of inspecting officials.
  - .5 To assist the Contractor in preparing his bid the manufacturer shall indicate the number of hours necessary to complete this inspection prior to closing of tenders, and the number of hours necessary to provide a seminar on the system for the building City.
- .2 The system shall be tested and verified according to requirements of CAN/ULC-S537 Standard for Verification of Fire Alarm System Installations. The complete verification procedure will be under the control and supervision of the Contract Administrator. The services of the Contractor and representatives of the fire alarm manufacturer are required for the verification. The following is a rough breakdown of the responsibilities of each party participating in the verification. The following is a rough breakdown of the responsibilities of each party participating in the verification. This list does not necessarily note all the required Work. The Contractor and fire alarm manufacturer shall provide equipment and manpower as necessary to complete the verification to the Contract Administrator's requirements and approval.
- .3 Contractor:
- .1 Remove/reinstall devices
  - .2 Activate alarms
  - .3 Activate trouble alarms
  - .4 Provide 1 pair of radios
  - .5 All Work to be 100 percent complete
  - .6 Provide necessary manpower
  - .7 Correct deficiencies
  - .8 Coordinate and schedule verification (all two weeks notice)
- .4 Manufacturer:
- .1 Ensure correct operation of all alarms, signals, auxiliary functions, trouble indication.

**FIRE ALARM SYSTEMS**

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- .2 Record all data and issue report and certificate of verification
- .3 Correct any deficiencies
- .4 Check, calibrate, adjust and confirm correct operation of control panels, annunciator
- .5 Generally assure that all aspects of system function properly
- .6 Provide all test equipment, including sound pressure level meter, volt meter, aerosol test smoke
- .5 Contract Administrator:
  - .1 Direct and supervise verification.
  - .2 Check and ensure that system is applied and installed to all applicable codes.
  - .3 Review test documentation, give to the City and fire authorities.
- .6 All costs involved in this inspection, including manufacturers, electrical Contractors included in total price.
- .7 Inspection Certification: on completion of the inspection and when all of the above conditions have been complied with, the manufacturer shall issue to the Contract Administrator:
  - .1 A copy of the inspecting technician's report showing location of each device and certifying the test results of each device.
  - .2 A certificate of verification confirming that the inspection has been completed and showing the conditions upon which such inspection and certification have been rendered.
  - .3 Seal the certificate with the seal of a Professional Engineer registered in the Province of Manitoba.
  - .4 Proof of liability insurance for the inspection.
- .8 Include for complete verification and test of all devices, etc. at six months after completion of initial verification.

**END OF SECTION**

## **SECURITY DOOR SUPERVISION**

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### **1. GENERAL**

#### **1.1 Related Work**

- .1 General Electrical Requirements: Section 16010
- .2 Conduits, Conduit Fastening and Conduit Fittings: Section 16111
- .3 Wire and Cables - 0 - 1000 V: Section 16122
- .4 Outlet Boxes, Conduit Boxes and Fittings: Section 16132
- .5 Instrumentation and Control: Division 17

#### **1.2 Requirements**

- .1 Installation subject to approval, inspection, and test prior to final acceptance.
- .2 All equipment to be CSA or ULC approved.
- .3 Installation shall conform to the requirements of the Canadian Electrical Code.

#### **1.3 Scope of Work**

- .1 Provide motion detector and door contacts at locations indicated on the Drawings and specified herein.
- .2 Provide complete conduit system for motion detection door access controllers and door contacts as indicated on Drawings.
- .3 Supply and install a complete security CCTV system as indicated on the Drawings and specified herein. System shall be complete with cameras, lenses, housing, mounting hardware, cable and miscellaneous equipment to form a complete operating system. System to be connected to existing switcher and monitoring system located in the Main Administration Building Server Room. Exact termination location to be determined on-site.

#### **1.4 Shop Drawings**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements.

### **2. PRODUCTS**

#### **2.1 Motion Detectors**

- .1 Motion detectors for use in rooms indicated to detect unauthorized movement within the range of the detector. Refer to Instrument Specification sheet I-102 in Division 17.

## **SECURITY DOOR SUPERVISION**

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### **2.2 Door Switches**

- .1 Door switches: suitable for surface mounting on inside of door as indicated. Refer to Instrument Specification sheet I-103 in Division 17.

### **2.3 Security CCTV System**

- .1 Cameras to be Pelco CCC2400S-4 colour CCD camera complete with 8 mm wide-angle lens and indoor housing, Pelco EH100-8 wall mounted enclosure.
- .2 Camera to be Pelco CCC2400S-4 colour CCD camera complete with 8 mm wide-angle lens and out door heated housing, Pelco EH3508 wall mounted enclosure.
- .3 Camera housing to be suitable for damp location within the building and weatherproof with internal heater for exterior camera.

## **3. EXECUTION**

### **3.1 Installation**

- .1 Install a complete wire and conduit system for security equipment as indicated. Minimum conduit size to be 20 mm.
- .2 Minimum wire size No. 18 AWG for all hardware. Data link cables to be in accordance with manufactures recommendations. Terminate system wiring in Control Panel UV CP1. Refer to Division 17 for detail of copper to fibre conversion and extension
- .3 Conductors termination in panels shall be made on terminal strips with separate point for each conductor. All such stripes to be number identified.
- .4 All wiring shall be labeled at each end, termination point or junction.
- .5 Install all security equipment indicated.
- .6 Test complete system to ensure compliance with the Specification and manufactures recommendations.
- .7 Provide power from local 120 V circuits to each camera. All security cameras shall be powered from the same phase.
- .8 Security Equipment and CCTV camera units to be connected to new Local PLC Control Panel for conversion from copper wire to fibre optic. The fibre optics will be installed from Local PLC Control Panel control panel to existing main related monitoring equipment located in the Administration Building Server Room. Final connections at this point shall be determined on-site.

**END OF SECTION**

## **MOTOR STARTERS TO 600 V**

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### **1. GENERAL**

#### **1.1 References**

- .1 NEMA Contactors and Motor-starters

#### **1.2 Related Work**

- .1 Variable Frequency Drive: Section 16815
- .2 Thermistors: Section 16930
- .3 Connections to Mechanical Equipment: Section 16950

#### **1.3 Starter Requirements**

- .1 In general, there are categories of starting equipment for 3-phase motors.
  - .1 Integral Mounted Starters: some items of mechanical equipment such as boilers, have the starter mounted as part of the equipment. For this equipment, supply disconnects and wire to the terminals of the equipment.
  - .2 Separately Mounted Starters: for motors without integral mounted starters, supply separately mounted starters as indicated on the Drawings and wire the equipment.
  - .3 Starters in Motor Control Centres (MCCs): for motors fed from motor control centre, wire from the equipment to the MCC.
- .2 Provide manual starters for all single phase motors unless otherwise indicated on the motor schedule.
- .3 Provide interlocking between starters where required.
- .4 All starter accessories such as pilot lights, Hand-Off-Auto, Start-Stop, etc. whether integrally or remote mounted shall be heavy-duty oil tight, unless otherwise specified.

#### **1.4 Shop Drawings and Product Data**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements and Division 1.
- .2 Indicate:
  - .1 Mounting method and dimensions
  - .2 Starter size and type
  - .3 Layout of identified internal and front panel components



## **MOTOR STARTERS TO 600 V**

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- .4 Enclosure types
- .5 Wiring diagram for each type of starter
- .6 Interconnection diagrams

### **1.5 Operation and Maintenance Data**

- .1 Provide operation and maintenance data for motor starters for incorporation into manual specified in Section 16010 - Electrical General requirements.
- .2 Include operation and maintenance data for each type and style of starter.

### **1.6 Maintenance Materials**

- .1 Provide maintenance materials in accordance with Division 01 Maintenance Materials, Special Tools and Spare Parts.
- .2 Provide listed spare parts for each different size and type of starter:
  - .1 Three (3) contacts, stationary
  - .2 Three (3) contacts, movable
  - .3 One (1) contact, auxiliary
  - .4 One (1) control transformer
  - .5 One (1) operating coil
  - .6 Two (2) fuses
  - .7 10 percent indicating lamp bulbs used

## **2. PRODUCTS**

### **2.1 Materials**

- .1 Starters to NEMA Standards.

### **2.2 Enclosure**

- .1 All individually mounted motor starters shall be enclosed in a general purpose sheet steel enclosure unless in wet areas where they shall be watertight EEMAC 4.
- .2 For all motors 22.4 kW and above, the starters shall contain thermistor control relay and accessories.

## MOTOR STARTERS TO 600 V

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### 2.3 Manual Motor Starters

- .1 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
  - .3 Rated volts and poles to suit application
- .2 Accessories:
  - .1 Toggle switch or push-button: heavy duty oil-tight labelled as indicated.
  - .2 Indicating lights: heavy duty oil tight type and colour as indicated.
  - .3 Locking tab to permit padlocking in "ON" or "OFF" position.

### 2.4 Full Voltage Non Reversing (FVNR) Magnetic Starters

- .1 Magnetic and combination magnetic starters of size, type, rating, and enclosure type as indicated with components as follows:
  - .1 Contactor solenoid operated rapid action type.
  - .2 Motor overload protective device in each phase, manually reset from outside enclosure.
  - .3 Wiring and schematic diagram inside starter enclosure in visible location.
  - .4 Identify each wire and terminal for external connections, within starter, with permanent number marking identical to diagram.
- .2 Combination type starters to include motor circuit interrupter with operating lever on outside of enclosure to control motor circuit interrupter, and provision for:
  - .1 Locking in "OFF" position with up to three (3) padlocks.
  - .2 Independent locking of enclosure door.
  - .3 Provision for preventing switching to "ON" position while enclosure door open.
- .3 Accessories:
  - .1 Pushbuttons or Selector switches: heavy-duty oil tight labelled as indicated.
  - .2 Indicating lights: heavy duty oil tight type and red pilot light to indicate energized motor circuit and where called for, green pilot light to indicate de-energized motor circuit. Pilot lights to be push-to-test transformer type.

## **MOTOR STARTERS TO 600 V**

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- .3 In addition to standard, 1-N/O and 1-N/C spare auxiliary contacts unless otherwise indicated.

### **2.5 Control Transformer**

- .1 A control transformer of sufficient VA capacity, dry type, with primary voltage as indicated and 120 V secondary, complete with primary and secondary fuses (HRC Form J), installed in with starter as indicated.
- .2 Size control transformer for control circuit load +20 percent spare capacity.

### **2.6 Finishes**

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

### **2.7 Equipment Identification**

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

## **3. EXECUTION**

### **3.1 Installation**

- .1 Install starters, connect power and control as indicated.
- .2 Ensure correct fuses and overload devices elements installed.

### **3.2 Starter Verification**

- .1 Field check motor starters supplied prior to commissioning equipment. As a minimum, verify the following:
  - .1 Check of control circuits.
  - .2 Verify that overload relay installed is correctly sized for motor used.
  - .3 Record overload relay size and motor nameplate amperage.
  - .4 Visual inspection of fuses and contactors.
  - .5 Ensure all connections are tight.

### **MOTOR STARTERS TO 600 V**

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- .2 Measure and record motor amps, under load conditions and compare with full load amps and motor service factor. Report any excessive readings and unbalance. Measure voltage as close to motor terminals as possible while motor is running
- .3 Set all motor circuit protectors to the minimum level which will consistently allow the motor to start under normal starting conditions.

#### **3.3 Overload Relays**

- .1 For starters provided, select overload relays in accordance with relay and motor manufacturers' recommendations, considering motor service factors, ambient temperature, temperature differences between motor and starter locations. Monitor motor operation during startup to ensure motor operation is satisfactory and relays provide proper protection. For side inlet fans and other long acceleration time loads, provide special overload relays to suite the start-up condition. Provide manufacturers' curves and data sheets where necessary to provide supporting data for motor protection.

#### **3.4 Field Quality Control**

- .1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems 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.

**END OF SECTION**

## **VARIABLE FREQUENCY DRIVES**

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### **1. GENERAL**

#### **1.1 Related Work**

- .1 Mechanical: Division 15
- .2 Process: Division 11

#### **1.2 Scope**

- .1 Division 11 Contractor shall supply Variable Frequency Drive (VFD) controllers for process equipment as herein specified.
- .2 Division 15 Contractor shall supply Variable Frequency Drive (VFD) controllers for heating, ventilation, and air conditioning (HVAC) equipment as herein specified.
- .3 Division 16 Contractor shall install, wire and connect HVAC VFD controllers and indicated on the drawings.

#### **1.3 Standards Motor**

- .1 All VFDs supplied under this Contract meet or exceed the following Specifications.
- .2 Provide a complete inventory (as specified) of spare cooling fans, and fuses, for each VFD supplied.
- .3 The adjustable frequency controller shall be designed to operate standard squirrel cage induction motor with a 1.15 S.F. or definite purpose motors meeting NEMA MG1 Part 31.
- .4 Harmonic loading will not exceed a motor service factor of 1.0.
- .5 Products shall comply with Institute of IEEE Standard 519.
- .6 VFD unit shall be UL listed and CSA certified.
- .7 VFD unit shall comply with applicable requirements of the latest standards of CSA, ANSI, IEEE and the Canadian Electrical Code.

#### **1.4 Tests**

- .1 Factory testing
  - .1 VFD units are to be factory tested prior to shipment. Provide confirmation from factory of actual tests completed and results.
  - .2 Provide certified copies of production test results required by CSA and EEMAC, prior to acceptance of the equipment.

## VARIABLE FREQUENCY DRIVES

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### .2 Field testing

1. The VFD supplier shall provide on-site startup, fine-tuning, commissioning, operator training and instruction.
2. The VFD supplier shall provide Site functionality test reports indicating loading/current levels during testing as well as control point proving results.
3. The VFD supplier shall ensure shaft to ground voltages do not exceed 1.5 V at any speed or load requirement.
4. Allow for all costs and labour for as many trips as necessary to complete requirements.
5. It is the intent of this Specification to provide a VFD installation that does not adversely affect the electrical system. Included in the Contract Documents is information on the electrical system including:
  - .1 Single line Drawing
  - .2 Additional information on electrical system layout and load profile.
  - .3 The VFD supplier can use this information to evaluate the predicted effect of the VFD installation on the electrical system and advise the Contract Administrator of these effects. For the purposes of analysis, the point of common coupling (PCC) will be taken as the secondaries of the main distribution transformers.
6. The Contractor shall conduct a harmonic analysis for the entire electrical system upon completion of the fine-tuning and commissioning of the installation. The harmonic analysis shall be conducted at 50 percent, 75 percent and 100 percent speed for all VFDs and at 50 percent, 75 percent and 100 percent loading of all the non-linear loads and perform a Fourier (FFT) transform analysis spectrum for each waveform covering the fundamental to the 31<sup>st</sup> harmonic. The Contractor shall submit a report to the Contract Administrator. The harmonic analysis shall be done by J.R. Stephenson Mtg. Ltd.

Should the waveform analysis indicate that the harmonic levels (voltage and current) at the various points and under various load conditions as defined in the previous paragraph exceed recommended levels as stated in the IEEE 519 Recommended Practices and Recommends for Harmonic Control in Electrical Power Systems, than the Contractor shall provide all the necessary line filtering equipment to correct the harmonic distortion.

The Contractor shall allow in his bid a lump some of \$80,000.00 to cover the cost of additional filtering equipment, if the additional equipment is required.

- .3 Provide certified copies of all production test results required by CSA and NEMA.

## VARIABLE FREQUENCY DRIVES

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### 1.5 Warranty

- .1 The VFD supplier shall provide a warranty coverage for a period of two years upon the Contractor being granted Final Acceptance and the warranty period has commenced.
- .2 VFD supplier will review Specifications of motors for application compatibility. The Contractor shall obtain and submit written approval from both the motor and VFD suppliers confirming that both pieces of equipment are compatible when used together to maintain the required warranty.
- .3 The Contractor shall indicate the level of local support detailing response time if a piece of equipment should happen to fail or malfunction. Details are to include estimated replacement part delivery times, as well as nearest parts depot location and a contact name and phone number. This must be included with all bid submissions.
- .4 The VFD supplier shall guarantee that parts for drive units will be available for a minimum of ten years from time of delivery.

## 2. PRODUCTS

### 2.1 Variable Frequency Drives

- .1 Variable Frequency Drives as supplied by one of the following acceptable manufacturers:
  - .1 Asea Brown Boveri Ltd. (ABB) - ACS 800 series.
- .2 Variable speed controller shall be electronic adjustable frequency and voltage output unit.
- .3 The VFD shall employ a minimum 6-pulse pulse width modulated (PWM) inverter system utilizing Insulated Gate Bipolar Transistors (IGBT) power switching devices and come complete with line reactors or DC link filters.
- .4 The drive shall be rated for continuous duty while operating a NEMA design induction motor of the sizes and operating voltages as shown in the following schedules and indicated on the drawings. Drive output shall be sized for a 1.0 motor service factor. The VFD shall have a current rating at least 10 percent in excess of the motor full load amp rating. Overload service factors of 110 percent for thirty minutes and 135 percent for one minute must be provided to ensure adequate safety margins. VFD selection shall be based on load current at constant torque ratings. Do not size VFD's based on variable torque maximums.
- .5 Input voltage shall be as indicated on motor schedules and Drawings (line voltage variation  $\pm 10$  percent) based on 347/600 volt systems (Not 575V). Line frequency variation  $\pm 5$  percent. Output voltage shall vary with motor speed to nominal motor voltage. Speed stability shall be  $\pm 1$  percent. Drive shall match torque characteristic of load.
- .6 Input frequency setting signal will be selective between 4-20 mA or 0-10 VDC. Output speed monitoring signal shall be selective between 4-20 mA or 0-10 VDC.

### **VARIABLE FREQUENCY DRIVES**

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- .7 Enclosure:
  - .1 Drive shall be installed in individual CSA 1 enclosure, drip proof, NEMA 12 or NEMA 4 in Fan Room and remote locations as indicated on drawings. Filters to be provided for any forced air-cooled enclosures as required by the supplier. VFD(s) shall be suitable for mounting in a typical building electrical room and shall be able to operate under these conditions with no special cleaning requirements. VFD cabinets shall be mounted in such a way that there is adequate room for ventilation and no build up of heat. The minimum clearance in front of VFDs is 1 m.
  
- .8 Protective devices to be incorporated are:
  - .1 Fast acting electronic circuit board protective devices for protection of electronic components.
  - .2 Line reactor, DC link or filter in the drive input to protect electronic components from transient voltage conditions.
  - .3 Integral electronic motor overload protection adjustable up to 150 percent of motor rating for 60 seconds.
  - .4 Overcurrent instantaneous trip 250 percent.
  - .5 Programmable short-circuit protection.
  - .6 Programmable ground fault protection.
  - .7 Overvoltage/overcurrent DC bus monitor/protection.
  - .8 Undervoltage protection.
  - .9 Loss of phase and phase unbalance protection.
  - .10 Inverter over-temperature protection.
  - .11 Capable of running without motor for startup.
  - .12 Output filter package (as required) to limit motor voltage to 1200 V maximum at motor terminals. A reflective wave trap mounted at the motor may be used to accomplish this.
  - .13 Longlead (motor feeder) filter package, as required for these installations. Supplier is responsible to determine where this will be required, and must indicate as to the requirement or non-requirement of longlead filter package components in their bid submission, and the Contractor is responsible for carrying all such costs in their bid price.
  - .14 Maximum acceptable noise level is 80 dBA at 1 m.



### **VARIABLE FREQUENCY DRIVES**

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- .9 Operation features:
  - .1 Integral flush mounted display in VFD cover with keypad for programming, monitoring and operating of drive, accessible through password or other acceptable security measure only. Remote keypads, completely duplicating functions of integral keypads, shall also be provided for all VFD(s) located inside a fan plenum. The remote keypads in these cases shall be located adjacent to the door entering the plenum.
  - .2 Fault shutdown and indication
  - .3 Automatic restart following power outage
  - .4 Ability to disconnect motor load for setup or trouble
  - .5 Manual speed control (potentiometer or keypad)
  - .6 Adjustable maximum and minimum speed
  - .7 Acceleration and deceleration time adjustment
  - .8 Controller “stop” interlock from a NC dry contact
  - .9 Drive fault contact
  - .10 Stop/start push buttons on keypad
  - .11 Transient voltage protection
  - .12 Provide three (3) dry “C” type contacts programmable for any combination of the following:
    - .1 Running (output frequency being generated)
    - .2 Fault lockout
    - .3 Stopped
    - .4 At speed
    - .5 Under speed
    - .6 Forward/Reverse
    - .7 Low reference
    - .8 Manual/Auto Mode
    - .9 Local/Remote Mode

### VARIABLE FREQUENCY DRIVES

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- .13 Soft start sequence
- .14 Regenerative braking
- .15 Minimum of three (3) skip frequencies
- .16 Provide Hand/Off/Auto selector switch. Keypad HOA is not an acceptable replacement.
- .17 Password protection of parameter programming or some method to prevent unauthorized changes.
- .18 Output speed monitoring signal to be selective between 4-20 mA or 0-10 V.
- .19 Supply a by-pass contactor with VFD for the Exhaust Fan C510-F to be mounted in the same cabinet structure with the VFD.
- .20 Data communication link.
  - .1 Data communication links shall be provided with various components in the electrical distribution system as defined in various Section of this Division and as shown on drawings. The data communication link shall Ethernet/IP.
    - .1 Motor control data communication link.
    - .2 Each variable frequency drive connected to operating motors 20HP (15kW) or larger shall be provided with an Ethernet data communication link capable of communicating with the DCS System.
- .10 Environmental Capabilities: The drive shall operate without mechanical or electrical damage under any combination of conditions as follows:
  - .1 Ambient temperature -0°C to 40°C
  - .2 Humidity 0 to 90 percent (non condensing)
  - .3 Vibration up to 0.5 g
  - .4 Altitude 0 to 1250 m
- .11 Diagnostic and indicating features:
  - .1 Power on indication
  - .2 Percentage speed indicator
  - .3 Overload indication
  - .4 Short circuit indication

### **VARIABLE FREQUENCY DRIVES**

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- .5 Ground fault indication
- .6 Overvoltage indication
- .7 Undervoltage indication
- .8 High temperature (controller)
- .9 AC voltmeter (output)
- .10 AC ammeter (output)
- .11 Inverter ready
- .12 Inverter fault
- .13 External fault
- .12 Cooling System:
  - .1 VFD supplier to provide adequate proven cooling devices for VFD equipment.
  - .2 VFD supplier to ensure any enclosure utilized will not allow a build up of heat. This can be accomplished by use of fans and / or sufficient guarded, filtered openings.
- .13 Normal Distribution
  - .1 Normal power distribution is subject to voltage surges and sags as a normal condition of operation. Design and supply with each VFD the required inverter protection such that the VFD will not be stressed or damaged, in the following conditions:
    - .1 Line transients of up to 3,000 V with energy levels of 50 joules.
    - .2 Line surges of up to 115 percent of rated voltage for up to 10 cycles. Based on 347/600 Volt systems.
    - .3 Line voltage sags down to 85 percent of rated voltage of up to one (1) second duration.
  - .2 Control wiring shall be TEW 105°C rise.
  - .3 Terminal blocks in separate control enclosures for remote interface shall be Weidmueller SAK6N or approved equivalent.
  - .4 Provide wire markers at both ends of all control wires, Electrovert Type Z or approved equivalent.

## VARIABLE FREQUENCY DRIVES

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### 3. EXECUTION

#### 3.1 Operations Manual Information

- .1 The Contractor will provide the VFD manufacturer and as built of each motor application. Motor application data will include at a minimum, the following:
  - .1 Motor manufacturer
  - .2 Class
  - .3 Motor model number
  - .4 Motor serial number
  - .5 Motor frame
  - .6 Motor power in kW
  - .7 Motor full load amps
  - .8 Motor conductor size
  - .9 Ground conductor
  - .10 Length of conductors from VFD to motor
  - .11 Motor MCP or fuse and overload
- .2 Installation
  - .1 Identify mounting requirements and include all materials and labour, including concrete pads for all floor-mounted equipment.
  - .2 Install VFD(s) in locations as indicated on drawings, and connect up all necessary wiring. All VFD(s) are to be mounted as close to the motor as possible. Follow manufacturer's recommendations for maximum distance between the VFD and the motor. The minimum clearance in front of VFDs is 1 m. Where required, install longlead motor package.
  - .3 Division 17 shall extend analog input signal cable, analog speed indicating output cable, shutdown contact and drive fault contact from the drive to the DCS System. Analog cable shall be No. 16 shielded twisted pair cable. Control wiring shall be run in conduit separate from VFD supply and motor feeder conduits.
  - .4 Contractor shall connect all interlocks including (but not limited to) vibration switch, freeze stats, and fire alarms to the VFD. These interlocks will be active in both the Hand (local) and Auto (remote) configurations.

### VARIABLE FREQUENCY DRIVES

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- .5 Contractor shall ensure that all control and stop commands shut down the drive as per manufacture's recommended procedure (example, ramp to stop, ramp and hold, or coast to stop). Contactors on the line or load side of the drive are not an approved method of control.
  - .6 MCC disconnect switch, VFD and motor isolation switch are to be labelled with proper shutdown procedures as follows:  
  

**“Caution”**

“\* Ensure VFD is stopped before operating this switch”

“\* Record all faults before resetting”
  - .7 Motor supply cables/conductors shall be run in conduits separate from supply feeders to line side of VFD. No conductors (supply or motor feeders) are to be taped or otherwise bundled within the conduits.
- .3 Field Quality Control
- .1 Contractor shall be responsible for complete commissioning of each variable speed drive to satisfaction of the Prime Contractor and the City. Contractor shall allow for factory representative to completely calibrate all drive circuits after installation on Site.
  - .2 Contractor shall be responsible to bring Factory representative back to reset, repair, and re-commission the VFD during the two (2) year warranty period if problems arise with the normal operation of the VFD. This includes prevention of any motor shaft voltages exceeding 1.5 V when referenced to ground.
- .4 Variable Frequency Drive Check-list
- .1 Upon the award of the Contract to the successful Contractor, the Prime Contractor will furnish a VFD checklist that is to be completed and submitted with the VFD Shop Drawings. An example of the VFD checklist is attached to this Specification section.
- .5 Software
- .1 Provide VFD programming / troubleshooting software to City.
  - .2 Provide VFD Parameter list “as programmed during commissioning” for each VFD.
- .6 VFD Shop Drawings.
- .1 The Shop Drawings for each type/size of VFD must be specific to that unit. Generic Shop Drawing shall not be acceptable. The Shop Drawings are to include dimensions and physical details of the cabinets, a wiring diagram and a ladder diagram showing both internal connections and terminals for field wiring. Separate diagrams are required for each VFD/motor functions. Generic diagrams shall not be acceptable.

**VARIABLE FREQUENCY DRIVES**

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- .2 Provide labels/lamacoids on each VFD, MCC disconnect, isolation switch as follows:

**“Caution”**

“\* Ensure VFD is stopped before operating this switch”

“\* Record all faults before resetting”

- .3 All drawings, manuals, parameter settings, and test reports are to be included with the “Electrical Maintenance Manual”. This manual shall be issued in both Hard Copy, and Electronic format.

**END OF SECTION**

**VARIABLE FREQUENCY DRIVES**

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**INSTALLED VFD TEST**

VFD EQUIPMENT NO. \_\_\_\_\_ DATE OF TEST \_\_\_\_\_

DRIVEN MOTOR EQUIPMENT NO. \_\_\_\_\_

DRIVEN LOAD CHARACTERISTIC: CONSTANT TORQUE \_\_\_\_\_  
VARIABLE TORQUE \_\_\_\_\_

**SETPOINTS:**

MINIMUM FREQUENCY \_\_\_\_\_ Hz

MAXIMUM FREQUENCY \_\_\_\_\_ Hz

ACCELERATION TIME \_\_\_\_\_ Sec

DECELERATION TIME \_\_\_\_\_ Sec

SPEED RANGE: MANUAL \_\_\_\_ RPM, \_ RPM

CDACS \_\_\_\_ RPM, \_ RPM

VFD CURRENT AT FULL LOAD: PH.A. \_\_\_\_\_ Amp, PH.B \_\_\_\_\_ Amp, PH.C \_\_\_\_\_ Amp.

MOTOR CURRENT: PH.A. \_\_\_\_\_ Amp, PH.B \_\_\_\_\_ Amp, PH.C \_\_\_\_\_ Amp.

**MOTOR NAMEPLATE DATA:**

MFR.: \_\_\_\_\_ MFR. TYPE \_\_\_\_\_ FRAME \_\_\_\_\_ hp \_\_\_\_\_

VOLTS: \_\_\_\_\_ PHASE \_\_\_\_\_ RPM \_\_\_\_\_ SERVICE FACTOR \_\_\_\_\_

AMPS \_ FREQ. Hz AMBIENT TEMP. RATING \_\_\_\_\_ °C

TIME RATING \_\_\_\_\_ DESIGN LETTER \_\_\_\_\_

KVA CODE LETTER \_ INSULATION CLASS \_\_\_\_\_

CERTIFIED \_\_\_\_\_ Date \_\_\_\_\_  
Contractor's Representative

**WITNESSED** \_\_\_\_\_

**DATE** \_\_\_\_\_

## **MOTOR CONTROL CENTRE**

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### **1. GENERAL**

#### **1.1 Related Work**

- .1 Motor Starters to 600 V: Section 16811
- .2 Connections to Mechanical Equipment: Section 16950

#### **1.2 References**

- .1 Canadian Standards Association CAN/CSA-Q9000, Quality Management and Quality Assurance Standards - Guidelines for Selection and Use.

#### **1.3 Shop Drawings**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements and Division 1.
- .2 Indicate:
  - .1 Outline dimensions
  - .2 Configuration of identified compartments
  - .3 Floor anchoring method and dimensioned foundation template
  - .4 Cable entry and exit locations
  - .5 Dimensioned position and size of busbars and details of provision for future extension
  - .6 Schematic and wiring diagrams

#### **1.4 Operation and Maintenance Data**

- .1 Provide operation and maintenance data for MCC for incorporation into manual specified in Section 16010 - Electrical General Requirements.
- .2 Include data for each type and style of starter.

#### **1.5 Maintenance Materials**

- .1 Provide maintenance materials in accordance with Section 01300 - Submittals.
- .2 Provide Spare Parts as recommended by the manufacturer.



## **MOTOR CONTROL CENTRE**

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### **1.6 Source Quality Control**

- .1 Provide manufacturer's type test certificates including short circuit fault damage certification up to short circuit values specified under bus bracing.
- .2 Manufacturer to provide proof of quality control program in accordance with CAN/CSA-Q9000.

## **2. PRODUCTS**

### **2.1 Supply Characteristics**

- .1 600 V, 60 Hz, delta connected, 3-phase, 3 wire, grounded.

### **2.2 General Description**

- .1 Compartmentalized vertical sections with common power busbars.
- .2 Metal enclosed, free standing, enclosed dead front.
- .3 Indoor EEMAC Type 1A gasketed enclosure, front mounting.
- .4 Class I Type B.
- .5 Pre Approved: Square D, Allen-Bradley, Eaton Cutler-Hammer

### **2.3 Vertical Section Construction**

- .1 Independent vertical sections fabricated from rolled flat steel sheets bolted together to form rigid, completely enclosed assembly.
- .2 Each vertical section divided into compartment units, minimum 305 mm high, as indicated.
- .3 Each unit to have complete top and bottom steel plate for isolation between units.
- .4 Horizontal wireways, equipped with cable supports, across top and bottom, extending full width of MCC, isolated from busbars by steel barriers.
- .5 Vertical wireways complete with doors for load and control conductors extending full height of vertical sections, and equipped with cable tie supports. Installation wiring to units accessible with doors open and units in place.
- .6 Openings, with removable coverplates, in side of vertical sections for horizontal wiring between sections.
- .7 Incoming cables to enter at top as indicated.
- .8 Provision for outgoing cables to exit via top.

## MOTOR CONTROL CENTRE

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- .9 Removable lifting means.
- .10 Provision for future extension of both ends of MCC including busbars without need for further drilling, cutting or preparation in field.
- .11 Divide assembly for shipment to Site, complete with hardware and instructions for re-assembly.

### 2.4 Sills

- .1 Continuous 75 mm x 25 mm channel iron floor sills for mounting bases with 19 mm diameter holes for bolts.

### 2.5 Busbars

- .1 Main horizontal and branch vertical, three phase high conductivity tin plated copper busbars in separate compartment self-cooled, extending entire width and height of MCC, supported on insulators and rated:
  - .1 Main horizontal busbars: 800 A
  - .2 Branch vertical busbars: 300 A
- .2 Branch vertical busbars for distribution of power to units in vertical sections.
- .3 No other cables, wires, equipment in main and branch busbar compartments.
- .4 Brace buswork to withstand effects of short-circuit current of 65 kA rms symmetrical.
- .5 Bus supports: with high dielectric strength, low moisture absorption, high impact material and long creepage surface designed to discourage collection of dust.

### 2.6 Ground Bus

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

### 2.7 Motor Starters and Devices

- .1 Equip the MCC with the combination starters as specified in Section 16811 - Motor Starters to 600 V, and as shown on the Drawings.

### 2.8 Starter Unit Compartments

- .1 Units EEMAC size 5 and smaller, circuit breaker units 225 A and smaller, plug-in type with self-disconnect. Guide rail supports for units to ensure that stabs make positive contact with vertical bus. Provision for units to be installed or removed, off load, while buses energized.

## **MOTOR CONTROL CENTRE**

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- .2 Unit mounting:
  - .1 Engaged position - unit stabbed into vertical bus.
  - .2 Withdrawn position - unit isolated from vertical bus but supported by structure.
  - .3 Provision for positive latching in either engaged or withdrawn position and padlocking in withdrawn position.
  - .4 Stab-on connectors free floating tin plated clips, self-aligning, backed up with steel springs.
- .3 External operating handle of circuit switch interlocked with door to prevent door opening with switch in "on" position. Provision for one (1) and four (4) padlocks to lock operating handle in "off" position and lock door closed.
- .4 Hinge unit doors on same side.
- .5 Overload relays manually reset from front with door closed.
- .6 Pushbuttons and indicating lights mounted on door front.
- .7 Devices and components by one manufacturer to facilitate maintenance.
- .8 Pull-apart terminal blocks for power and control to allow removal of starter units without removal of field wiring.

### **2.9 Wiring Identification**

- .1 Provide wiring identification in accordance with Section 16010 - Electrical General Requirements.

### **2.10 Equipment Identification**

- .1 Provide equipment identification in accordance with Section 16010 - Electrical General Requirements.
  - .1 MCC main nameplate: Size 7, engraved as indicated.
  - .2 Individual compartment nameplates: Size 5, engraved as indicated.

### **2.11 Finishes**

- .1 Apply finishes in accordance with Section 16010 - Electrical General Requirements.
- .2 Paint MCC exterior light grey and interiors white.

## MOTOR CONTROL CENTRE

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### 3. EXECUTION

#### 3.1 Installation

- .1 Set and secure MCC in place on channel bases, rigid, plumb and square to building floor and wall.
- .2 Make field power and control connections as indicated.
- .3 Ensure correct overload heater elements are installed.
- .4 Some re-arrangement of compartments is permitted from that indicated to suite manufacturer's standards, provided that re-arrangement given approximately the spaces shown on the Drawings. Submit arrangement Drawings to the Contract Administrator before starting detailed Drawings.
- .5 Coordinate concrete pad with bevelled edges as shown on the Drawings, sized to suit MCC, install and level channel sills and mount MCC.
- .6 Provide control centres with vertical sections, each 2286 mm high, 508 mm deep and 508 mm wide, assembled into a group having a common power bus and forming an enclosure to which additional sections may be readily added.
- .7 Design for all power and control connections to be made from the front. All bus and feeder bolted connections shall be accessible from the front.
- .8 Sections with horizontal wiring spaces top and bottom and with 102 mm full height vertical wiring spaces with cable tile supports. Insulate wireways from horizontal and vertical bus.
- .9 Incorporate starters, circuit breakers, panels, etc. as detailed. Provide shop drawings for review before commencing fabrication.
- .10 Provide all spaces complete with bussing hardware and other accessories required so that additional combination starter units can be readily installed. Provide barriers to isolate the space from all buswork.
- .11 For each section of structure, provide a 3-phase horizontal bus rated as shown, and a 3-phase vertical bus rated 300 A. Tin plate vertical and horizontal bus at each joint. Provide a continuous copper ground bus in bottom of each section. where indicated on MCC schedule, provide fully rated neutral. Bus shall be copper with labyrinth design insulation - isolation for vertical bus.
- .12 Contain each complete control device within an individual metal enclosure complete isolated from all other equipment. Provide plug-in type units.
- .13 Provide tin-plated copper busbar stabs reinforced with strong spring steel to ensure high contact pressure.

## MOTOR CONTROL CENTRE

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- .14 Equip door of each individual unit with a removable plate replaceable with similar plate complete with pushbuttons, pilot lights or selector switches as required. Use pilot lights of push-to-test type and push button of heavy-duty oil tight construction.
- .15 Provide appropriate flanges and bus connections for incoming line and feeders.
- .16 All joints and connections to be tin plated, cadmium plate all bolts, nuts and lock washers to resist corrosion.
- .17 Provide pull apart terminal block plug in each starter for all external control connections, such that each starter unit may be easily removed. All terminals shall be identified.
- .18 Provide barriers to isolate all buswork to prevent accidental contact when starter units are removed or spaced are provided. Barriers shall also provide phase-to-phase isolation of the vertical bus.
- .19 Complete control wiring diagrams for each starter with conductor identification clearly shown shall be affixed to the interior cover of the starter section or provide a book of wiring diagrams for all starters in each MCC.
- .20 MCCs shall be fitted with on main 600 V / 120 V control transformer of sufficient V.A. capacity to handle the control requirements of the whole unit plus capacity for external control devices.
- .21 Primary and secondary high rupturing capacity (HRC) fusing shall be installed on the control transformer.
- .22 Each MCC containing 3 or more vertical sections shall contain a control terminal section consisting of one full stack in height and depth. It shall be barriered from the adjacent 600 V section. The control terminal section shall be complete with a solid back pan at the rear for the installation of control terminals.
- .23 Control wiring shall be extended from each starter module to the control terminal section, including all auxiliary contacts. A multi unit style terminal block having screw type terminal connections shall be installed on standoff supports on back plate.
- .24 All terminals shall be number coded or otherwise suitably identified to indicate which section or module of the MCC they are associated with and their function.

### 3.2 Starter Verification

- .1 Field check motor starters supplied prior to commissioning equipment. As a minimum, verify the following:
  - .1 Check of control circuits.
  - .2 Verify that overload relay installed in correctly sized for motor used.
  - .3 Record overload relay size and motor nameplate amperage.
  - .4 Visual inspection of fuses and contactors.

## **MOTOR CONTROL CENTRE**

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- .5 Ensure all connections are tight.
- .2 Measure and record motor amps, under load conditions and compare with full load amps and motor service factor. Report any excessive readings and unbalance. Measure voltage as close to motor terminals as possible while motor is running.
- .3 Set all motor circuit protectors to the minimum level which will consistently allow the motor to start under normal starting conditions.

### **3.3 Overload Relays**

- .1 For starters provided, select overload relays in accordance with relay and motor manufacturers' recommendations, considering motor service factors, ambient temperature, temperature differences between motor and starter locations. Monitor motor operation during start-up to ensure motor operation is satisfactory and relays provide proper protection. For side inlet fans and other long acceleration time motors, provide special overload relays to suit the start-up condition. Provide manufacturers' curves and data sheets where necessary to provide supporting data for motor protection.

### **3.4 Field Quality Control**

- .1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems.
- .2 Ensure moving and working parts are lubricated where required.
- .3 Operate starters in sequence to prove satisfactory performance of MCC during an eight hour period.

**END OF SECTION**

## **CONTROL DEVICES**

---

### **1. GENERAL**

#### **1.1 Work Included**

- .1 Control equipment such as (a) pushbutton stations, indicating lights, control and relay panels, are provided under this specification to form complete control system in conjunction with (b) starters, and (c) items provided under Division 15 for example, pressure flow, float, solenoid valves, panels, pneumatic electric switches, transducers, duct and space thermostats except heating systems. Some or all of preceding items are interconnected under Part 3 of this specification. Specify control components and assemblies, relative work and interface between Divisions 15 and 16. Ensure Work required to be performed is indicated on layout drawings, diagrams, and motor starter and control list.

#### **1.2 Shop Drawings**

- .1 Submit Shop Drawings in accordance with Section 16010 - Electrical General Requirements.
- .2 Include schematic, wiring, interconnection diagrams.

### **2. PRODUCTS**

#### **2.1 AC Control Relays**

- .1 Convertible contact type: contacts field convertible from normally open (NO) to normally closed (NC), electrically held, solid state timer. Coil rating: as required. Contact rating: as required.
- .2 Sealed contact type: electrically held with required poles and front mounted contact block to provide additional poles. Coil rating: as required. Contact rating: as required.
- .3 Fixed contact plug-in type: general purpose with required poles. Coil rating: as required. Contact rating: as required.

#### **2.2 Relay Accessories**

- .1 Standard contact cartridges: NO - convertible to NC in field.

#### **2.3 Solid State Timing Relays**

- .1 Construction: AC operated electronic timing relay with solid-state timing circuit to operate output contact. Timing circuit and output contact completely encapsulated to protect against vibration, humidity and atmospheric contaminants.
- .2 Operation: on-delay or off-delay
- .3 Potentiometer: self-contained to provide time interval adjustment.

## **CONTROL DEVICES**

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- .4 Supply voltage: 120 VAC, 60 Hz.
- .5 Temperature range: -20°C to 60°C.
- .6 Output contact rating: maximum voltage 300 VAC or DC. Current: EEMAC B300.
- .7 Timing ranges: minimum 0.1 s, maximum 60 s.

### **2.4 Instantaneous Trip Current Relays**

- .1 Enclosure: CSA Type 1.
- .2 Contacts: NO, NC automatic reset with adjustable tripping point.
- .3 Control: 3 wire, with provision for shorting contacts during accelerating period of motor.
- .4 Contact rating: EEMAC B600.

### **2.5 Operator Control Stations**

- .1 Enclosure: CSA Type 1 or 4 as required, surface mounting:

### **2.6 Pushbuttons**

- .1 Illuminated, Heavy duty oil tight. Operator flush type, as indicated. Green, with 1-NO and 1-NC contacts rated at as required, labels as indicated. Stop pushbuttons coloured red, provision for padlocking in depressed position labelled "emergency stop".

### **2.7 Selector Switches**

- .1 Maintained, 2 or 3 position labelled as indicated heavy-duty oil tight, operators wing lever, contact arrangement as indicated, rated as required.

### **2.8 Indicating Lights**

- .1 Heavy-duty Oil tight, transformer light emitting diode (LED) type, push-to-test, lens colour: as indicated, supply voltage: as required, lamp voltage: as required, labels as indicated.

### **2.9 Control and Relay Panels**

- .1 CSA Type 2 sheet steel enclosure with hinged padlockable access door, accommodating relays timers, labels, as indicated, factory installed and wired to identified terminals.

### **2.10 Control Circuit Transformers**

- .1 Single phase, dry type.
- .2 Primary: 600 V, 60 Hz AC.



## **CONTROL DEVICES**

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- .3 Secondary: 120 VAC
- .4 Rating: 150 VA minimum
- .5 Secondary fuse as required
- .6 Close voltage regulations as required by magnet coils and solenoid valves

### **3. EXECUTION**

#### **3.1 Installation**

- .1 Install pushbutton stations, control and relay panels, control devices.

#### **3.2 Field Quality Control**

- .1 Perform tests in accordance with Section 16980 - Testing, Adjusting and Balancing of Electrical Equipment and Systems.
- .2 Depending upon magnitude and complexity, divide control system into convenient sections, energize one section at a time and check out operation of section.
- .3 Upon completion of sectional test, undertake group testing.
- .4 Check out complete system for operational sequencing.
- .5 Submit to Contract Administrator one copy of test results.

**END OF SECTION**

## CONNECTIONS TO MECHANICAL EQUIPMENT

---

### 1. GENERAL

#### 1.1 Related Work

- .1 Mechanical: Division 15

#### 1.2 Requirements

- .1 Provide a complete system of wiring to motors and controls as specified herein and as shown on the Drawings.
- .2 Unless specifically noted otherwise, wire and leave in operation all electrically operated equipment supplied under all Contracts related to this project. Examine the Drawings and Shop Drawings of all Divisions for the extent of electrically operated equipment supplied under other Contracts.
- .3 All control-wiring diagrams shown on the Drawings 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 Drawings. Where necessary, obtain conduit locations from other trades' drawings and Shop Drawings.
- .7 Assist in placing in operation all mechanical equipment having electrical connections.
- .8 Provide all power wiring for all motors and control wiring as indicated on the Drawings.
- .9 In general, wiring for freezestats, firestats, E.P. switches, P.E. switches, dampers, temperature controllers, flow switches, solenoid valves, etc., for heating ventilating and air conditioning (HVAC) equipment will be part of Division 17. Where 120 V power is required for mechanical equipment, i.e., roll type filters, refrigerated aftercoolers, control cabinets, etc. wiring to the equipment terminals is the Work of this Division.
- .10 Refer to Motor Control Equipment Schedule.

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**CONNECTIONS TO MECHANICAL EQUIPMENT**

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**2. PRODUCTS**

**2.1 3-Phase 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 CSA 2 enclosures for indoor and CSA 3 for outdoor installation. Switches to be H.P. rated, Westinghouse heavy-duty type.

**2.2 120 V, 1-Phase Disconnect Switches**

- .1 Manual starter without overload relay.

**2.3 208 V, 1-Phase Motor Disconnect Switches**

- .1 Manual starter without overload relay.

**3. EXECUTION**

**3.1 Installation**

- .1 Provide disconnect switches adjacent to all motors.
- .2 Provide all wiring between all force flow and unit heaters and their thermostats. Install wiring between all flow switches and valve monitors and the fire alarm panel.
- .3 Do control wiring as indicated on the drawings and the motor control schedules.

**END OF SECTION**

## **STARTING OF ELECTRICAL EQUIPMENT AND SYSTEM**

---

### **1. GENERAL**

#### **1.1 Related Work**

- .1 Testing, Adjusting, and Balancing of Electrical Equipment and Systems: Section 16980
- .2 Electrical Equipment and Systems Demonstration and Instruction: Section 16990

#### **1.2 Coordination**

- .1 Coordinate starting of electrical equipment and systems with testing, adjusting, and balancing, and demonstration and instruction of:
  - .1 Electrical equipment and systems specified in Division 16
  - .2 Mechanical equipment and systems specified in Division 15
  - .3 Other equipment and systems specified in other Divisions
- .2 Where any equipment or system requires testing, adjusting or balancing prior to starting, ensure that such Work has been completed prior to starting of electrical equipment and systems.

### **2. PRODUCTS**

- .1 Not Used

### **3. EXECUTION**

#### **3.1 Energizing Electrical System**

- .1 Prior to energizing the new electrical system:
  - .1 Verify supply authority voltage and phase rotation.
  - .2 Close and open all devices to ensure proper mechanical operation.

#### **3.2 Starting Motors**

- .1 Prior to starting motors:
  - .1 Confirm motor nameplate data with motor starter heater overloads.

**STARTING OF ELECTRICAL EQUIPMENT AND SYSTEM**

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**3.3 Energizing Equipment**

- .1 Prior to energizing equipment provided under other Sections and equipment provided by the City, confirm equipment nameplate with characteristics of power supply.

**END OF SECTION**

**TESTING, ADJUSTING AND BALANCING OF ELECTRICAL EQUIPMENT AND SYSTEMS**

---

**1. GENERAL**

**1.1 Intent**

- .1 Except where otherwise specified, arrange and pay for testing, adjusting, balancing and related requirements specified herein.
- .2 If test results do not conform to applicable requirements, repair, replace, adjust or balance equipment and systems. Repeat testing as necessary until acceptable results are achieved.
- .3 Provide all labour, materials, instruments and equipment necessary to perform the tests specified.
- .4 All tests shall be witnessed by persons designated by the Contract Administrator, who shall also sign the test documentation.
- .5 Submit procedures proposed in writing for approval two weeks prior to test.

**1.2 Related Work**

- .1 Electrical General Requirements: Section 16010
- .2 Starting of Electrical Systems and Equipment: Section 16960

**1.3 Manufacturer's Production Test Records**

- .1 If requested, submit copies of production test records for production tests required by EEMAC and CSA standards for manufactured electrical equipment.

**1.4 Site Testing Reports**

- .1 Log and tabulate test results on appropriate test report forms.
- .2 Submit forms to Contract Administrator for approval prior to use.
- .3 Submit completed test report forms as specified, immediately after tests are performed.

**1.5 Reference Documents**

- .1 Perform tests in accordance with:
  - .1 The Contract Documents.
  - .2 Requirements of authorities having jurisdiction.
  - .3 Manufacturer's published instructions.
  - .4 Applicable CSA, IEEE, IPCEA, EEMAC, and ASTM standards.
- .2 If requirements of any of the foregoing conflict, notify Contract Administrator before proceeding with test and obtain clarification.

**TESTING, ADJUSTING AND BALANCING OF ELECTRICAL EQUIPMENT AND SYSTEMS**

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**1.6 Manufacturer's Site Services**

- .1 Arrange and pay for the Site Services of appropriately qualified manufacturer's representatives where Site testing, adjusting, or balancing of electrical equipment or systems' performed by manufacturer's representatives is:
  - .1 Specified, or
  - .2 Otherwise required to ensure that electrical equipment and systems are operational in full compliance with the Contract Documents.

**1.7 Sequencing and Scheduling**

- .1 Except where otherwise specified, perform all testing, adjusting, balancing and related requirements specified herein prior to Interim Acceptance of the Work.
- .2 Perform voltage testing and adjusting after user occupancy or utilization of facility.

**2. PRODUCTS**

**2.1 Test Equipment**

- .1 Provide all equipment and tools necessary to perform testing, adjusting and balancing specified herein and as otherwise required.

**3. EXECUTION**

**3.1 Testing of Wiring and Wiring Devices**

- .1 All power and control wiring shall be tested for insulation resistance value with a 1000 V megger. Resistance values shall be as recommended by cable manufacturer. Test results shall be properly tabulated, signed, dated and submitted with maintenance manuals.
- .2 Test service grounding conductors for ground resistance.
- .3 Test all wiring devices for correct operation.
- .4 Test all receptacles for proper polarity and circuitry.

**3.2 Ground Resistance Testing**

- .1 Measure ground resistance with earth test meter to verify compliance with CSA C22.2 No. 0.4 and Canadian Electrical Code.

**3.3 Load Balance Testing**

- .1 Perform load tests when as many loads as possible, prior to Interim Acceptance of the Work, are operable.
- .2 Turn on all possible loads.

**TESTING, ADJUSTING AND BALANCING OF ELECTRICAL EQUIPMENT AND SYSTEMS**

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- .3 Test load balance on all feeders at distribution centres, motor control centre and panelboards.
- .4 If load balance exceeds 15 percent, reconnect circuits to balance loads.

**3.4 Voltage Testing and Adjusting**

- .1 Test voltage at all panelboards.
- .2 Adjust transformer tap settings to compensate for under-voltage or over-voltage conditions, if directed to do so by Contract Administrator.

**3.5 Testing of Transformer**

- .1 Each transformer shall be completely factory tested and the results certified, proving the performance of the units to provide capacities as listed in these specifications.
- .2 Factory tests for each transformer to include:
  - .1 Resistance measurements of all windings
  - .2 Ratio test at rated connection and on all taps
  - .3 Polarity and phase relation tests
  - .4 Audible sound level tests
  - .5 No load loss at rated voltage and losses at 25 percent, 50 percent, 75 percent and 100 percent load
  - .6 Exciting current at rated voltage
  - .7 Impedance
  - .8 Applied potential test
  - .9 Induced potential test
  - .10 95 kV B.I.L. test
  - .11 Hi-pot test
  - .12 Heat run, temperature rise tests on each transformer.
- .3 Submittals
  - .1 Submit for review, Shop Drawings of all items specified in this Section in accordance with "Shop Drawings" in the General Conditions.
  - .2 At completion of Work the prior to final acceptance, provide maintenance manuals for all items specified in this Section.



**TESTING, ADJUSTING AND BALANCING OF ELECTRICAL EQUIPMENT AND SYSTEMS**

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**3.6 Coordination and Short Circuit Study**

- .1 Provide a coordination/protective system study and short circuit study of all equipment specified herein and submit for review. Refer to Section 16405.

**3.7 Calibration and Verification**

- .1 Description
  - .1 Calibrate and verify the following equipment items supplied under this Contract:
    - .1 Primary switchgear.
    - .2 5 kV 600 V Dry Type Transformers.
    - .3 480 and 600 V switchgear.
  - .2 The calibration and Verification shall be carried out in the field after installation and connection of equipment, but prior to energization, in the presence of the City and the Contract Administrator.
  - .3 Related Work in Other Sections
    - .1 Unit substation to 15 kV: Section 16311
    - .2 Coordination and Short Circuit Study: Section 16405
  - .4 Submittals
    - .1 Submit details of all test procedures and instruments, together with technicians' names, to the Contract Administrator, prior to proceeding.
    - .2 Submit written verification report after installation is completed to reflect as-built conditions.
  - .5 Qualification
    - .1 Work shall be performed by a firm specializing in and with relevant experience in testing 15 kV and 600 V switchgear and protective relaying.
    - .2 This firm shall also perform the final checkout and testing of the equipment specified in Item 3.7 of this Section.
  - .6 Products
    - .1 Not applicable

**TESTING, ADJUSTING AND BALANCING OF ELECTRICAL EQUIPMENT AND SYSTEMS**

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.7 Calibration and Verification

- .1 The calibration and verification shall be carried out in the following stages:
  - .1 Primary switchgear
  - .2 5 kV Unit Substation Transformer
  - .3 600 V switchgear
- .2 The Electrical Contractor shall advise well in advance when each stage is ready for the calibration and verification and he shall:
  - .1 Ensure that all equipment is installed, connected and cleaned inside and out.
  - .2 Provide 120 V convenience receptacles.
  - .3 Provide a qualified electrician to assist in the calibration and verification.
  - .4 Provide all other facilities, equipment and personnel as reasonably required to assist in the calibration and verification.
- .3 For each circuit breaker, calibrate all protective relays and overcurrent device time and instantaneous trips in accordance with requirements of the protected equipment and overall coordination scheme. Field set each relay according to the recommend settings.
- .4 Verify all transformer ratios, insulation values, fuse sizes, C.T. and P.T. ratios, etc. and certify that the installation is in accordance with the requirements of the manufacturer and the Coordination/Short Circuit Study. Submit a written report on this verification to the Contract Administrator.
- .5 Carry out the tests required of calibration and verification firm as specified in the other related sections.
- .6 Ensure all bus and cable connections are tightened to manufacturer's specifications.
- .7 All relays are to be cleaned with dry, dust-free compressed air.

**END OF SECTION**

**ELECTRICAL EQUIPMENT AND SYSTEMS DEMONSTRATION AND INSTRUCTION**

---

**1. GENERAL**

**1.1 Intent**

- .1 Provide demonstration and instruction sessions to familiarize the City's operation and maintenance personnel with electrical systems and their operation and maintenance.
- .2 Submit system sign off sheets for each system listed prior to Substantial Completion.
- .3 Complete a motor survey sheet for each motor and submit prior to Substantial Completion. Include a control-wiring diagram for each motor neatly drawn in ladder form. Indicate all terminal and wire numbers. Identify all associated control components. Provide typed copies of these lists and diagrams in the O&M manuals. Include motor overload selection charts for each type and application of overload relay.
- .4 All sign-off and survey sheets shall be typewritten.

**1.2 Manufacturer's Site Services**

- .1 Arrange and pay for appropriately qualified manufacturers' representatives to provide or assist in providing electrical equipment and system demonstration and instruction as specified herein.

**1.3 Coordination**

- .1 The Contract Administrator will chair demonstration and instruction sessions.
- .2 Establish agenda for demonstration and instruction sessions in conjunction with the Contract Administrator. Coordinate scheduling of sessions with the Contract Administrator.

**2. PRODUCTS**

- .1 Not used

**3. EXECUTION**

**3.1 Systems Demonstration**

- .1 Demonstrate operation of the following systems:
  - .1 4160 V Transformers
  - .2 600/347 V Electrical System
  - .3 208/120 V System
  - .4 Mechanical Equipment Connections and Controls (including interface with the fire alarm system)

**ELECTRICAL EQUIPMENT AND SYSTEMS DEMONSTRATION AND INSTRUCTION**

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**MOTOR SURVEY SHEET**

Motor Name & Number \_\_\_\_\_

Manufacturer \_\_\_\_\_

H.P. \_\_\_\_\_ Max. Ambient \_\_\_\_\_ °C

R.P.M. \_\_\_\_\_ Service Factor \_\_\_\_\_

Volts \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_ Insulation Class \_\_\_\_\_

AMPS \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_ EEMAC Design \_\_\_\_\_

PHASE \_\_\_\_\_ Time Rating \_\_\_\_\_

Frame \_\_\_\_\_ Type \_\_\_\_\_

Serial # \_\_\_\_\_

Model # \_\_\_\_\_

Starter \_\_\_\_\_ Type \_\_\_\_\_

**OPERATING CONDITIONS**

Full Load Operating Amps \_\_\_\_\_ A \_\_\_\_\_ B \_\_\_\_\_ C \_\_\_\_\_

Full Load Operating Voltage \_\_\_\_\_ A-B \_\_\_\_\_ B-C \_\_\_\_\_ C-A \_\_\_\_\_  
at Motor

Overload Relay Installed \_\_\_\_\_ Adjustable Setting \_\_\_\_\_ %

M.C.P. AMPS \_\_\_\_\_ Adjustable Setting \_\_\_\_\_

Acceleration Time (If over 5 seconds) \_\_\_\_\_

Reduced Voltage Starter Tap Setting \_\_\_\_\_

Reduced Voltage Starter Transition Time Setting \_\_\_\_\_

Special Controls and Remarks (Thermistor and Relay Type, Capacitors and where connected, etc.)

\_\_\_\_\_  
\_\_\_\_\_

**ELECTRICAL EQUIPMENT AND SYSTEMS DEMONSTRATION AND INSTRUCTION**

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**SYSTEM COMPLETION AND COMMISSIONING**

**SYSTEM:** \_\_\_\_\_

The above system is installed as per the drawings and specifications, is complete and has been commissioned.

**Electrical Contractor**

Signed by: \_\_\_\_\_ Dated: \_\_\_\_\_

**General Contractor**

Signed by: \_\_\_\_\_ Dated: \_\_\_\_\_

Deficiencies Attached

This system has been reviewed by:

**The Contract Administrator**

Signed by: \_\_\_\_\_ Dated \_\_\_\_\_

The City's personnel have been instructed in the operation and maintenance of the above system:

**The City**

Signed by: \_\_\_\_\_ Dated \_\_\_\_\_

The above does not constitute a waiver of any of the requirements of the Contract Documents.

ELECTRICAL  
CONTRACTOR

GENERAL  
CONTRACTOR

Address:

_____	_____
_____	_____
_____	_____
_____	_____

Phone:

_____	_____
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**END OF SECTION**