

## **PART 1 - GENERAL**

### **1.1 SUMMARY**

- .1 Section Includes:
  - .1 General requirements for building Energy Monitoring and Control System (EMCS). This system is also generally referred to as EMCS, DDC, BMS, BCS, etc.

### **1.2 RELATED SECTIONS**

- .1 Coordinate all related Work among all specification sections, as well as between other Divisions, and that the tender price includes all related work.

### **1.3 REFERENCES**

- .1 American National Standards Institute (ANSI)
  - .1 ANSI/ISA 5.5-1985, Graphic Symbols for Process Displays.
- .2 American National Standards Institute (ANSI)/ Institute of Electrical and Electronics Engineers (IEEE).
  - .1 ANSI/IEEE 260.1-2004, American National Standard Letter Symbols Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).
- .3 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
  - .1 ASHRAE 135-2010, BACNET - Data Communication Protocol for Building Automation and Control Network.
- .4 Canadian Standards Association (CSA International).
  - .1 CAN/CSA Z234.1-00(R2011), Metric Practice Guide.
- .5 Consumer Electronics Association (CEA).
  - .1 CEA-709.1-B-10, Control Network Protocol Specification.
- .6 Department of Justice Canada (Jus).
  - .1 Canadian Environmental Assessment Act (CEAA).
  - .2 Canadian Environmental Protection Act (CEPA).
- .7 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
- .8 Material Safety Data Sheets (MSDS).
- .9 Transport Canada (TC).
  - .1 Transportation of Dangerous Goods Act (TDGA).

- .10 National Electrical Manufacturers Association (NEMA)

## 1.4 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

- .1 Acronyms used in EMCS.
- .1 AEL - Average Effectiveness Level
  - .2 AI - Analog Input
  - .3 AO - Analog Output
  - .4 BACnet - Building Automation and Control Network
  - .5 BC(s) - Building Controller(s)
  - .6 BECC - Building Environmental Control Centre
  - .7 CAB - Canadian Automated Building (CAB) Protocol
  - .8 CAD - Computer Aided Design
  - .9 CDL - Control Description Logic
  - .10 CDS - Control Design Schematic
  - .11 COSV - Change of State or Value
  - .12 CPU - Central Processing Unit
  - .13 DDC - Direct Digital Control
  - .14 DI - Digital Input
  - .15 DO - Digital Output
  - .16 DP - Differential Pressure
  - .17 ECU - Equipment Control Unit
  - .18 EMCS - Energy Monitoring and Control System
  - .19 HVAC - Heating, Ventilation, Air Conditioning
  - .20 IDE - Interface Device Equipment
  - .21 I/O - Input/Output
  - .22 ISA - Industry Standard Architecture
  - .23 LAN - Local Area Network
  - .24 LCU - Local Control Unit
  - .25 MCU - Master Control Unit
  - .26 NC - Normally Closed
  - .27 NO - Normally Open
  - .28 OS - Operating System
  - .29 O&M - Operation and Maintenance
  - .30 OWS - Operator Work Station
  - .31 PC - Personal Computer
  - .32 PCI - Peripheral Control Interface
  - .33 PCMCIA - Personal Computer Micro-Card Interface Adapter
  - .34 PID - Proportional, Integral and Derivative.
  - .35 RAM - Random Access Memory
  - .36 ROM - Read Only Memory
  - .37 SP - Static Pressure
  - .38 TCU - Terminal Control Unit
  - .39 USB - Universal Serial Bus
  - .40 UPS - Uninterruptible Power Supply
  - .41 WAN- Wide Area Network

## 1.5 DEFINITIONS

- .1 Point: may be logical or physical.

- .1 Logical points: values calculated by system such as setpoints, totals, counts, derived corrections and may include, but not limited to result of and statements in CDL's.
- .2 Physical points: inputs or outputs which have hardware wired to controllers which are measuring physical properties, or providing status conditions of contacts or relays which provide interaction which related equipment (stop, start) and value or damper actuators.
- .2 Point Name: Use a naming system consistent with the Contract Documents, NSDTIR requirements and other systems on camps.
- .3 Point Object Type: points fall into following object types:
  - .1 AI (analog input)
  - .2 AO (analog output)
  - .3 DI (digital input)
  - .4 DO (digital output)
  - .5 Pulse inputs
- .4 Symbols and engineering unit abbreviations utilized in displays: to ANSI/ISA S5.5.
  - .1 Printouts: to ANSI/IEEE 260.1.
  - .2 Refer also to Section 25 05 54 - EMCS: Identification.

## **1.6 SYSTEM DESCRIPTION**

- .1 Refer to control schematics, sequences of operation and related Divisions of specifications for system architecture.
- .2 Work covered by sections referred to above consists of fully operational EMCS, including, but not limited to, following:
  - .1 Building Controllers.
  - .2 Control devices as listed in I/O point summaries and/or shown on the control drawings.
  - .3 OWS
  - .4 Data communications equipment necessary to affect EMCS data transmission system.
  - .5 Field control devices.
  - .6 Software/Hardware complete with full documentation.
  - .7 Complete operating and maintenance manuals.
  - .8 Training of personnel.
  - .9 Acceptance tests, technical support during commissioning, full documentation.
  - .10 Wiring interface co-ordination of equipment supplied by others (including the laboratory airflow control system).
  - .11 Miscellaneous work as specified in these sections and as indicated.
- .3 Design Requirements:
  - .1 Design and provide conduit and wiring linking elements of system.
  - .2 Supply sufficient programmable controllers of types to meet project requirements. Quantity and points contents as reviewed prior to installation.
  - .3 Location of controllers as reviewed by the Departmental Representative prior to installation.
  - .4 Provide utility and emergency power to EMCS.

- .5 Metric references: in accordance with CAN/CSA Z234.1.
- .4 Language Operating Requirements:
  - .1 Provide English interface to system through operator selectable access codes.
  - .2 Use non-linguistic symbols for displays on graphic terminals wherever possible. Other information to be in English.
  - .3 Operating system executive: provide primary hardware-to-software interface specified as part of hardware purchase with associated documentation to be in English.
  - .4 System manager software: include in English system definition point database, additions, deletions or modifications, control loop statements, use of high level programming languages, report generator utility and other OS utilities used for maintaining optimal operating efficiency.
- .5 Include, in English:
  - .1 Input and output commands and messages from operator-initiated functions and field related changes and alarms as defined in CDL's or assigned limits (i.e. commands relating to day-to-day operating functions and not related to system modifications, additions, or logic re-definitions).
  - .2 Graphic "display" functions, point commands to turn systems on or off, manually override automatic control of specified hardware points. To be in English at specified OWS. Point name expansions in English.
  - .3 Reporting function such as trend log, trend graphics, alarm report logs, energy report logs, maintenance generated logs.
- .6 The network design to be a fully distributed network, with each primary system having its own locally mounted dedicated controller. Any failure in the network shall not in any way affect the control of these primary systems. Connecting hardware points from one system to more than one controller is not acceptable. Any points associated with a system are to be connected to one dedicated controller. Each dedicated controller to have a locally mounted control and display device to allow the operator to view and adjust any point on the controller.

## **1.7 SYSTEM WIRING**

- .1 All wiring associated with the EMCS communication network as well as all control wiring, power wiring for control system, and conduit associated with the EMCS at 120 volts or less shall be by the controls contractor. Refer to contract electrical Drawings and specifications for requirements and locations of breakers in electrical panels dedicated for use by the control system contractor.
- .2 BACnet compliance: full compliance to the BACnet standard (ANSA/ASHRAE) 135, BACnet - A Data communication Protocol for Building Automation and Control Networks is mandatory. Down to the field device level, the EMCS system must meet BACnet standards for system architecture and administration, and use open communication protocols and user friendly programming and graphics. Install the EMCS installed to communicate at the supervisory layer to the WAN using the BACnet TCP/IP protocol implemented on Ethernet.
- .3 The EMCS system for this facility to be accessible by designated personnel via the WAN for monitoring and programming purposes. Provide all the required hardware, software, gateways, etc. needed to permit connection of the EMCS to the WAN. This includes all hardware, software, programming, start-up and commissioning required. Supply and install

all the required hardware and software on the WAN file server to allow for this remote operation monitoring and programming to take place. Supply and install all the required hardware and software on the operator workstation(s) located in the Owner's facilities management department. In addition, a remote dial in access directly to the system shall be provided.

## **1.8 SUBMITTALS**

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures and 25 05 02 - EMCS: Submittals and Review Process.
- .2 Submit for review:
  - .1 Equipment list and systems manufacturers within 10 days after award of contract.
- .3 Quality Control:
  - .1 Provide equipment and material from manufacturer's regular production, CSA certified, manufactured to standard quoted plus additional specified requirements.
  - .2 Where CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.
  - .3 Submit proof of compliance to specified standards with shop drawings and product data in accordance with Section 25 05 02 - EMCS: Submittals and Review Process. Label or listing of specified organization is acceptable evidence.
  - .4 In lieu of such evidence, submit certificate from testing organization, approved by third party engineer registered in Canada, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.
  - .5 For materials whose compliance with organizational standards/codes/ specifications is not regulated by organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.
  - .6 Permits and fees: in accordance with general conditions of contract.
  - .7 Existing devices intended for re-use: submit test report.

## **1.9 QUALITY ASSURANCE**

- .1 Have local office for at least five (5) years staffed by factory trained personnel capable of installing and providing instruction, routine maintenance and emergency service on systems.
- .2 Provide record of successful previous installations submitting tender showing experience with similar installations utilizing computer-based systems.
- .3 Have access to local supplies of essential parts and provide seven (7) year guarantee of availability of spare parts after obsolescence.
- .4 Confirm factory qualified supervisory personnel continuously direct and monitor work and attend site meetings.
- .5 Health and Safety:
  - .1 Do construction occupational health and safety in accordance with Section 01 35 29 - Health and Safety Requirements.

- .2 Provide factory trained personnel on site within 24 hours' notice or provide instructions on maintenance and emergency service on system.
- .3 BACnet devices to bear BACnet testing laboratories BTL mark and listed on BACnet manufacturer's association web site.

## **1.10 DELIVERY, STORAGE AND HANDLING**

- .1 Material Delivery Schedule: provide Departmental Representative with "Materials Delivery Schedule" within two (2) weeks after award of contract.
- .2 Waste Management and Disposal:
  - .1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
  - .2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
  - .3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
  - .4 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste in accordance with Waste Management Plan.
  - .5 Place materials defined as hazardous or toxic in designated containers.
  - .6 Handle and dispose of hazardous materials in accordance with CEPA, TDGA, Regional, Municipal, and Provincial regulations.
  - .7 Label location of salvaged material's storage areas and provide barriers and security devices.
  - .8 Seal emptied containers and store safely.
  - .9 Divert unused metal materials from landfill to metal recycling facility as approved by the Departmental Representative.
  - .10 Fold up metal and plastic banding, flatten and place in designated area for recycling.

## **PART 2 - PRODUCTS**

### **2.1 ACCEPTABLE SYSTEMS, MANUFACTURERS**

- .1 Existing Delta (Controls and Equipment) controls system is to remain and be expanded as indicated in controls drawings.

### **2.2 CONTROL PANELS**

- .1 Panel to be NEMA rated to suit environmental requirements.
- .2 Panels to have hinged doors equipped with standard keyed-alike cabinet locks, keyed existing NSAC common panelkey.
- .3 Wiring within panels to be contained within properly sized rigid PVC slotted wall wire duct. All wiring within the wire duct to be concealed with a non-slip cover.

- .4 Properly identify terminations for the connection of power wiring, communication wiring and field mounted devices at terminal blocks mounted within the control panel.
- .5 Provide control panels with an internally mounted 120 volt duplex power receptacle.
- .6 Identify control panels with permanently mounted Lamecoid tags to identify the control pan and the systems served by the control panel. Submit schedule of labels with shop drawing submission.
- .7 Provide low voltage transformers in panels or elsewhere as required.
- .8 Provide adaptors between metric and imperial components.

### **PART 3 - EXECUTION**

#### **3.1 MANUFACTURER'S RECOMMENDATIONS**

- .1 Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

#### **3.2 PAINTING**

- .1 Paint in accordance with NEMA requirements.
- .2 Clean and touch up marred or scratched surfaces of factory finished equipment to match original finish.
- .3 Restore to new condition, finished surfaces which have been damaged too extensively to be primed and touched up to make good.
- .4 Clean and prime exposed hangers, racks, fastenings, and other support components.
- .5 Paint all unfinished equipment installed indoors to NEMA.

**END OF SECTION**

## **PART 1 - GENERAL**

### **1.1 REFERENCES**

- .1 American National Standards Institute (ANSI)
  - .1 ANSI/ASME B16.22-2013, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
  - .2 ANSI C2-2007, National Electrical Safety Code.
  - .3 ANSI/NFPA 70-2014, National Electrical Code.
- .2 Canadian Standards Association (CSA)
  - .1 CSA C22.1-2015, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations.
  - .2 CAN/CSA C22.3 No.1-15, Overhead Systems.
  - .3 CSA C22.3 No. 7-15, Underground Systems.
  - .4 CAN/CSA C22.2 No. 45.1-07 (R2012), Electrical Rigid Metal Conduit - Steel.
  - .5 CAN/CSA C22.2 No. 56-2013, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
  - .6 CAN/CSA C22.2 No. 83-M1985(R2013), Electrical Metal Tubing.

### **1.2 SYSTEM DESCRIPTION**

- .1 Electrical:
  - .1 Provide power wiring from emergency power panels where emergency power is provided to EMCS field panels. Provide UPS Device for each panel. Circuits to be for exclusive use of EMCS equipment. Identify panel breakers on panel legends tags and locks applied to breaker switches.
  - .2 Hard wiring between field control devices and EMCS field panels.
  - .3 Communication wiring between EMCS field panels and OWS's including main control centre BECC.
- .2 Pneumatic:
  - .1 Pneumatic tubing, valves and fittings for field control devices.
- .3 Mechanical:
  - .1 Supply and install pipe taps required for EMCS equipment. This Work may be done by the mechanical subcontractor.
  - .2 Supply and install wells and control valves. This Work may be done by the mechanical subcontractor.
  - .3 Have installation of air flow stations, dampers, and other devices requiring sheet metal trades mounted by mechanical subcontractor.
  - .4 Supply and install all control wiring and conduit.
- .4 VAV Terminal Units and Laboratory Airflow Controls.
  - .1 Coordinate with and provide all field wiring/components for the operation of these systems.

- .5 Structural:
  - .1 Special steelwork as required for installation of work.

### **1.3 PERSONNEL QUALIFICATIONS**

- .1 Qualified factory trained supervisory personnel to:
  - .1 Continuously direct and monitor all work.
  - .2 Attend site meetings.

### **1.4 EXISTING CONDITIONS**

- .1 Cutting and Patching: refer to Section 01 73 29. Requirements supplemented as specified herein.
- .2 Repair all surfaces damaged during execution of work.
- .3 Turn over to the Departmental Representative existing materials removed from work not identified for re-use.

## **PART 2 - PRODUCTS**

### **2.1 PIPING**

- .1 Domestic H&CWS: refer to Section 22 11 16 - Domestic Water Piping - Copper.
- .2 Sanitary, storm water: refer to Section 22 13 17 - Drainage Waste and Vent Piping - Cast Iron and Copper
- .3 Sleeves, escutcheons: refer to Section 23 05 05 - Installation of Pipework.
- .4 Hangers and supports: refer to Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- .5 Insulation: refer to Section 23 07 13 - Thermal Insulation for Ducting.

### **2.2 SPECIAL SUPPORTS**

- .1 Structural grade steel primed and painted after construction and before Installation.

### **2.3 PIPING FOR PNEUMATIC CONTROL SYSTEMS (IF REQUIRED)**

- .1 Copper:
  - .1 Tubing: Type L, Hard Drawn

- .2 Fittings: wrought copper solder type to ANSI/ASME B16.22, and 95.5 antimonial tin solder. At instruments use compression fittings.
- .3 At panels and junction boxes where there is a transition from plastic to copper use bulkhead fittings.
- .2 Plastic:
  - .1 Flame retardant, black PVC with minimum burst strength 1.3 MPa at 23EC installed in conduit.
  - .2 Fittings: compression or barbed type as required.

## **2.4 WIRING**

- .1 As per requirements of Electrical Divisions.
- .2 For 50V and above copper conductor with chemically cross-linked thermosetting polyethylene insulation rated RW90 and 600V. Colour code to CSA 22.1.
- .3 For wiring under 50 volts use FT6 rated wiring where wiring is not run in conduit. All other cases use FT4 wiring.
- .4 Sizes:
  - .1 120V Power supply: to match or exceed breaker, size #12 minimum.
  - .2 Wiring for safeties/interlocks for starters, motor control centres, to be stranded, #14 minimum.
  - .3 Field wiring to digital device: #18AWG or 20AWG stranded twisted pair.
  - .4 Analog input and output: shielded #18 minimum solid copper or #20 minimum stranded twisted pair. Wiring must be continuous without joints.
  - .5 More than four (4) conductors: #22 minimum solid copper.
- .5 Terminations:
  - .1 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.

## **2.5 CONDUIT**

- .1 As per requirements of Section 26 05 34.
- .2 Electrical metallic tubing to CSA C22.2 No. 83. Flexible and liquid tight flexible metal conduit to CSA C22.2 No. 56. Rigid steel threaded conduit to CSA C22.2 No. 45.1.
- .3 Junction and pull boxes: welded steel.
  - .1 Surface mounting cast FS: screw-on flat covers.
  - .2 Flush mounting: covers with 25mm minimum extension all round.
- .4 Cabinets: sheet steel, for surface mounting, with hinged door, latch lock, two (2) keys, complete with perforated metal mounting backboard. Panels to be keyed alike for similar functions and or entire contract as approved.
  - .1 Outlet boxes: 100mm minimum, square.

- .5 Conduit boxes, fittings:
  - .1 Bushings and connectors: with nylon insulated throats.
  - .2 With push pennies to prevent entry of foreign materials.
- .6 Fittings for rigid conduit:
  - .1 Couplings and fittings: threaded type steel.
  - .2 Double locknuts and insulated bushings: use on sheet metal boxes.
  - .3 Use factory "ells" where 90 degree bends required for 25mm and larger conduits.
- .7 Fittings for thin wall conduit:
  - .1 Connectors and couplings: steel, set screw type.

## **2.6 WIRING DEVICES, COVER PLATES**

- .1 Conform to CSA.
- .2 Receptacles:
  - .1 Duplex: CSA type 5-15R.
  - .2 Single: CSA type 5-15R.
  - .3 Cover plates and blank plates: finish to match other plates in area.

## **2.7 SUPPORTS FOR CONDUIT, FASTENINGS, EQUIPMENT**

- .1 Solid masonry, tile and plastic surfaces: lead anchors or nylon shields.
- .2 Hollow masonry walls, suspended drywall ceilings: toggle bolts.
- .3 Exposed conduits or cables:
  - .1 50mm diameter and smaller: one-hole steel straps.
  - .2 Larger than 50mm diameter: two-hole steel straps.
- .4 Suspended support systems:
  - .1 Individual cable or conduit runs: support with 6mm diameter threaded rods and support clips.
  - .2 Two (2) or more suspended cables or conduits: support channels supported by 6mm diameter threaded rod hangers.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- .1 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.

### **3.2 PIPING**

- .1 Domestic H&CWS: refer to Section 22 11 16 - Domestic Water Piping Copper.
- .2 Sanitary, storm water: refer to Section 22 13 17 - Drainage Waste and Vent Piping - Cast Iron and Copper.
- .3 Insulation: refer to Section 23 07 13 - Thermal Insulation for Ducting.

### **3.3 MECHANICAL PIPING**

- .1 Install piping in accordance with Section 23 05 05 - Installation of Pipework.

### **3.4 SUPPORTS**

- .1 Install special supports as required and as indicated.

### **3.5 PNEUMATIC CONTROL SYSTEMS (IF REQUIRED)**

- .1 General:
  - .1 Install tubing in accessible concealed locations, straight, parallel and close to building structure with required grades for drainage and venting.
  - .2 Install drip legs and drains at low points.
  - .3 Tubing to be free from surface damage.
  - .4 Tubing NOT to pass through or touch unheated ducts or enclosures.
  - .5 Do not cover pneumatic tubing with insulation.
  - .6 Test tubing, check joints after connection to system.
- .2 Copper tubing:
  - .1 Not to come into contact with dissimilar metal. Use non-metallic stand-offs on air handling systems.
  - .2 Install dielectric couplings where dissimilar metals are connected.
- .3 Plastic tubing:
  - .1 Inaccessible locations: install plastic tubing in conduit.
  - .2 Inside panels: install in tube trays or racks, or clip individually to back of panel.
  - .3 Multiple tube bundles: install in tube trays, conduit or armoured flexible cable.

### **3.6 ELECTRICAL GENERAL**

- .1 Do complete installation in accordance with requirements of:
  - .1 Electrical Divisions, this specification.
  - .2 CSA 22.1, Canadian Electrical Code.
  - .3 ANSI/NFPA 70.
  - .4 ANSI C2.

- .2 Fully enclose or properly guard electrical wiring, terminal blocks, high voltage (above 50 V) contacts and mark to prevent accidental injury.
- .3 Do underground installation to CAN/CSA C22.3 No.7, except where otherwise specified.
- .4 Conform to manufacturer's recommendations for storage, handling and installation.
- .5 Check factory connections and joints. Tighten where necessary to ensure continuity.
- .6 Install electrical equipment between 1.0m and 2.0m above finished floor wherever possible and adjacent to related equipment.
- .7 Protect exposed live equipment such as panel, mains, outlet wiring during construction for personnel safety.
- .8 Shield and mark live parts "LIVE 120 VOLTS" or other appropriate voltage.
- .9 Install conduits and sleeves prior to pouring of concrete.
- .10 Holes through exterior wall and roofs: flash and make weatherproof.
- .11 Make necessary arrangements for cutting of chases, drilling holes and other structural work required to install electrical conduit, cable, pull boxes, outlet boxes.
- .12 Install cables, conduits and fittings which are to be embedded or plastered over, neatly and closely to building structure to minimize furring.

### **3.7 CONDUIT SYSTEM**

- .1 Install communication wiring in conduit. Provide complete conduit system to link Building Controllers to BECC and the campus wide control system. Conduit sizes to suit wiring requirements and to allow for future expansion capabilities specified for systems. Maximum conduit fills not to exceed 40%. Design drawings do not show conduit layout.
- .2 Install conduits parallel or perpendicular to building lines, to conserve headroom and to minimize interference.
- .3 Do not run exposed conduits in normally occupied spaces unless otherwise indicated or unless impossible to do otherwise. Obtain approval from the Departmental Representative before starting such work. Provide complete conduit system to link field panels and devices with main control centre. Conduit size to match conductors plus future expansion capabilities as specified.
- .4 Locate conduits at least 150mm from parallel steam or hot water pipes and at least 50mm at crossovers.
- .5 Bend conduit so that diameter is reduced by less than 1/10th original diameter.
- .6 Field thread on rigid conduit to be of sufficient length to draw conduits up tight.
- .7 Limit conduit length between pull boxes to less than 30.0m.

- .8 Use conduit outlet boxes for conduit up to 32mm diameter and pull boxes for larger sizes.
- .9 Fastenings and supports for conduits, cables, and equipment:
  - .1 Provide metal brackets, frames, hangers, clamps and related types of support structures as indicated and as required to support cable and conduit runs.
  - .2 Provide adequate support for raceways and cables, sloped vertically to equipment.
  - .3 Use supports or equipment installed by other trades for conduit, cable and raceway supports only after written approval from the Departmental Representative.
- .10 Install polypropylene fish cord in empty conduits for future use.
- .11 Where conduits become blocked, remove and replace blocked sections.
- .12 Pass conduits through structural members only after receipt of the Departmental Representative written approval.
- .13 Conduits may be run in flanged portion of structural steel.
- .14 Group conduits wherever possible on suspended or surface channels.
- .15 Pull boxes:
  - .1 Install in inconspicuous but accessible locations.
  - .2 Support boxes independently of connecting conduits.
  - .3 Fill boxes with paper or foam to prevent entry of construction material.
  - .4 Provide correct size of openings. Reducing washers not permitted.
  - .5 Mark location of pull boxes on record drawings.
  - .6 Identify AC power junction boxes, by panel and circuit breaker.
- .16 Install terminal blocks or strips indicated in cabinets to Electrical Division.
- .17 Install bonding conductor for 120 volt and above in conduit.

### **3.8 WIRING**

- .1 Install multiple wiring in ducts simultaneously.
- .2 Do not pull spliced wiring inside conduits or ducts.
- .3 Use CSA certified lubricants of type compatible with insulation to reduce pulling tension.
- .4 Tests: use only qualified personnel. Demonstrate that:
  - .1 Circuits are continuous, free from shorts, unspecified grounds.
  - .2 Resistance to ground of all circuits is greater than 50 Megohms.
  - .3 Provide the Departmental Representative with test results showing locations, circuits, results of tests.
  - .4 Remove insulation carefully from ends of conductors and install to manufacturer's recommendations. Accommodate all strands in lugs. Where insulation is stripped in excess, neatly tape so that only lug remains exposed.

- .5 Wiring in main junction boxes and pull boxes to terminate on terminal blocks only, clearly and permanently identified. Junctions or splices not permitted for sensing or control signal covering wiring.
- .6 Do not allow wiring to come into direct physical contact with compression screw.
- .7 Install all strands of conductor in lugs of components. Strip insulation only to extent necessary for installation.

### **3.9 WIRING DEVICES, COVER PLATES**

- .1 Receptacles:
  - .1 Install vertically in gang type outlet box when more than one (1) receptacle is required in one (1) location.
- .2 Cover plates:
  - .1 Install suitable common cover plate where wiring devices are grouped.
  - .2 Use flush type cover plates only on flush type outlet boxes.

### **3.10 STARTERS, CONTROL DEVICES**

- .1 Install and make control connections as indicated. Have the electrical subcontractor install Power connections above 50V.
- .2 Install correct over-current devices.
- .3 Identify each control wire, terminal for external connections with permanent number marking identical to diagram.
- .4 Performance Verification:
  - .1 Operate switches and controls to verify functioning.
  - .2 Perform start and stop sequences of contactors and relays.
  - .3 Check that interlock sequences, with other separate related starters, equipment and auxiliary control devices, operate as specified.

### **3.11 GROUNDING**

- .1 Install complete, permanent, continuous grounding system for equipment, including conductors, connectors and accessories.
- .2 Install separate grounding conductors in conduit within building.
- .3 Install ground wire in all PVC ducts and in tunnel conduit systems.
- .4 Tests: perform ground continuity and resistance tests, using approved method appropriate to site conditions.

### **3.12 TESTS**

- .1 General:
  - .1 Perform following tests in addition to tests specified Section 25 08 20 - EMCS: Warranty and Maintenance.
  - .2 Give 14 days' written notice of intention to test.
  - .3 Conduct in presence of the Departmental Representative and authority having jurisdiction.
  - .4 Conceal work only after tests satisfactorily completed.
  - .5 Report results of tests to the Departmental Representative in writing.
  - .6 Preliminary tests:
    - .1 Conduct as directed to verify compliance with specified requirements.
    - .2 Make needed changes, adjustments, replacements.
    - .3 Insulation resistance tests:
      - .1 Megger all circuits, feeders, equipment for 120 - 600V with 1000V instrument. Resistance to ground to be more than required by Code before energizing.
      - .2 Test insulation between conductors and ground, efficiency of grounding system to satisfaction of the Departmental Representative and authority having jurisdiction.

### **3.13 IDENTIFICATION**

- .1 Refer to Section 25 05 54- EMCS: Identification.

**END OF SECTION**