1 GENERAL

1.01 SUMMARY

.1 Section Includes:
  .1 Methods and procedures for start-up, verification and commissioning, for building Energy Monitoring and Control System (EMCS) and includes:
    .1 Start-up testing and verification of systems
    .2 Check-out demonstration or proper operation of components.
    .3 On-site operational tests

1.02 RELATED SECTIONS

.1 Coordinate all related work among all specification sections, as well as between all Divisions.

1.03 DEFINITIONS

.1 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

.2 AEL (Average Effectiveness Level): ratio between total test period less any system downtime accumulated within that period and test period.

.3 Downtime: results whenever EMCS is unable to fulfill required functions due to malfunction of equipment defined under responsibility of EMCS contractor. Downtime is measured by duration, in time, between time that Contractor is notified of failure and time system is restored to proper operating condition. Downtime not to include following:
  .1 Outage of main power supply in excess of back-up power sources, provided that:
    .1 Automatic initiation of back-up was accomplished.
    .2 Automatic shut-down and re-start of components was as specified.
  .2 Failure of communications link, provided that:
    .1 Controller automatically and correctly operated in stand-alone mode.
    .2 Failure was not due to failure of any specified EMCS equipment.
  .3 Functional failure resulting from individual sensor inputs or output devices, provided that:
    .1 System recorded said fault.
    .2 Equipment defaulted to fail-safe mode.
    .3 AEL of total of all input sensors and output devices

is at least 99 % during test period.

1.04 DESIGN REQUIREMENTS

.1 Confirm with the Departmental Representative that Design Criteria and Design Intents are still applicable.

.2 Commissioning personnel to be fully aware of and qualified to interpret Design Criteria and Design Intents.

1.05 SUBMITTALS

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.

.2 Final Report: submit report to Departmental Representative.
- .1 Include measurements, final settings and certified test results.
- .2 Bear signature of commissioning technician and supervisor
- .3 Report format to be approved by Departmental Representative before commissioning is started.
- .4 Revise "as-built" documentation, commissioning reports to reflect changes, adjustments and modifications to EMCS as set during commissioning and submit to Departmental Representative in accordance with Section 01 78 00.
- .5 Recommend additional changes and/or modifications deemed advisable in order to improve performance, environmental conditions or energy consumption.

1.06 CLOSEOUT SUBMITTALS

.1 Provide documentation, O&M Manuals, and training materials of O&M personnel for review by Departmental Representative before interim acceptance in accordance with Section 01 78 00 and Section 25 05 03 - EMCS: Project Record Documents.

1.07 COMMISSIONING

.1 Do commissioning in accordance with Division 01 and the Commissioning Plan.

.2 Carry out final witness functional testing after completion of all installer testing and when the systems are known to be operating stably and completely under automatic control. Final witness testing shall be under the direction of the Departmental Representative and in presence of Departmental Representative and Commissioning Coordinator.

.3 Inform, and obtain approval from the Departmental Representative in writing at least 14 days prior to witness testing or each

test. Indicate:
.1 Location and part of system to be tested or commissioned.
.2 Testing/commissioning procedures, anticipated results.
.3 Names of testing/commissioning personnel.

.4 Correct deficiencies, re-test in presence of Departmental Representative until satisfactory performance is obtained.

.5 Acceptance of tests will not relieve Contractor from responsibility for ensuring that complete systems meet every requirement of Contract.

.6 Load system with project software. Install software for access to EMCS via dial up modem at a designated site for use during commissioning and for their use afterwards. Where high speed internet is available, use web browser software, compatible with Windows Vista with access via Internet Explorer (latest edition).

.7 Perform tests as required.

1.08 COMPLETION OF COMMISSIONING

.1 Commissioning will be considered as satisfactorily completed when objectives of commissioning have been achieved and reviewed by Departmental Representative and Commissioning Coordinator.

1.09 ISSUANCE OF FINAL CERTIFICATE OF COMPLETION

.1 Final Certificate of Completion will not be issued until receipt of written approval indicating successful completion of specified commissioning activities including receipt of commissioning documentation.

2 PRODUCTS

2.01 EQUIPMENT

.1 Provide sufficient instrumentation to verify and commission the installed system. Provide two-way radios.

.2 Instrumentation accuracy tolerances: higher order of magnitude than equipment or system being tested.

.3 Independent testing laboratory to certify test equipment as accurate to within approved tolerances no more than two (2) months prior to tests.

.4 Locations to be approved, readily accessible and readable.

.5 Application: to conform to normal industry standards.

3 EXECUTION

3.01 PROCEDURES

.1 Test each system independently and then in unison with other related systems.

.2 Commission each system using procedures prescribed by the Commissioning Coordinator and/or Departmental Representative and by the manufacturers recommended best practices.

.3 Commission integrated systems using procedures prescribed by Commissioning Coordinator and/or Departmental Representative and by the manufacturers recommended best practices.

.4 Debug system software.

.5 Optimize operation and performance of systems by fine-tuning PID values and modifying CDLs as required.

.6 Test full scale emergency evacuation and life safety procedures including operation and integrity of smoke management systems under normal and emergency power conditions as applicable.

3.02 FIELD QUALITY CONTROL

.1 Pre-Installation Testing:
- .1 General: consists of field tests of equipment just prior to installation.
- .2 Testing may be on site or at Contractor's premises as approved by Departmental Representative.
- .3 Configure major components to be tested in same architecture as designed system. Include all required network and control components.
- .4 Equip each Building Controller with sensor and controlled device of each type (AI, AO, DI, DO).
- .5 Additional instruments to include:
  - .1 DP transmitters.
  - .2 VAV supply duct SP transmitters.
  - .3 DP switches used for dirty filter indication and fan status.
- .6 In addition to test equipment, provide inclined manometer, digital micro-manometer, milli-amp meter, source of air pressure infinitely adjustable between 0 and 500 Pa, to hold steady at any setting and with direct output to milli-amp meter at source.
- .7 After setting, test zero and span in 10% increments through entire range while both increasing and decreasing pressure.
- .8 Departmental Representative to mark instruments tracking within 0.5 % in both directions as "approved for

installation".

.9 Transmitters above 0.5 % error will be rejected.

.10 DP switches to open and close within 2% of set point.

.2 Completion Testing:

.1 General: test after installation of each part of system and after completion of mechanical and electrical hook-ups, to verify correct installation and functioning.

.2 Include following activities:

.1 Test and calibrate field hardware including stand-alone capability of each controller.

.2 Verify each A-to-D convertor.

.3 Test and calibrate each AI using calibrated digital instruments.

.4 Test each DI to ensure proper settings and switching contacts.

.5 Test each DO to ensure proper operation and lag time.

.6 Test each AO to ensure proper operation of controlled devices. Verify tight closure and signals.

.7 Test operating software.

.8 Test application software and provide samples of logs and commands.

.9 Verify each CDL including energy optimization programs.

.10 Debug software.

.11 Blow out flow measuring and static pressure stations with high pressure air at 700 kPa.

.12 Provide point verification list in table format including point identifier, point identifier expansion, point type and address, low and high limits and Engineering units. This document will be used in final startup testing.

.3 Final Startup Testing: Upon satisfactory completion of tests, perform point-by-point test of entire system and provide:

.1 Technical personnel capable of re-calibrating field hardware and modifying software.

.2 Detailed daily schedule showing items to be tested and personnel available.

.3 Testers signature shall be on executive and applications programs.

.4 Commissioning to commence during final startup testing.

.5 O&M personnel to assist in commissioning procedures as part of training.

.6 Commissioning to be supervised by qualified supervisory personnel and the Departmental Representative.

.7 Commission systems considered as life safety systems

before affected parts of the facility are occupied.

.8 Operate systems as long as necessary to commission entire project.

.9 Monitor progress and keep detailed records of activities and results.

.4 Final Operational Testing: to demonstrate that EMCS functions in accordance with contract requirements.

.1 Prior to beginning of 30 day test demonstrate that operating parameters (set points, alarm limits, operating control software, sequences of operation, trends, graphics and CDL's) have been implemented to ensure proper operation and operator notification in event of off-normal operation.

.1 Repetitive alarm conditions to be resolved to minimize reporting of nuisance conditions.

.2 Test to last at least 30 consecutive 24 hour days.

.3 Tests to include:

.1 Demonstration of correct operation of monitored and controlled points.

.2 Operation and capabilities of sequences, reports, special control algorithms, diagnostics, software.

.4 System will be accepted when:

.1 EMCS equipment operates to meet overall performance requirements. Downtime as defined in this Section must not exceed allowable time calculated for this site.

.2 Requirements of Contract have been met.

.5 In event of failure to attain specified AEL during test period, extend test period on day-to- day basis until specified AEL is attained for test period.

.6 Correct defects when they occur and before resuming tests.

.5 Commissioning Coordinator and/or Departmental Representative to verify reported results.

3.03 ADJUSTING

.1 Final adjusting: upon completion of commissioning as reviewed by Departmental Representative set and lock devices in final position and permanently mark settings.

3.04 DEMONSTRATION

.1 Demonstrate to Commissioning Manager and/or Departmental Representative operation of systems including sequence of operations in regular and emergency modes, under normal and emergency conditions, start-up, shut-down interlocks and lock-outs in accordance with the Commissioning Plan.

END OF SECTION

1.01 SUMMARY

.1 Section Includes:
.1 Requirements and procedures for training program, instructors and training materials, for building Energy Monitoring and Control System (EMCS) Work.

1.02 DEFINITIONS

.1 CDL - Control Description Logic.

.2 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements

1.03 SUBMITTALS

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures and supplemented and modified by requirements of this Section.

.2 Submit reports within one week after completion of training program that training has been satisfactorily completed.

1.04 QUALITY ASSURANCE

.1 Provide competent instructors thoroughly familiar with aspects of EMCS installed in facility.

.2 The Departmental Representative reserves right to approve instructors.

1.05 INSTRUCTIONS

.1 Provide instruction to designated personnel in adjustment, operation, maintenance and pertinent safety requirements of EMCS installed.

.2 Training to be project-specific.

1.06 TIME FOR INSTRUCTION

.1 Number of days of instruction to be as specified in this section (1 day = 7 hours including two 15 minute breaks and excluding lunch time).

1.07 TRAINING MATERIALS

.1 Provide equipment, visual and audio aids, and materials for classroom training.

.2 Supply manual for each trainee, describing in detail data included in each training program.
.1 Review contents of manual in detail to explain aspects of operation and maintenance (O&M).

1.08 TRAINING PROGRAM

.1 Allow one (1) day for on-site training.

.2 Training to include:
.1 Train O&M personnel in functional operations and procedures to be employed for system operation.
.2 Supplement with on-the-job training during 30 day test period.
.3 Include overview of system architecture, communications, operation of computer and peripherals, report generation.
.4 Include detailed training on operator interface functions for control of mechanical systems, CDL's for each system, and elementary preventive maintenance.
.5 Introduction to Direct Digital Controls and BACnet protocol.
.6 Identification of Control Components.
.7 Review of DDC Network Diagram for building.
.8 Review of shop drawings for building.
.9 Detailed discussion of sequences of operation
.10 Walk through of mechanical systems.

1.09 ADDITIONAL TRAINING

.1 List courses offered by name, duration and approximate cost per person per week. Note courses recommended for training supervisory personnel.

1.10 MONITORING OF TRAINING

.1 The Departmental Representative to monitor training program and may modify schedule and content.

END OF SECTION

1 GENERAL

1.01 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.

1.02 RELATED SECTIONS

.1 Coordinate related work among all specification sections, as well as between other Divisions.

1.03 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 135-2016, 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).
  .1 Material Safety Data Sheets (MSDS).

.8 Transport Canada (TC).
  .1 Transportation of Dangerous Goods Act (TDGA).

.9 National Electrical Manufacturers Association (NEMA)

1.04 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

1.05 DEFINITIONS

.1 Point: may be logical or physical.
- .1 Logical points: values calculated by system such as set

points, 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.

1.06 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-definements).

.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.

1.07 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 will be by the controls contractor. Refer to the 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. The EMCS contractor to 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 facilities management department. In addition, a remote dial in access directly to the system shall be provided.

1.08 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.

1.09 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 Ensure 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 29.06 - Health and Safety Requirements.

.6 Be able to provide factory trained personnel on site within 24 hours’ notice or provide instructions on maintenance and emergency service on system.

.7 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.

2 PRODUCTS

2.01 ACCEPTABLE SYSTEMS, MANUFACTURERS

.1 Delta, Controls and Equipment. Existing campus controls system is to remain and be expanded as indicated in controls drawings.

2.02 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 panel key.

.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 Terminations for the connection of power wiring, communication wiring and field mounted devices to be at properly identified 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 lamicoid tags to identify the control panel 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.

3 EXECUTION

3.01 MANUFACTURER'S RECOMMENDATIONS

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

3.02 PAINTING

.1 Painting to be in accordance with NEMA, supplemented as follows:

.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

1.01 SUMMARY

.1 Section Includes:
  .1 Methods and procedures for shop drawings submittals, preliminary and detailed review process include review meetings for building Energy Monitoring and Control System (EMCS).

1.02 RELATED SECTIONS

.1 Coordinate related work among all specification sections as well as between all Divisions.

1.03 DEFINITIONS

.1 Acronyms and definitions: refer to Section 25 05 01 - EMCS: General Requirements.

1.04 DESIGN REQUIREMENTS

.1 Preliminary Design Review: to contain following contractor and systems information.
  .1 Location of local office.
  .2 Description and location of installing and servicing technical staff.
  .3 Location and qualifications of programming design and programming support staff.
  .4 List of spare parts.
  .5 Location of spare parts stock.
  .6 Names of sub-contractors and site-specific key personnel.
  .7 Sketch of site-specific system architecture.
  .8 Specification sheets for each item including memory provided, programming language, speed, type of data transmission.
  .9 Descriptive brochures.
  .10 Sample CDL and graphics (systems schematics).
  .11 Response time for each type of command and report.
  .12 Item-by-item statement of compliance.
  .13 Proof of demonstrated ability of system to communicate utilizing BACnet protocol.

1.05 SUBMITTALS

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures and coordinate with requirements in this Section.

.2 Submit preliminary design document within 30 working days after contract award for review by the Departmental Representative.

.3 Shop Drawings to consist of three (3) hard copies and one (1) soft copy of design documents, shop drawings, product data and software.

.4 Hard copy to be completely indexed and coordinated package to assure compliance with contract requirements and arranged in same sequence as specification and cross-referenced to specification section and paragraph number.

.5 Soft copy to be in AutoCAD - latest version and Microsoft Word latest version format, or PDF structured using menu format for easy loading and retrieval on OWS.

.6 Submittals shall consist of:
- .1 Data sheets of all products.
- .2 Wiring and piping interconnection diagrams including panel and device power, and sources.
- .3 List of materials of all proposed devices and equipment.
- .4 Software documentation:
- .5 Sequence of operation, in text form.
- .6 Application programs.
- .7 Point Schedules
- .8 Controls schematics and system diagrams.
- .9 Project installation schedule.
- .10 Names of sub trades working for EMCS contractor.
- .11 Mounting support details for components installed in airflow, water flow and steam systems.

.7 Submit shop drawings in a package which contains the various schedules and drawings which completely describe the control system installed. At a minimum the shop drawing package to contain the following items described in Clauses 1.5.8 to 1.5.28.

.8 Network drawing showing the network connection of all network control units, programmable control units, terminal control units and operator workstations to indicate the location of each of these elements.

.9 Schematic control diagram for each system being controlled. Where there are typical systems a drawing to be provided for each system. This drawing to be on a AB size sheet (11" x 17") and shall include a title block which includes as a minimum the drawing title, drawing number, project title, Contractor's name, Contractor's address, Contractor's phone and fax numbers, contractor's project number and a section to provide a record for revision information.

.10 The schematic control diagram to include a bill of materials which provides a list of all part numbers and descriptions for the control components on the drawing list to include field

equipment as well as panel mounted components.

.11 The schematic control diagram to include a complete wiring diagram for all electrical connections, including motor starters, heating coils, coiling coils etc.

.12 The schematic control diagram to include a layout of the control panels for each system. This layout to show the mounting of all panel equipment, including transformers, power supplies, controllers, transducers, sensors, relays, contactors and any other panel mounted equipment.

.13 The contractor to include with the shop drawing submittal drawings, showing all wiring details for the connections of sensors, transducers, relays and contactors these details to show terminal numbers and be referenced to the appropriate schedules and drawings.

.14 The contractor to supply with the shop drawing package a complete point schedule to show every point connected to the system. This schedule to be in tabular format and provide the point identification, point type, wire tag, termination details reference, referenced drawings, device mounting location and device code numbers.

.15 The point schedule to provide at a minimum the following information on the software attributes of the point:
.1 Tag name - ex. EPT-1
.2 Point type - ex. AO-3
.3 System name - ex. A/C-1
.4 Object name - H-VLV.
.5 Expanded ID- Heating control valve
.6 Units of measurement - %.

.16 Point schedule to provide at a minimum the following information on the digital controller to which the point is connected:
.1 Controller type - ex. Unitary controller
.2 Controller address ex. 256.
.3 Cable destination - the termination at the controller, ex. AO-1.
.4 Terminal numbers - the termination at the controller.

.17 The point schedule to provide at minimum the following information on the control panel:
.1 Panel identification
.2 Panel location
.3 Reference drawing

.18 The point schedule to provide at a minimum the following information on any intermediate device which may be associated

with the point:
.1 Type of wiring or tubing used
.2 Device part number
.3 Location of the device.
.4 Reference details.

.19 The point schedule to provide at a minimum the following information on any field device which may be associated with the point;
.1 Type of wiring or tubing used
.2 Device part number
.3 Location of the devices
.4 Reference details

.20 Supply the shop drawing package for a complete room schedule, showing the equipment associated with the room controls. Schedule to be in tabular format and provide the room number and location, terminal unit number, part numbers for the terminal unit controller, sensors and actuators. Included on this schedule terminal unit type, size, minimum flow and maximum flow.

.21 Sequence of operation for each system controlled. Sequence to be in complete conformance with the sequence of operations included with this specification or on the Drawings. Any changes require the approval of the Departmental Representative in writing. Sequence to include all modes of operation including fail safe, emergency and fire modes.

.22 Valve schedule including design flow, CV, size, type, actuator, pressure drop and maximum shut off pressure differential for each control valve.

.23 Damper schedule including design air flow, size, type actuator and torque requirements for each control damper.

.24 Provide one permanent, not fading, as built copy of each control drawing, enclosed by an aluminum frame with glass cover, or sealed by plastic laminate in rigid metal bound frame. To be installed at each respective control panel location.

.25 Catalogue cut sheets of all equipment used. This includes, but is not limited to: DDC panels, peripherals, sensors, actuators, dampers, control air system components, etc.

.26 Range and scale information for all transmitters and sensors. This sheet to clearly indicate one device and any applicable options. Where more than one (1) device to be used is on a single sheet, submit two (2) sheets, individually marked.

.27 Hardware data sheets for all operator workstations, local access

panels, and portable operator terminals.

.28 Software manuals for all applications programs to be provided as a part of the operator workstations, portable operator terminals, programming devices, and so forth.

1.06 PRELIMINARY SHOP DRAWING REVIEW

.1 Submit preliminary shop drawings within 30 working days of award of contract and include the following:
- .1 Specification sheets for each item. To include manufacturer's descriptive literature, manufacturer's installation recommendations, specifications, drawings, diagrams, performance and characteristic curves, catalogue cuts, manufacturer's name, trade name, catalogue or model number, nameplate data, size, layout, dimensions, capacity, other data to establish compliance.
- .2 Detailed system architecture showing all points associated with each controller including, signal levels, pressures where new EMCS ties into existing control equipment.
- .3 Spare point capacity of each controller by number and type.
- .4 Controller locations.
- .5 Auxiliary control cabinet locations.
- .6 Single line diagrams showing cable routings, conduit sizes, spare conduit capacity between control center, field controllers and systems being controlled.
- .7 Valves: complete schedule listing including following information: designation, service, manufacturer, model, point ID, design flow rate, design pressure drop, required Cv, Valve size, actual Cv, spring range, pilot range, required torque, actual torque and close off pressure (required and actual).
- .8 Dampers: sketches showing module assembly, interconnecting hardware, operator locations, operator spring range, pilot range, required torque, actual torque.
- .9 Flow measuring stations: complete schedule listing designation, service, point ID, manufacturer, model, size, velocity at design flow rate, manufacturer, model and range of velocity transmitter.
- .10 Compressor schematic and sizing data.

1.07 DETAIL SHOP DRAWING REVIEW

.1 Submit detailed shop drawings within 60 working days after award of contract and before start of installation and include following:
- .1 Corrected and updated versions (hard copy only) of submissions made during preliminary review.
- .2 Wiring diagrams.
- .3 Piping diagrams and hook- ups.

.4 Interface wiring diagrams showing termination connections and signal levels for equipment to be supplied by others.
.5 Shop drawings for each input/output point, sensors, transmitters, showing information associated with each particular point including:
.1 Sensing element type and location.
.2 Transmitter type and range.
.3 Associated field wiring schematics, schedules and terminations.
.4 Pneumatic schematics and schedules.
.5 Complete Point Name Lists.
.6 Set points, curves or graphs and alarm limits (high and low, 3 types critical, cautionary and maintenance), signal range.
.7 Software and programming details associated with each point.
.8 Manufacturer's recommended installation instructions and procedures.
.9 Input and output signal levels or pressures where new systems ties into existing control equipment.
.6 Control schematics, narrative description, CDL's fully showing and describing automatic and manual procedure required to achieve proper operation of project, including under complete failure of EMCS.
.7 Graphic system schematic displays of air and water systems with point identifiers and textual description of system, and typical floor plans as specified.
.8 Complete system CDL's including companion English language explanations on same sheet but with different font and italics. CDL's to contain specified energy optimization programs.
.9 Listing of an example of specified reports.
.10 Listing of time of day schedules.
.11 Mark up to-scale construction drawing to detail control room showing location of equipment and operator work space.
.12 Type and size of memory with statement of spare memory capacity.
.13 Full description of software programs provided.
.14 Sample of "Operating Instructions Manual" to be used for training purposes.
.15 Outline of proposed start-up and verification procedures. Refer to Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

1.08 QUALITY ASSURANCE

.1 Preliminary Design Review Meeting: Convene meeting within 45 working days of award of contract to:
.1 Undertake functional review of preliminary design

documents, resolve inconsistencies.

.2 Resolve conflicts between contract document requirements and actual items (e.g.: points list inconsistencies).

.3 Review interface requirements of materials supplied by others.

.4 Review "Sequence of Operations".

.2 Contractor's factory trained programmer to attend meeting.

.3 The Departmental Representative retains right to revise sequence or subsequent CDL prior to software finalization without cost to the contract.

END OF SECTION

1.01 SUMMARY

.1 Section Includes:
  .1 Requirements and procedures for final control diagrams and operation and maintenance (O&M) manual, for building Energy Monitoring and Control System (EMCS) Work.

1.02 DEFINITIONS

.1 BECC - Building Environmental Control Centre.

.2 OWS - Operator Work Station.

.3 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements

1.03 SUBMITTALS

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures and 01 78 00 - Closeout Submittals, supplemented and modified by requirements of this Section.

.2 Submit Record Documents, As-built drawings, Operation and Maintenance Manual to the Departmental Representative in English.

.3 Provide soft copies and hard copies in hard-back, 50mm, 3 ring, D-ring binders.
  .1 Binders to be 2/3 maximum full.
  .2 Provide index to full volume in each binder.
  .3 Identify contents of each manual on cover and spine.
  .4 Provide Table of Contents in each manual.
  .5 Assemble each manual to conform to Table of Contents with tab sheets placed before instructions covering subject.

1.04 AS-BUILTS

.1 Provide one (1) copy of detailed shop drawings generated in Section 25 05 02 - EMCS: Submittals and Review Process and include:
  .1 Changes to contract documents as well as addenda and contract extras.
  .2 Changes to interface wiring.
  .3 Routing of conduit, wiring and control air lines associated with EMCS installation.
  .4 Locations of obscure devices to be indicated on drawings.
  .5 Listing of alarm messages.
  .6 Panel/circuit breaker number for sources of normal/emergency power.
  .7 Names, addresses, telephone numbers of each sub-contractor

having installed equipment, local representative for each item of equipment, each system.

.8 Test procedures and reports: provide records of start-up procedures, test procedures, checkout tests and final commissioning reports as specified in Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

.9 Basic system design and full documentation on system configuration.

.2 Submit for final review by the Departmental Representative.

.3 Provide before acceptance four (4) hard and one (1) soft copy incorporating changes made during final review.

1.05 O&M MANUALS

.1 Custom design O&M Manuals (both hard and soft copy) to contain material pertinent to this project only, and to provide full and complete coverage of subjects referred to in this Section.

.2 Provide two (2) complete sets of hard and soft copies prior to system or equipment tests.

.3 Include complete coverage in concise language, readily understood by operating personnel using common terminology of functional and operational requirements of system. Do not presume knowledge of computers, electronics or in- depth control theory.

.4 Functional description to include:

.1 Functional description of theory of operation.

.2 Design philosophy.

.3 Specific functions of design philosophy and system.

.4 Full details of data communications, including data types and formats, data processing and disposition data link components, interfaces and operator tests or self-test of data link integrity.

.5 Explicit description of hardware and software functions, interfaces and requirements for components in functions and operating modes.

.6 Description of person- machine interactions required to supplement system description, known or established constraints on system operation, operating procedures currently implemented or planned for implementation in automatic mode.

.5 System operation to include:

.1 Complete step-by-step procedures for operation of system including required actions at each OWS.

.2 Operation of computer peripherals, input and output formats.

.3 Emergency, alarm and failure recovery.
.4 Step-by-step instructions for start-up, back-up equipment operation, execution of systems functions and operating modes, including key strokes for each command so that operator need only refer to these pages for keystroke entries required to call up display or to input command.

.6 Software to include:
.1 Documentation of theory, design, interface requirements, functions, including test and verification procedures.
.2 Detailed descriptions of program requirements and capabilities.
.3 Data necessary to permit modification, relocation, reprogramming and to permit new and existing software modules to respond to changing system functional requirements without disrupting normal operation.
.4 Software modules, fully annotated source code listings, error free object code files ready for loading via peripheral device
.5 Complete program cross reference plus linking requirements, data exchange requirements, necessary subroutine lists, data file requirements, other information necessary for proper loading, integration, interfacing, program execution.
.6 Software for each Controller and single section referencing Controller common parameters and functions.

.7 Maintenance: document maintenance procedures including inspection, periodic preventive maintenance, fault diagnosis, repair or replacement of defective components, including calibration, maintenance, repair of sensors, transmitters, transducers, controller and interface firmware, plus diagnostics and repair/replacement of system hardware.

.8 System configuration document:
.1 Provisions and procedures for planning, implementing and recording hardware and software modifications required during operating lifetime of system.
.2 Information to ensure co- ordination of hardware and software changes, data link or message format/content changes, sensor or control changes in event that system modifications are required.

.9 Programmer control panel documentation: provide where panels are independently interfaced with BECC, including interfacing schematics, signal identification, timing diagrams, fully commented source listing of applicable driver/handler.

END OF SECTION

1 GENERAL

1.01 SUMMARY

.1 Section Includes:
  .1 Requirements and procedures for identification of devices, sensors, wiring, tubing, conduit and equipment, for building Energy Monitoring and Control System (EMCS) Work and nameplates, materials, colours and lettering sizes.

1.02 REFERENCES

.1 Canadian Standards Association (CSA International).
  .1 CSA C22.1-2015, The Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

1.03 DEFINITIONS

.1 For acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

1.04 SYSTEM DESCRIPTION

.1 Language Operating Requirements: provide identification for control items in English.

1.05 SUBMITTALS

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures and Section 25 05 02 - EMCS: Submittals and Review Process supplemented and modified by requirements of this Section.

.2 Submit to the Departmental Representative for approval samples of nameplates, identification tags and list of proposed wording.

2 PRODUCTS

2.01 NAMEPLATES FOR PANELS

.1 Identify by plastic laminate, 3 mm thick melamine, matt white finish, black core, square corners, lettering accurately aligned and engraved into core, mechanically attached with self-tapping screws.

.2 Sizes: 25 mm x 41mm minimum.

.3 Lettering: minimum 6 mm high, black.

.4 Inscription: machine engraved to identify function.

2.02 NAMEPLATES FOR FIELD DEVICES

.1 Identify by plastic encased cards attached by plastic tie.

.2 Sizes: 50 mm x 100 mm minimum.

.3 Lettering: minimum 6 mm high produced from laser printer in black.

.4 Data to include: point name and point address, make, model number.

.5 Companion cabinet: identify interior components using plastic enclosed cards with point name and point address.

2.03 NAMEPLATES FOR ROOM SENSORS

.1 Identify by stick-on labels using point identifier.

.2 Location: as directed by the Departmental Representative.

.3 Letter size: to suit, clearly legible.

2.04 WARNING SIGNS

.1 Equipment including motors, starters under remote automatic control: supply and install orange coloured signs warning of automatic starting under control of EMCS.

.2 Sign to read: "Caution: This equipment is under automatic remote control of EMCS" as reviewed by the Departmental Representative.

2.05 WIRING

.1 Supply and install numbered tape markings on wiring at panels, junction boxes, splitters, cabinets and outlet boxes.

.2 Colour coding: to CSA C22.1. Use colour coded wiring in communications cables, matched throughout system.

.3 Power wiring: identify circuit breaker panel/circuit breaker number inside each EMCS panel.

.4 All low voltage control wiring must be yellow.

2.06 PNEUMATIC TUBING

.1 Numbered tape markings on tubing to provide uninterrupted tracing capability.

2.07 CONDUIT

.1 Colour code EMCS conduit.

.2 Pre-paint box covers, inside and out, and conduit fittings.

.3 Coding: use red and white paint and confirm colour with the Departmental Representative during "Preliminary Design Review".

3 EXECUTION

3.01 NAMEPLATES AND LABELS

.1 Confirm manufacturer's nameplates, CSA labels and identification nameplates are visible and legible at all times.

3.02 EXISTING PANELS

.1 Correct existing nameplates and legends to reflect changes made during work.

END OF SECTION

1 GENERAL

1.01 REFERENCES

.1 American National Standards Institute (ANSI)
- .1 ANSI/ASME B16.22-2013, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- .2 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.1-2015, Overhead Systems.
- .3 CSA C22.3 No. 7-2015, 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.

1.02 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. Panel breakers to be identified on panel legends tagged 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 center BECC.

.2 Mechanical:
- .1 Pipe taps required for EMCS equipment will be supplied and installed by Mechanical Division.
- .2 Wells and control valves shall be supplied by EMCS Contractor and installed by Mechanical.
- .3 Installation of air flow stations, dampers, and other devices requiring sheet metal trades to be mounted by Mechanical. Costs to be carried by designated trade.
- .4 All control wiring and conduit is by Division 25 contractor.

.3 VAV Terminal Units and Laboratory Airflow Controls.
- .1 Coordinate with and provide all field wiring/components for the operation of these systems.

.4 Structural:

.1 Special steelwork as required for installation of work.

1.03 PERSONNEL QUALIFICATIONS

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

1.04 EXISTING CONDITIONS

.1 Repair all surfaces damaged during execution of work.

.2 Turn over to the Departmental Representative existing materials removed from work not identified for re-use.

2 PRODUCTS

2.01 SPECIAL SUPPORTS

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

2.02 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 centers, 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.

2.03 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 25 mm 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.

.5 Outlet boxes: 100mm minimum, square.

.6 Conduit boxes, fittings:
- .1 Bushings and connectors: with nylon insulated throats.
- .2 With push pennies to prevent entry of foreign materials.

.7 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 25 mm and larger conduits.

.8 Fittings for thin wall conduit:
- .1 Connectors and couplings: steel, set screw type.

2.04 WIRING DEVICES, COVER PLATES

.1 Conform to CSA.

.2 Receptacles:

.3 Duplex: CSA type 5-15R.

.4 Single: CSA type 5-15R.

.5 Cover plates and blank plates: finish to match other plates in area.

2.05 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 6 mm diameter threaded rods and support clips.
.2 Two (2) or more suspended cables or conduits: support channels supported by 6 mm diameter threaded rod hangers.

3 EXECUTION

3.01 INSTALLATION

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

3.02 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.

.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 1.2m and 2.4 m 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.

3.03 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 center. 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 100 feet.

.8 Use conduit outlet boxes for conduit up to 28mm in 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.

3.04 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.

.5 Provide the Departmental Representative with test results showing locations, circuits, results of tests.

.6 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.

.7 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.

.8 Do not allow wiring to come into direct physical contact with compression screw.

.9 Install ALL strands of conductor in lugs of components. Strip insulation only to extent necessary for installation.

3.05 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.

3.06 STARTERS, CONTROL DEVICES

.1 Install and make control connections as indicated. Power connections above 50V by Electrical Division.

.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.

3.07 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.

3.08 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.

3.09 IDENTIFICATION

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

END OF SECTION

1 GENERAL

1.01 SUMMARY

.1 Section Includes:
  .1 Requirements and procedures for warranty and activities during warranty period and service contracts, for building Energy Monitoring and Control System (EMCS).

1.02 REFERENCES

.1 Canada Labour Code (R.S., c. L- 2)/Part I - Industrial Relations.

1.03 DEFINITIONS

.1 OWS - Operator Work Station.

.2 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

1.04 SUBMITTALS

.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit detailed preventative maintenance schedule for system components to the Departmental Representative.

.3 Submit detailed inspection reports the Departmental Representative.

.4 Submit dated, maintenance task lists to the Departmental Representative and include the following sensor and output point detail, as proof of system verification:
  .1 Point name and location.
  .2 Device type and range.
  .3 Measured value.
  .4 System displayed value.
  .5 Calibration detail
  .6 Indication if adjustment required,
  .7 Other action taken or recommended.

.5 Submit network analysis report showing results with detailed recommendations to correct problems found.

.6 Records and logs: in accordance with Section 01 78 00.
  .1 Maintain records and logs of each maintenance task on site.
  .2 Organize cumulative records for each major component and for entire EMCS homologically.

.3 Submit records to the Departmental Representative, after inspection indicating that planned and systematic maintenance have been accomplished.

.7 Revise and submit to the Departmental Representative in accordance with Section 01 78 00. "As-built drawings" documentation and commissioning reports to reflect changes, adjustments and modifications to EMCS made during warranty period.

1.05 MAINTENANCE SERVICE DURING WARRANTY PERIOD

.1 Provide services, materials, and equipment to maintain EMCS for warranty period of one year after date of substantial completion. Provide detailed preventative maintenance schedule for system components as described in Submittal article.

.2 Emergency Service Calls:
- .1 Initiate service calls when EMCS is not functioning correctly.
- .2 Qualified control personnel to be available during warranty period to provide service to "CRITICAL" components whenever required at no extra cost.
- .3 Furnish the Departmental Representative with telephone number where service personnel may be reached at any time.
- .4 Service personnel to be on site ready to service EMCS after receiving request for service.
- .5 Perform work continuously until EMCS restored to reliable operating condition.

.3 Operation: foregoing and other servicing to provide proper sequencing of equipment and satisfactory operation of EMCS based on original design conditions and as recommended by manufacturer.

.4 Work requests: record each service call request, when received separately on approved form and include:
- .1 Serial number identifying component involved.
- .2 Location, date and time call received.
- .3 Nature of trouble.
- .4 Names of personnel assigned.
- .5 Instructions of work to be done.
- .6 Amount and nature of materials used.
- .7 Time and date work started.
- .8 Time and date of completion.

.5 Provide system modifications in writing.
- .1 No system modification, including operating parameters and control settings, to be made without prior written approval of the Departmental Representative.

1.06 SERVICE CONTRACTS

.1 Provide in-depth technical expertise and assistance to the Departmental Representative and Commissioning Manager in preparation and implementation of service contracts and in-house preventive maintenance procedures. Service contracts duration is for the warranty period.

.2 Service Contracts to include:
- .1 Annual verification of field points for operation and calibration.
- .2 Four (4) visits per year.
- .3 Two (2) responses to emergency calls during day, per year.
- .4 Two (2) responses to emergency calls during silent hours, per year.
- .5 Silent hours defined as 1630 h - 0800 h and on weekends and statutory holidays.
- .6 Complete inventory of installed system.

2 PRODUCTS Not applicable

3 EXECUTION

3.01 FIELD QUALITY CONTROL

.1 Perform as minimum (3) three minor inspections and one major inspection (more often if required by manufacturer) per year. Provide detailed written report to the Departmental Representative as described in Submittal article.

.2 Perform inspections during regular working hours, 0800 to 1630 h, Monday through Friday, excluding statutory holidays.

.3 Following inspections are minimum requirements and should not be interpreted to mean satisfactory performance:
- .1 Perform calibrations using test equipment having traceable, certifiable accuracy at minimum 50% greater than accuracy of system displaying or logging value.
- .2 Check and calibrate random sample of 10% field input/output devices in accordance with Canada Labour Code - Part I.
- .3 Provide dated, maintenance task lists, as proof of execution of complete system verification.

.4 Minor inspections to include, but not limited to:
- .1 Perform visual, operational checks to BC's, peripheral equipment, interface equipment and other panels.
- .2 Check equipment cooling fans as required.
- .3 Visually check for mechanical faults, air leaks and proper

pressure settings on pneumatic components.

.4 Review system performance with Operations Supervisor and/or the Departmental Representative to discuss suggested or required changes.

.5 Major inspections to include, but not limited to:

.1 Minor inspection.

.2 Clean OWS(s) peripheral equipment, BC(s), interface and other panels, micro-processor interior and exterior surfaces.

.3 Check signal, voltage and system isolation of BC(s), peripherals, interface and other panels.

.4 Verify calibration/accuracy of each input and output device and recalibrate or replace as required.

.5 Provide mechanical adjustments, and necessary maintenance on printers.

.6 Run system software diagnostics as required.

.7 Install software and firmware enhancements to ensure components are operating at most current revision for maximum capability and reliability.

.1 Perform network analysis and provide report as described in Submittal article.

.6 Rectify deficiencies revealed by maintenance inspections and environmental checks.

.7 Continue system debugging and optimization.

.8 Testing/verification of occupancy and seasonal-sensitive systems to take place during four (4) consecutive seasons, after facility has been accepted, taken over and fully occupied.

.1 Test weather-sensitive systems twice: first at near winter design conditions and secondly under near summer design conditions.

END OF SECTION

1.01 SUMMARY

.1 Section Includes:
.1 System requirements for Local Area Network (LAN) for Building Energy Monitoring and Control System (EMCS).

1.02 REFERENCES

.1 Canadian Standards Association (CSA International).
.1 CAN/CSA C22.2 No. 262-04(R2013), Optical Fiber Cable and Communication Cable Raceway System.

.2 Institute of Electrical and Electronics Engineers (IEEE)/Standard for Information Technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements.
.1 IEEE 802.3-2012, IEEE Standard for Ethernet.

.3 Treasury Board Information Technology Standard (TBITS).
.1 TBITS 6.9, Profile for the Telecommunications Wiring System in Government Owned and Leased Buildings- Technical Specifications.

1.03 DEFINITIONS

.1 Acronyms and definitions: refer to Section 25 05 01 - EMCS: General Requirements.

1.04 SYSTEM DESCRIPTION

.1 Data communication network to link Operator Workstations and Master Control Units (MCU) in accordance with CAN/CSA C22.2 No. 262.
.1 Provide reliable and secure connectivity of adequate performance between different sections segments of network.
.2 Allow for future expansion of network, with selection of networking technology and communication protocols.

.2 Data communication network to included, but not limited to:
.1 EMCS-LAN.
.2 Modems.
.3 Network interface cards.
.4 Network management hardware and software.
.5 Wireless hardware.
.6 Network components necessary for complete network.

1.05 DESIGN REQUIREMENTS

.1 EMCS Local Area Network (EMCS- LAN):
.1 High Speed, high performance, local area network over MS/TP

with MCUs and OWSs communicate with each other directly on peer to peer basis in accordance with IEEE 802.3

.2 EMCS-LAN: BACnet Protocol

.3 Each EMCS-LAN to be capable of supporting at least 50 devices.

.4 Support of combination of MCUs and OWSs directly connected to EMCS- LAN.

.5 High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, upload/download information between network devices. Bit rate to be 10 Megabits per second minimum.

.6 Detection and accommodation of single or multiple failures of either OWSs, MCUs or network media. Operational equipment to continue to perform designated functions effectively in event of single or multiple failures.

.7 Commonly available, multiple sourced, networking components and protocols to allow system to co-exist with other networking applications including office automation.

.2 Dynamic Data Access:

.1 LAN to provide capabilities for OWSs, either network resident or connected remotely to access point status and application report data or execute control functions for other devices via LAN.

.2 Access to data to be based upon logical identification of building equipment.

.3 Network Medium:

.1 Network medium: twisted cable, shielded twisted cable, or fiber optic cable compatible with network protocol to be used within buildings. Fiber optic cable to be used between buildings.

1.06 WARRANTY

.1 Provide a five (5) year parts and labour warranty for all components in the EMCS LAN.

2 PRODUCTS Not Applicable.

3 EXECUTION Not Applicable.

END OF SECTION

1 GENERAL

1.01 SUMMARY

.1 Section includes:
  .1 Hardware and software requirements for an Operator Work Station (OWS) in a Building Energy Monitoring and Control System (EMCS).

1.02 DEFINITIONS

.1 Acronyms and definitions: refer to Section 25 05 01 - EMCS: General Requirements.

.2 Remote Auxiliary OWS: performs identical user interface functions as primary OWS.

1.03 OWS SYSTEM DESCRIPTION

.1 No OWS will be provided for this project. The existing Delta control system will be modified and/or expanded to include sequences as indicated on drawings.

2 PRODUCTS **Not Applicable.**

3 EXECUTION **Not Applicable.**

END OF SECTION

1 GENERAL

1.01 SUMMARY

.1 Section Includes:
  .1 Materials and installation for building automation controllers including:
    .1 Master Control Unit (MCU).
    .2 Local Control Unit (LCU)
    .3 Equipment Control Unit (ECU).
    .4 Terminal Control Unit (TCU).

1.02 REFERENCES

.1 American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. (ASHRAE).
  .1 ASHRAE, Applications Handbook, SI Edition.
  .2 ASHRAE Standard 135-2016-BAC net, A Data Communications Protocol for Building Automation and Control Networks.
  .3 ASHRAE Standard 135.1-2013, Method of Test Conformance to BAC net.

.2 Canadian Standards Association (CSA)
  .1 CSA C22.2 No.205-2012, Signal Equipment.

.3 Institute of Electrical and Electronics Engineers (IEEE)
  .1 IEEE C37.90.1-2012, Surge Withstand Capabilities Test for Protective Relays and Relays Systems Associated with Electric Power Apparatus.

1.03 DEFINITIONS

.1 Acronyms used in this section include: see Section 25 05 01 - EMCS: General Requirements.

1.04 SYSTEM DESCRIPTION

.1 General: Network of controllers comprising of MCU('s), LCU('s), ECU('s) or TCU('s) to be provided as indicated in System Architecture Diagram to support building systems and associated sequence(s) of operations as detailed in these specifications.
  .1 Provide sufficient controllers to meet intents and requirements of this section.
  .2 Controllers quantity, and point contents to be approved by the Departmental Representative at time of preliminary design review.

.2 Controllers: stand-alone intelligent Control Units:
  .1 Incorporate programmable microprocessor, non-volatile

program memory, RAM, power supplies, as required to perform specified functions.
.2 Incorporate communication interface ports for communication LANs to exchange information with other Controllers.
.3 Capable of interfacing with operator interface device.
.4 Execute its logic and control using primary inputs and outputs connected directly to its onboard input/output field terminations or slave devices, and without need with other controller. Secondary input used for reset such as outdoor air temperature may be located in other Controller(s).

1.05 DESIGN REQUIREMENTS

.1 To include:
.1 Scanning of AI and DI connected inputs for detection of change of value and processing the detection of alarm conditions.
.2 Perform On-Off digital control of connected points, including the resulting required states generated through programmable logic output.
.3 Perform Analog control using programmable logic, (including PID) with adjustable dead bands and deviation alarms.
.4 Control of systems as described in sequence of operations.
.5 Execution of optimization routines as listed in this section.

.2 Total spare capacity for MCUs and LCUs: at least 25% of each point type distributed throughout the MCUs and LCUs.

.3 Field Termination and Interface Devices.
.1 To conform to CSA C22.2 No. 205.
.2 Electronically interface sensors and control devices to processor unit.
.3 Include, but not be limited to, following:
.1 Programmed firmware or logic circuits to meet functional and technical requirements.
.2 Power supplies for operation of logic devices and associated field equipment.
.3 Lockable wall cabinet.
.4 Required communications equipment and wiring.
.5 Leave controlled system in "fail-safe" mode in event of loss of communication with, or failure of, processor unit.
.6 Input/Output interface to accept as minimum AI, AO, DI, DO functions as specified.
.7 Wiring terminations: use conveniently located screw type or spade lug terminals.
.4 AI interface equipment to:
.1 Convert analog signals to digital format with 12 bit

analog- to-digital resolution.

.2 Provide for following input signal types and ranges:
.1 4 - 20 mA;
.2 0-10V DC
.3 10 K ohm.

.3 Meet IEEE C37.90.1 surge withstand capability.

.4 Have common mode signal rejection greater than 60 dB to 60 Hz.

.5 Where required, dropping resistors to be certified precision devices which complement accuracy of sensor and transmitter range specified.

.5 AO interface equipment:
.1 Convert digital data from controller processor to acceptable analog output signals using 12 bit digital-to-analog resolution.

.2 Provide for following output signal types and ranges:
.1 4 - 20 mA.
.2 0 - 10 V DC.
.3 Meet IEEE C37.90.1 surge withstand capability.

.6 DI interface equipment:
.1 Able to reliably detect contact change of sensed field contact and transmit condition to controller.

.2 Meet IEEE C37.90.1 surge withstand capability.

.3 Accept pulsed inputs up to 2 kHz.

.7 DO interface equipment:
.1 Respond to controller processor output, switch respective outputs. Each DO hardware to be capable of switching up to 0.5 amps at 24 V AC.

.2 Switch up to 5 amps at 220 V AC using optional interface relay.

.4 Controllers and associated hardware and software: operate in conditions of 0EC to 44EC and 20 % to 90 % non-condensing RH.

.5 Controllers (MCU, LCU): mount in wall mounted cabinet with hinged, keyed- alike locked door.
.1 Provide for conduit entrance from top, bottom or sides of panel.

.2 ECUs to be mounted in equipment enclosures or separate enclosures.

.3 Mounting details as approved by the Departmental Representative for ceiling mounting.

.6 Cabinets to provide protection from water dripping from above, while allowing sufficient airflow to prevent internal overheating.

.7 Provide surge and low voltage protection for interconnecting wiring connections.

1.06 SUBMITTALS

.1 Make Submittals in accordance with Section 01 33 00 - Submittal Procedures and Section 25 05 02 - EMCS: Submittals and Review Process.
  .1 Submit product data sheets for each product item proposed for this project.

1.07 MAINTENANCE PROCEDURES

.1 Provided manufacturers recommended maintenance procedures for insertion in Section 25 05 03 - EMCS: Project Record Documents.

1.08 WARRANTY

.1 Provide parts and labour warranty for all controllers and field devices for five (5) years after substantial completion.

2 PRODUCTS

2.01 MASTER CONTROL UNIT (MCU)

.1 Primary function of MCU is to provide co- ordination and supervision of subordinate devices. Supervisory role shall include coordination of subordinate devices in the execution of optimization routines such as demand limiting or enthalpy control.

.2 Include high speed communication LAN Port for Peer to Peer communications with OWS(s) and other MCU level devices. Include support for Open System Protocols, BACnet.

.3 MCU to have local I/O capacity as follows;
  .1 To have at least 16 I/O points of which minimum to be 2AO, 6AI, 4DI, 4DO.
  .2 LCU's to be added to support system functions as indicated in I/O Summary List.

.4 Central Processor Unit (CPU)
  .1 Processor to consist of at minimum a 16 bit microprocessor capable of supporting software to meet specified requirements.
  .2 CPU idle time to be more than 30 % when system configured to maximum input and output with worst case program use.
  .3 Minimum addressable memory to be at manufacturer's discretion but to support at least all performance and technical specifications. Memory to include:
    .1 Non-volatile EEPROM to contain operating system, executive, application, sub-routine, other

configurations definition software. Tape media not acceptable.

.2 Battery backed (72 hour minimum capacity) RAM (to reduce the need to reload operating data in event of power failure) RAM to contain CDLs, application parameters, operating data or software that is required to be modifiable from operational standpoint such as schedules, set points, alarm limits, PID constants and CDL and hence modifiable on-line through operator panel or remote operator's interface. RAM to be downline loadable from OWS, CAB-Gateway, or locally installed floppy disk.

.4 Include uninterruptible clock accurate to plus or minus 5 secs/month, capable of deriving month/day/hour/minute/second, with rechargeable batteries for minimum 72 hour operation in event of power failure.

.5 Local Operator Terminal (OT)

.1 OT to:

.1 Have integral access/display panel where immediate access to OWS is not available.

.2 Support operator's terminal for local command entry, instantaneous and historical data display, programs additions and modifications.

.3 Simultaneously display minimum of 16 points with full English identification to allow operator to view single screen dynamic displays depicting entire mechanical systems.

.2 Functions to include, but not be limited to, following:

.1 Start and stop points.

.2 Modify set points.

.3 Modify PID loop set points.

.4 Override PID control.

.5 Change time/date.

.6 Add/modify/start/stop weekly scheduling.

.7 Add/modify set point weekly scheduling.

.8 Enter temporary override schedules.

.9 Define holiday schedules.

.10 View analog limits.

.11 Enter/modify analog warning limits.

.12 Enter/modify analog alarm limits.

.13 Enter/modify analog differentials.

.3 OT to provide access to real and calculated points in controller to which it is connected or to any other controller in network. This capability not to be restricted to subset of predefined "global points" but to provide totally open exchange of data between OT and any other controller in network.

.4 Operator access to OTs to the same as OWS user password.

Password changes to automatically be downloaded to controllers on network.

.5 OT to provide prompting to eliminate need for user to remember command format or point names. Prompting to be consistent with user's password clearance and types of points displayed to eliminate possibility of operator error.

.6 Identity of real or calculated points to be consistent with network devices. Use same point identifier as at OWS's for access of points at OT to eliminate cross-reference or look-up tables.

2.02 LOCAL CONTROL UNIT (LCU)

.1 Provide multiple control functions for typical built-up and package HVAC, hydronic and electrical systems.

.2 Minimum of 16 I/O points of which minimum be 4 AOs, 4 AIs, 4 DIs, 4 DOs.

.3 Points of one Building System to be connected to one controller as listed in I/O Summary designations.

.4 Microprocessor capable of supporting necessary software and hardware to meet specified requirements. As per MCU requirements (section 2.3.4) above with the following additions:

.1 Include as minimum two (2) interface ports for connection to local computer terminal.

.2 Design so that shorts, opens or grounds on any input or output will not interfere with other input or output signals.

.3 Physically separate line voltage (50V and over) circuits from DC logic circuits to permit maintenance on either circuit with minimum hazards to technician and equipment.

.4 Include power supplies for operation of LCU and associated field equipment.

.5 In event of loss of communications with, or failure of, MCU, LCU to continue to perform control. Controllers that use defaults or fail to open or close positions not acceptable.

.6 Provide conveniently located screw type or spade lug terminals for field wiring.

.7 LCU to have 25% spare input and 25% output point capacity without addition of cards, terminals, etc.

2.03 TERMINAL/ EQUIPMENT CONTROL UNIT (TCU/ECU)

.1 Microprocessor capable of supporting necessary software and hardware to meet TCU/ECU functional specifications.

.2 The TCU definition to be consistent with those defined in ASHRAE HVAC Applications Handbook.

.3 Controller to communicate directly with EMCS through EMCS LAN and provide access from EMCS OWS for setting occupied and unoccupied space temperature set points, flow set points, and associated alarm values, permit reading of sensor values, field control values (% open) and transmit alarm conditions to EMCS OWS.

.4 VAV Terminal Controller
- .1 Microprocessor based controller with integral flow transducer, including software routines to execute PID algorithms, calculate airflow for integral flow transducer and measure temperatures as per I/O Summary required inputs. Sequence of operation to ASHRAE HVAC Applications Handbook.
- .2 Controller to support point definition; in accordance with section 25 05 01 - EMCS: General Requirements.
- .3 Controller to operate independent of network in case of communication failure.
- .4 Controller to include damper actuator and terminations for input and output sensors and devices.

2.04 SOFTWARE

.1 General:
- .1 Include as minimum: operating system executive, communications, application programs, operator interface, and systems sequence of operation - CDL's.
- .2 To include "firmware" or instructions which are programmed into ROM, EPROM, EEPROM or other non-volatile memory.
- .3 Include initial programming of all Controllers, for entire system.

.2 Program and data storage:
- .1 Store executive programs and site configuration data in ROM, EEPROM or other non-volatile memory.
- .2 Maintain CDL and operating data such as set points, operating constants, alarm limits in battery-backed RAM or EEPROM for display and modification by operator.

.3 Programming languages:
- .1 Control Description Logic software to be programmed using English like or graphical, high level, general control language.
- .2 Structure software in modular fashion to permit simple restructuring of program modules if future software additions or modifications are required. GO TO constructs not allowed.

.4 Operator terminal interface:
.1 MCU to perform operating and control functions specified Section 25 10 02 - EMCS: Operator Work Stations (OWS), as well as:
.1 Multi-level password access protection to allow user/manager to limit workstation control.
.2 Alarm management: processing and messages.
.3 Operator commands.
.4 Reports.
.5 Displays.
.6 Point identification.
.2 The operator interface must be Web-based. The control system server shall be accessed using a Web browser over the control system network, the Owner's local area network, and (at the Owner's discretion) over the Internet. No special software other than a Web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers. Provide internet access for Owner and Departmental Representative.

.5 Pseudo or calculated points:
.1 Software to have access to any value or status in controller or other networked controller so as to define and calculate pseudo point from other values/status of controller. When current pseudo point value is derived, normal alarm checks must be performed or value used to totalize.
.2 Inputs and outputs for any process to be able to include data from controllers to permit development of network-wide control strategies. Processes also to permit operator to use results of one process as input to any number of other processes (eg. cascading).

.6 Control Description Logic (CDL):
.1 Capable of generating on- line project-specific control loop algorithms (CDLs). CDLs to be software based, programmed into RAM or EEPROM and backed up to OWS. Owner must have access to these algorithms for modification or to be able to create new ones and to integrate these into CDLs on BC(s) from OWS.
.2 Write CDL in high level language that allows algorithms and interlocking programs to be written simply and clearly. Use parameters entered into system (eg. set points) to determine operation of algorithm. Operator to be able to alter operating parameters on-line from OWS or BC(s) and to tune control loops.
.3 Perform changes to CDL on- line.
.4 Control logic to have access to values or status of all

points available to controller including global or common values, allowing cascading or inter-locking control.

.5 Energy optimization routines such as enthalpy control, supply temperature reset, etc. to be LCU or MCU resident functions and form part of CDL.

.6 MCU to be able to perform following pre-tested control algorithms:

.1 Two position control.

.2 Proportional Integral and Derivative (PID) control.

.3 Automatic control loop tuning.

.7 Control software to provide the ability to define the time between successive starts for each piece of equipment to reduce cycling of motors.

.8 Provide protection against excessive electrical-demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

.9 Power Fail Restart: Upon detection of power failure system to verify availability of emergency power as determined by emergency power transfer switches and analyze controlled equipment to determine its appropriate status under emergency power conditions and start or stop equipment as defined by I/O Summary. Upon resumption of normal power as determined by emergency power transfer switches, MCU to analyze status of controlled equipment, compare with normal occupancy scheduling, turn equipment on or off as necessary to resume normal operation.

.7 Event and Alarm management: The system to use a management by exception concept for Alarm Reporting. This is a system wide requirement. This approach will insure that only principal alarms are reported to OWS. Events which occur as a direct result of the primary event to be suppressed by the system and only events which fail to occur to be reported. Such event sequence to be identified in I/O Summary and sequence of operation. Examples of above are, operational temperature alarms limits which are exceeded when main air handler is stopped, or General Fire condition shuts air handlers down, only Fire alarm status shall be reported. The exception is, when an air handler which is supposed to stop or start fails to do so under the event condition.

.8 Energy management programs: The following programs shall include specific summarizing reports, to include the date stamp indicating sensor details which activated and or terminated the feature.

.1 MCU in coordination with subordinate LCU, TCU, ECU to provide for the following energy management routines:

.1 Time of day scheduling.

.2 Calendar based scheduling.
.3 Holiday scheduling.
.4 Temporary schedule overrides.
.5 Optimal start stop.
.6 Night setback control.
.7 Enthalpy (economizer) switchover.
.8 Peak demand limiting.
.9 Temperature compensated load rolling.
.10 Fan speed/flow rate control.
.11 Cold deck reset.
.12 Hot deck reset.
.13 Hot water reset.
.14 Chilled water reset.
.15 Condenser water reset.
.16 Chiller sequencing.
.17 Night purge.

.2 Programs to be executed automatically without need for operator intervention and be flexible enough to allow customization.

.3 Apply programs to equipment and systems as specified or requested by the Departmental Representative.

.9 Function/Event Totalization: features to provide predefined reports which show daily, weekly, and monthly accumulating totals and which include high rate (time stamped) and low rate (time stamped) and accumulation to date for month.

.1 MCUs to accumulate and store automatically run-time for binary input and output points.

.2 MCU to automatically sample, calculate and store consumption totals on daily, weekly or monthly basis for user- selected analog or binary pulse input-type points.

.3 MCU to automatically count events (number of times pump is cycled off and on) daily, weekly or monthly basis.

.4 Totalization routine to have sampling resolution of 1 min or less for analog inputs.

.5 Totalization to provide calculations and storage of accumulations up to 99,999.9 units (eg. kWh, liters, tonnes, etc.).

.6 Store event totalization records with minimum of 9,999,999 events before reset.

.7 User to be able to define warning limit and generate user-specified messages when limit reached.

2.05 LEVELS OF ADDRESS

.1 Upon operator's request, EMCS to present status of any single 'point', 'system' or point group, entire 'area', or entire network on printer or OWS as selected by operator.

.1 Display analog values digitally to 1 place of decimals with

negative sign as required.

.2 Update displayed analog values and status when new values received.

.3 Flag points in alarm by blinking, reverse video, different colour, bracketed or other means to differentiate from points not in alarm.

.4 Updates to be change-of- value (COV)-driven or if polled not exceeding 2 second intervals.

2.06 POINT NAME SUPPORT

.1 Controllers (MCU, LCU) to support point naming convention as defined in Section 25 05 01 - EMCS: General Requirements.

3 EXECUTION

3.01 LOCATION

.1 Have location of Controllers approved by the Departmental Representative.

3.02 INSTALLATION

.1 Install Controllers in secure enclosures as indicated.

.2 Provide necessary power from local 120 V branch circuit panel for equipment.

.3 Install tamper locks on breakers of circuit breaker panel.

.4 Use Uninterruptible Power Supply (UPS) and emergency power when equipment must operate in an emergency and coordinating mode.

END OF SECTION

1 GENERAL

1.01 REFERENCES

.1 American National Standards Institute (ANSI):
  .1 ANSI C12.7-2014, Requirements for Watthour Meter Sockets.
  .2 ANSI/IEEE C57.13-2016, Requirements for Instrument Transformers.

1.02 SUBMITTALS

.1 Submit shop drawings and manufacturer's installation instructions in accordance with Section 25 05 02 - EMCS: Submittals and Review Process.

.2 Include:
  .1 Information as specified for each device.
  .2 Manufacturers detailed installation instructions.

.3 Pre-Installation Tests
  .1 Submit samples at random from equipment shipped, as requested by the Departmental Representative for testing before installation. Replace devices not meeting specified performance and accuracy.

.4 Manufacturer's Instructions
  .1 Submit manufacturer's installation instructions for specified equipment and devices.

1.03 CLOSEOUT SUBMITTALS

.1 Submit operating and maintenance data for inclusion in operation and maintenance manual in accordance with Section 25 05 03 - EMCS: Project Records Documents.

1.04 WARRANTY

.1 Provide a five (5) year parts and labour warranty for all EMCS field devices, starting from the date of substantial completion.

2 PRODUCTS

2.01 GENERAL

.1 Control devices of each category to be of same type and manufacturer.

.2 External trim materials to be corrosion resistant. Internal parts to be assembled in watertight, shockproof, vibration-proof, heat resistant assembly.

.3 Operating conditions: 0 - 32°C with 10 - 90% RH (non-condensing) unless otherwise specified.

.4 Terminations: use standard conduit box with slot screwdriver compression connector block unless otherwise specified.

.5 Transmitters to be unaffected by external transmitters (e.g. walkie talkies).

.6 Account for hysteresis, relaxation time, maximum and minimum limits in applications of sensors and controls.

.7 Outdoor installations: use weatherproof construction in CSA 4X enclosures.

.8 Devices to be installed in user occupied space must not exceed Noise Criteria (NC) of 35. Noise generated by any device must not be detectable above space ambient conditions.

2.02 ROOM TEMPERATURE SENSOR

.1 Provide wall mounted temperature sensors as shown on control drawings.

.2 Temperature sensors to meet, at minimum, the following requirements:
- .1 White protective enclosure.
- .2 Thermistor or RTD compatible with BMS.
- .3 BMS to report the monitored temperature with an accuracy of 0.5 EC (1.0EF).
- .4 3.5 digit LCD display of room temperature and set-point.
- .5 Push button set-point adjustment.
- .6 Override switch.
- .7 LED.

2.03 FLAT PLATE ROOM TEMPERATURE SENSOR

.1 Provide wall mounted stainless plate temperature sensors as indicated on control drawings.

.2 Temperature sensors shall have the following features:
- .1 Stainless plate sensors to fit 100mm x 50mm junction box.
- .2 Thermistor or RTD compatible with BMS.
- .3 BMS shall report the monitored temperature with an accuracy of 0.5EC (1.0EF).

2.04 COMBINATION ROOM TEMPERATURE, CO2, RH SENSOR

.1 Provide wall mounted combination sensors as shown on control drawings.

.2 Combination sensors shall meet, at minimum, the following requirements:
- .1 White protective enclosure.
- .2 Thermistor or RTD compatible with BMS.
- .3 BMS to report the monitored temperature with an accuracy of 0.5 EC (1.0EF).
- .4 4-20 mA two wire, 0-10 VDC and/or 0-5 VDC output proportional to relative humidity range of 0% to 100% and compatible with BMS.
- .5 2% accurate (5-95% RH).
- .6 CO2 gas detection. Range: 0-2000 ppm, 0-5%

2.05 DUCT TEMPERATURE SENSOR -SINGLE POINT

.1 Provide duct mounted, single point, temperature sensors as indicated in the drawings with the following features:

.2 6mm stainless steel probe of length between one-third and two-thirds of the duct width.

.3 Thermistor of RTD compatible with BMS, sealed in probe with 3 part moisture protection system.

.4 BMS must report the monitored temperature with an accuracy of 1.0°F.

.5 Duct mounted ABS plenum rated housing with conduit entrance. Weather proof housing downstream of humidifiers.

2.06 SURFACE MOUNT TEMPERATURE SENSOR

.1 Provide surface mounted, single point, temperature sensors as indicated in the drawings with the following features:

.2 Thermistor of RTD compatible with BMS, sealed for moisture protection.

.3 BMS must report the monitored temperature with an accuracy of 1.0°F

2.07 DUCT TEMPERATURE SENSOR - AVERAGING

.1 Provide duct mounted, averaging, temperature sensors as indicated on control drawings.

.2 Temperature sensors shall meet, at minimum, the following requirements:
- .1 Probe length of 12 ft. minimum or 1 ft. per ft2 of duct cross-sectional area, whichever is greater.
- .2 Copper sheathed or plenum rated flexible construction.
- .3 Thermistor or RTD compatible with BMS.
- .4 BMS to report the monitored temperature with an accuracy of 2.0°F.
- .5 Duct mounted ABS plenum rated housing with conduit entrance. Weather proof housing as required.
- .6 Suitable supports at all bends and at intermediate points to prevent movement in the air systems.

2.08 TEMPERATURE SENSOR - OUTSIDE AIR

.1 Provide outside air temperature sensors as indicated on the control drawings.

.2 Temperature sensors shall meet, at minimum, the following requirements:
- .1 PVC with sun and windscreen.
- .2 Wall mount weatherproof enclosure with conduit entrance.
- .3 Thermistor or RTD compatible with BMS.
- .4 BMS to report the monitored temperature with an accuracy of 1.0°F.

2.09 DUCT MOUNT RELATIVE HUMIDITY SENSORS

.1 Provide duct mounted relative humidity sensors as indicated on the control drawings. Duct mounted relative humidity sensors shall meet, at minimum, the following requirements:
- .1 ABS housing with conduit entrance.
- .2 Sensor to be laser trimmed thermoset polymer based capacitive type.
- .3 24 VAC/DC power supply.
- .4 4-20 mA two wire, 0-10 VDC and/or 0-5 VDC output proportional to relative humidity range of 0% to 100% and compatible with BMS.
- .5 2% accurate (5-95% RH).
- .6 230mm (9@) probe length.
- .7 Operating temperature range of 0°C to 70°C (32°F to 158°F).
- .8 Reverse voltage protected and output limited.
- .9 60 micron HDPE filter.

2.10 DIFFERENTIAL PRESSURE SENSORS

.1 Requirements:
- .1 Output signal: 4 - 20 mA in 400 ohms, 0-5V into 5K ohms minimum, 0-10 V into 10K ohms minimum.

.2 Room sensors to be complete with stainless steel cover plates.

.3 Pressure ranges: 0-0.1" w.c.

2.11 DUCT MOUNT STATIC PRESSURE SENSOR

.1 Provide duct mounted static pressure sensors as indicated on the control drawings. Static pressure sensors shall meet, at minimum, the following requirements:
- .1 Input range must be appropriate for the application. Select range such that it covers from zero duct static pressure relative to the exterior of the duct up to a static pressure of between 20% and 50% in excess of the maximum static pressure that could be encountered in the duct relative to the duct exterior.
- .2 4-20mA, 0-5 or 0-10Vdc output proportional to pressure input range compatible with BMS system.
- .3 1% Full scale output accuracy.
- .4 Operating temperature range of 0°C to 60°C (32°F to 140° F).
- .5 Easily accessible, integral non-interacting zero adjustment.
- .6 Minimum over pressure input protection of two times rated input or 7 kPa (20 psi) whichever is greater.

2.12 FILTER DIFFERENTIAL PRESSURE SENSORS

.1 Provide air differential pressure sensors as indicated on the control drawings. Air differential pressure sensor shall meet, at minimum, the following requirements:
- .1 Sensors used for filter or coil differential pressures shall also have a display of the monitored differential pressure.
- .2 Output shall be 4-20mA, 0- 10Vdc or 0-5Vdc output proportional to pressure input range compatible with BMS.
- .3 Select range as required, taking into consideration pressure drop across filter or coil. Typically 0 to 500pa (0-2@ wc) range for low-pressure commercial duct.
- .4 Operating temperature range of 0°C to 60°C (32°F to 140°F).

2.13 PITOT RING

.1 Provide pitot tube air measuring stations as indicated and required for air flow monitoring. Tubes shall be 304 stainless steel. Tubes shall have precisely located burr-free static pressure holes and a calibration coefficient of "1". Conform to ASHRAE 51. Use a ring style for air flow measurement at the inlet of fans. Securely fasten pitot tubes to avoid any vibration or rattling.

2.14 AIRFLOW MONITORING STATION

.1 Provide one AMD with an integral airflow alarm for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.

.2 Each AMD shall be provided with a remotely mounted microprocessor-based transmitter and one or two sensor probes.

.3 The transmitter shall be provided with one of the following:

.4 Two scalable, protected and field selectable analog output signals (0-5 / 1-5 VDC or 0-10 / 2-10 VDC, choose one), or

.5 One non-isolated RS-485 network connection (field selectable BACnet MS/TP or Modbus RTU protocol). Provide individual 24 VAC transformers at each network transmitter requiring isolated RS-485 connection.

.6 One analog output shall be airflow (AO1), while the second output (AO2) shall be configurable as average temperature (default), adjustable airflow alarm or system alarm.

.7 When the alarm is active, the alarm condition shall be indicated on the LCD display.

.8 Alarm reset shall be manual or automatic.

.9 Alarm set points shall be adjustable by type, tolerance, delay, disable/enable, and analog signal indication for AO2.

.10 RS-485 network communications shall provide the average airflow rate, average temperature, system status alarm, Hi-Lo airflow alarm, individual sensor node airflow rates and individual sensor node temperatures.

.11 Each sensing node shall have an airflow accuracy of ±3% of reading (typical) ±4% max. from 0 to 3,000 FPM (15.24 m/s) over a temperature range of 0° F to 160° F (-18° to 71° C). Airflow accuracy shall be maintained at lower operating temperatures of -20° F to 160° F (-29° C to 71° C) but the velocity range shall be limited to 0 - 2,000 FPM (10.2 m/s).

.12 Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.

.13 Devices whose overall performance at the host controller input terminals is the combined accuracy of the transmitter and sensor probes shall demonstrate that the total accuracy meets the

performance requirements of this specification throughout the measurement range.

.14 Each sensor node shall be factory calibrated at a minimum of 7 airflow rates including zero (still air), to NIST Traceable standards

2.15 INFRARED CO2 GAS MONITORS

.1 Specifications:
.1 Gas Detected: CO2

.2 Detection Range: 0-2000 ppm, 0-5%

.3 Accuracy: +/- 3%

.4 Response Time: 35 sec. (for 90% of the reading)

.5 Sensor Life Expectancy: > 10 years

.6 Relay Output Rating: 5A, 30 VDC or 250 VAC (resistive load)

.7 Outputs: 4-20 mA or 0-5 VDC or 0-10 VDC, 1 SPDT Relay

.8 Operating Humidity Range: 0- 95% RH, Non-condensing

.9 Operating Temperature Range: 32°F to 100°F.

.10 Size: 5.25 x 3.5 x 2 in. 11 Weight:
.1 SM: 200g / 8.8 oz.
.2 DT: 1 300 g / 0.56 oz

.11 Power Requirement: 17-27 VAC or 24-38 VDC, 200 mA.

2.16 PROPORTIONAL CONTROL DAMPER MOTORS

.1 Specifications
.1 Power Requirements:
.1 20 to 30 VAC at 50/60 Hz or 24 VDC "10%; 14 VA supply from 32 to 122°F or 18 VA supply from -22 to 32°F, minimum, Class 2.

.2 Input Signal
.1 0 to 10 VDC or 0 to 20 mA

.3 Input Signal Adjustments
.1 Voltage or Current Input:
.2 Switch Selectable: 0 (2) to 10 VDC or 0 (4) to 20 mA
.3 Factory Setting: 0 to 10 VDC, CW rotation with signal increase

.4 Direction of action is user selectable Direct (CW) or Reverse (CCW) with signal increase.

.4 Input Impedance
.1 Voltage Input, 200,000 ohms; Current Input, 500 ohms.

.5 Feedback Signal
.1 0 to 10 VDC or 2 to 10 VDC for 90 (10 VDC at 1 mA) Corresponds to input signal span selection and rotation limits.

.6 Spring Return Factory Setting: CCW; Direction is selectable with the coupler.

.7 Mechanical Output Running Torque,

.8 All Models: 32 Nxm (280 lbxin) for two units in tandem.

.9 Rotation Range
.1 Adjustable from 30 to 90°, CW or CCW
.2 Mechanically limited to 93.

.10 Rotation Time
.1 70 to 130 seconds for 0 to 16 Nxm (0 to 140 lbxin); 90 seconds nominal at 50% rated load.

.11 Cycles 65,000 full stroke cycles.

.12 Electrical Connection:
.1 1/4 in. spade terminals with pluggable terminal blocks.
.2 Screw terminals for 22 to 14 AWG.

.13 Mechanical Connection 3/8 to 3/4 in. diameter round shaft or 3/8 to 5/8 in. square shaft.

.14 Enclosure: NEMA 2, IP42.

.15 Ambient Conditions:
.1 Operating: -22 to 122°F; 0 to 95% RH, non- condensing
.2 Storage: -40 to 186°F; 0 to 95% RH, non-condensing.

.16 Dimensions (H x W x D) 9.82 x 4.57 x 3.62 in.

.17 Shipping Weight 6.4 lb.

2.17 OPEN/CLOSE DAMPER MOTORS

.1 Specifications:
.1 Power Requirements:
.1 Nominal 9.8 VA running; 5.8 VA holding position.

.2 Input Signal: 20 to 30 VAC at 50/60 Hz Class 2

.3 Auxiliary Switch Rating.
- .1 One Single-Pole, Double-Throw switch.
- .2 Rating: 24 VAC: 50 VA pilot duty.
- .3 120 VAC: 5.8 A resistive, 1/4 hp, 275 VA pilot duty.
- .4 240 VAC, 5.0 A resistive, 1/4 hp, 275 VA pilot duty.

.4 Spring Return:
- .1 Direction is selectable with the mounting position of the actuator:
  - .1 CCW actuator face away from the damper for CCW spring return;
  - .2 CW actuator face is away from the damper for CW spring return.

.5 Mechanical Output: Running Torque: 6 Nxm (53 lbxin).

.6 Rotation Range:
- .1 Adjustable from 34.5 to 90 CW or CCW.
- .2 Mechanically limited to 93.

.7 Rotation Time:
- .1 Powered (On): 10 to 40 seconds for 0 to 6 Nxm (0 to 53 lbxin) at all operating conditions.
- .2 25 seconds nominal for 50% rated load.
- .3 Unpowered (Off): Spring return time is 35 seconds nominal, 70 seconds maximum.

.8 Cycles: 60,000 full stroke cycles; rated at 6 Nxm (53 lbxin).

.9 Audible Noise Rating 55 dBA nominal at 1 m.

.10 Electrical Connections:
- .1 Actuator: 48 in. cable with 18 AWG wire leads.
- .2 Auxiliary Switch: 48 in. cable with 18 AWG wire leads.

.11 Mechanical Connection 3/8 to 1/2 in. diameter round shaft or 3/8 in. square shaft.

.12 Enclosure; NEMA 2, IP42.

.13 Ambient Conditions:
- .1 Operating: -25 to 140°F; 10 to 90% RH, non-condensing.
- .2 Storage: -40 to 186°F; 5 to 95% RH, non-condensing.

.14 Dimensions (H x W x D)
- .1 BGA: 6.98 x 3.25 x 2.99 in.

.15 Shipping Weight 3.45 lb.

2.18 FIRESTAT

.1 Specifications:
- .1 Product A25AN-1 SPST, opens on temperature rise, set point knob adjustment.
- .2 Range 25 to 215°F.
- .3 Electrical Ratings Volts, AC 120 VAC 208 VAC 240 VAC 277 VAC.
- .4 Motor FLA* 16 9.2 8 -
- .5 Motor LRA* 96 55.2 48 -
- .6 Non-inductive A 16 16 16 16
- .7 Pilot Duty: 125 VA at 24/600 VAC
- .8 Ambient Temperature (Maximum)
  - .1 Case 104°F.
  - .2 Element 300°F.
- .9 Conduit Opening 7/8 in diameter hole for 1/2 in. conduit.
- .10 Switch Snap-acting contacts in dust protected enclosure.
- .11 Cover Finish Gray baked enamel.
- .12 High Limit Dial Stop 125 F.
- .13 Material:
  - .1 Case 0.063 in. galvanized steel.
  - .2 Cover 0.025 in. cold rolled steel.
- .14 Mounting Flange for flat surface.
- .15 Reset Positive, trip-free reset mechanism (manual reset 2 operation). Control can be reset when the temperature drops 20F below the dial setting.
- .16 Sensing Element Bi-metal rod and tube construction.
- .17 Shipping Weight:
  - .1 Individual pack 1.8 lb.
  - .2 Over pack of 12 units 23 lb.
- .18 Wiring Connections Screw-type terminals.

2.19 CONTROL STATUS RELAY

.1 Provide current sensing relays as required. Current sensing relays must meet, at minimum, the following specifications:
- .1 Rated for the applicable load.
- .2 The output relay must have an accessible trip adjustment over its complete operating range. Provide LED indication of relay status.
- .3 Current relay shall have input and output isolation via current transformer.
- .4 Current relay shall be self- powered with no insertion loss.
- .5 Relay shall be in dustproof housing.
- .6 Accuracy to be <2% of full- scale max.
- .7 Temperature rating of -15°C to 60°C (5°F to 140°F).

.2 Whenever the status of a single speed motor is monitored it shall be done via a current sensing relay. Differential pressure

switches shall not be used for this purpose. The BMS contractor shall provide current sensing relays at the MCC starters. The BMS contractor shall provide the current sensing relays for motors with local starters and no MCC starter.

2.20 CONTROL RELAY (SOLID STATE)

.1 Technical Performance: 240V 10 amp capacity. Normally open or normally closed to suit the application, suitable for switching inductive AC loads.

2.21 CONTROL RELAY (ELECTRO MECHANICAL)

.1 Technical Performance: a high impedance relay to produce a dry contact.

2.22 KW AND KWH TRANSDUCERS

.1 Provide kW and kWh transducers as identified on the control drawings and control sequences. Transducer to include, at minimum, the following:
- .1 True RMS conversion.
- .2 24 Bit DSP signal processor.
- .3 On board potential transformers for up to 600 VAC applications.
- .4 Configurable via RS-232C on personal computer.
- .5 4-20 mA proportional to KW demand output.
- .6 Opto-isolated open collector solid state form A relay rated at 30 VDC @150mA for kWh output.
- .7 Opto-isolated open collector solid state form A relay rated at 30 VDC @150mA for phase loss output.
- .8 Accuracy 1% or better of full scale.
- .9 Operating temperature of 0°C to 70°C (32°F to 158°F).
- .10 Provide disconnect/shorting bar and CTs compatible with amperage being sensed.

2.23 CURRENT SENSING RELAYS

.1 Requirements:
- .1 Complete with metering transformer ranged to match load, plug-in base and shorting shunt to protect current transformer when relay is removed from socket.
- .2 Suitable for single or three (3) phase metering into single relay.
- .3 To have adjustable latch level, adjustable delay on latch and minimum differential of 10 % of latch setting between latch level and release level.
- .4 3-Phase application: provide for discrimination between phases.
- .5 To have adjustable latch level to allow detection of worst

case selection. To be powered from control circuit of motor starter being metered. Relay and base to be mounted in adjacent auxiliary cabinet only if control circuit power to be brought into auxiliary cabinet. Adjustments to be acceptable from auxiliary cabinet.

.6 Relay contacts: capable of handling 10 amps at 240 VAC.

2.24 FLOW METERS

.1 Provide flow meters as indicated on control drawings.
- .1 Operating range must be suitable for the application.
- .2 4-20 mA output proportional to water flow.
- .3 Dual turbine insertion type.
- .4 2% accuracy over flow range
- .5 Hot tap installation.

2.25 PANELS

.1 Wall mounted enameled steel cabinets with hinged and key-locked front door.

.2 Multiple panels as required to handle requirements with additional space to accommodate 25% additional capacity as required by the Departmental Representative without adding additional cabinets.

.3 Panels to be lockable with same key.

2.26 WIRING

.1 All wiring including communications and power wiring to run in conduit.

.2 Wiring must be continuous without joints.

.3 Refer to Electrical Division.

3 EXECUTION

3.01 INSTALLATION

.1 Install field control devices, conduit and wire in accordance with manufacturers recommended methods, procedures and instructions. Wiring and conduit above 50 volts by electrical Division. Coordinate requirements with Electrical contractor.

.2 Temperature transmitters, humidity transmitters, current-to-pneumatic transducers, solenoid air valves, controllers, relays: install in CSA 2 enclosures or as required for specific

applications. Provide for electrolytic isolation in all cases when dissimilar metals make contact.

.3 Support field-mounted transmitters, sensors on pipe stands or channel brackets.

.4 Install wall mounted devices on plywood panel properly attached to wall.

3.02 TEMPERATURE AND HUMIDITY SENSORS

.1 Stabilize to ensure minimum field adjustments or calibrations.

.2 To be readily accessible and adaptable to each type of application so as to allow for quick easy replacement and servicing without special tools or skills.

.3 Outdoor installation:
- .1 Protect from solar radiation and wind effects by stainless steel shields.
- .2 Install in CSA 4X enclosures.

.4 Duct installations
- .1 Do not mount in dead air space.
- .2 Location to be within sensor vibration and velocity limits.
- .3 Securely mount extended surface sensor used to sense average temperature.
- .4 Thermally isolate elements from brackets and supports so as to respond to air temperature only.
- .5 Support sensor element separately from coils, filter racks.

.5 Averaging duct type temperature sensors:
- .1 Sensor length to be not less than 1m per square meter of duct cross- sectional area.
- .2 Use multiple sensors where single sensor does not meet minimum length ratio. Wire multiple sensors in series for freeze protection applications.
- .3 Wire multiple sensors separately for temperature measurement.
- .4 Use either software averaging algorithm to derive overall average for control purposes or separate inputs, based on site requirements.

.6 Thermowells: install for piping installations. Where pipe diameter is less than well insertion length, locate well in elbow. Thermowell to restrict flow by less than 30%.

3.03 PANELS

.1 Arrange for conduit and tubing entry from top, bottom or either side.

.2 Use modular multiple panels if necessary to handle all requirements, with space for additional 20% PCU or FID if applicable without adding additional panels. Space to accommodate maximum capacity of associated controller (ECU, LCU, MCU, PCU, TCU).

.3 Wiring and tubing within panels: locate in trays or individually clipped to back of panel.

.4 Identify wiring and conduit clearly.

3.04 MAGNEHELIC PRESSURE INDICATORS

.1 Install adjacent to fan system static pressure sensor and duct system velocity pressure sensors (as approved by the Departmental Representative).

.2 Locations to be as indicated or specified.

3.05 PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

.1 Install isolation valve and snubber on sensors between sensor and pressure source. In addition, protect sensing elements on steam and high temperature hot water service with pigtail syphon between valve and sensor.

3.06 PRESSURE GAUGES

.1 Install on pneumatic systems only.

.2 Install pressure gauges on pneumatic devices, I/P, pilot positioners, motor operators, switches, relays, valves, damper operators, valve actuators.

.3 Install pressure gauge on output of controller and auxiliary cabinet pneumatic devices.

3.07 IDENTIFICATION

.1 Identify field devices properly.

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

3.08 AIR FLOW MEASURING STATIONS

.1 Cap manifold until cleaning of ducts is completed.

3.09 TESTING

.1 Calibrate and test field devices for accuracy and performance. Submit report detailing tests performed, results obtained to the Departmental Representative for approval. The Departmental Representative will verify results at random. Provide testing equipment and manpower necessary for this verification.

3.10 COMMISSIONING

.1 Refer to Section 25 08 20 - EMCS: Warranty and Maintenance.

END OF SECTION

1 GENERAL

1.01 DESCRIPTION

.1 This specification describes a high performance variable frequency drive (VFD) used to control the speed of a NEMA design B induction motor.

.2 Load filters shall be supplied with all drives.

.3 A building automation system serial communication module and EMCS communication card shall be supplied with all drives.

1.02 RELATED SECTIONS

.1 Section 01 33 00 - Submittal Procedure

.2 Section 01 91 13 – Commissioning General Requirements.

1.03 REFERENCES

.1 Institute of Electrical and Electronic Engineers (IEEE)
  .1 IEEE 519-2014, Guide for Harmonic Content and Control.

.2 Underwriters laboratories (ULC)
  .1 UL 508C-2016, Power Conversion Equipment

.3 National Electrical Manufacturer's Association (NEMA)
  .1 ICS 7.0, AC Adjustable Speed Drivers

.4 International ElectroTechnical Commission (IEC)
  .1 IEC 61800 Adjustable Speed Electrical Power Drive Systems

.5 International Standards Organization (ISO)
  .1 ISO-9001:2015, Quality Management Systems

1.04 SUBMITTALS

.1 Submit the following information:
  .1 Outline dimensions, conduit entry locations and weight.
  .2 Customer connection and power wiring diagrams.
  .3 Complete technical product description include a complete list of options provided.
  .4 Compliance to IEEE 519 - harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).
    .1 The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line

filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5% impedance reactors, no exceptions.

.5 In accordance with Section 01 33 00.

1.05 QUALITY ASSURANCE

.1 The VFD manufacturing facility must be ISO 9001 certified. The VFD to be UL listed, Canadian UL listed, CSA listed, IEEE listed, and NEMA listed.

.2 All printed circuited boards must be completely tested and burned-in before being assembled into the completed VFD. The VFD shall then be subjected to a preliminary functional test, burn-in, and computerized final test. The burn-in shall be at 40°C, at full rated load, or cycled load. Drive input power must be continuously cycled for maximum stress and thermal variation. Include conformal coating of boards for each drive.

.3 Supply a drive designed to provide 250 000 hours mean time before failure (MTBF) when the specified preventative maintenance is performed.

.4 VFD manufacturer to have an analysis laboratory to evaluate the failure of any component. The failure analysis lab must allow the manufacturer to perform complete electrical testing, x-ray components, and decap or delaminate components and analyze failures within the component.

2 PRODUCTS

2.01 VARIABLE FREQUENCY DRIVES

.1 The VFD package as specified herein must be enclosed in a NEMA Type 1 or optional NEMA 12 enclosure, completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window must allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

.1 Environmental operating conditions: 0 to 40 C continuous duty. VFD's that can operate at 40 C intermittently (during a 24 hour period) are not acceptable and must be oversized. Altitude 0 to 1000m above sea level, less than 95% humidity, non-condensing.

.2 Enclosure shall be type NEMA 1 and shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable.

.2 All VFD's must have the following standard features:

.1 All VFD's must have the same customer interface, including digital display, and keypad, regardless of horsepower rating. Keypad to be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFD's.

.2 Keypad to include Hand-Off-Auto selections and manual speed control. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Hand" and "Auto" modes. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.

.3 There must be a built-in time clock in the VFD keypad. The clock will be used to date and time stamp faults and record operating parameters at the time of fault. The clock must also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays.

.4 VFD's to utilize pre-programmed application macros specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.

.5 The VFD must be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

.6 VFD to have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

.7 VFD to have an integral 5% impedance reactor to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD's with only one DC reactor shall add AC line reactors.

.8 VFD to include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.

.9 The VFD must be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.

.10 If the input reference (4-20mA or 2-10V) is lost, the VFD

will give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.

.3 All VFD's to have the following adjustments:

.1 Two (2) PID Setpoint controllers will be standard in the drive. Two (2) programmable analog inputs shall accept current or voltage signals.

.2 Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to frequency, motor speed, output voltage, output current, motor torque, motor power (kW), DC bus voltage, active reference, and other data.

.3 Six (6) programmable digital inputs. There will be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. The keypad shall display "start enable 1 (or 2) missing". The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC.

.4 Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. Default settings shall be for run, not faulted (fail safe), and run permissive. The relays shall be rated for maximum switching current 6 amps at 30 VDC and 250 VAC and 0.4 A at 120 VDC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true form C type contacts; open collector outputs are not acceptable.

.5 VFD to include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.

.6 VFD to include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency

without derating the VFD or operating at high carrier frequency only at low speeds.

.4 Serial Communications

.1 VFD to have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN, protocols for LonWorks, BACnet, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority. Use of non-certified protocols is not allowed.

.2 Serial communication capabilities to include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The EMCS shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus - keypad "Hand" or "Auto" selected, and the ability to change the PID setpoint. A minimum of 15 field parameters shall be capable of being monitored.

.3 The VFD must allow the EMCS to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function.

.5 EMI/RFI filters: VFD's to include EMI/RFI filters. The onboard filters will allow the VFD assembles to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

3 EXECUTION

3.01 INSTALLATION

.1 Install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

.2 Have power wiring completed by the electrical contractor. Three

copper conductors and a ground wire are required. Separate the input power wiring from the output power wiring in individual metallic conduit. Do not combine. Provide a separate metallic conduit for control wiring. Complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.02 START-UP

.1 Provide a certified factory start-up for each drive by a factory authorized service center in accordance with Section 01 91 13 - Commissioning (Cx) Requirements and Section 26 05 00 Common Work Results - Electrical. Fill out a certified start-up form for each drive with a copy provided to the Departmental Representative and keep a copy on file at the manufacturer.

3.03 PRODUCT SUPPORT

.1 Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

3.04 WARRANTY

.1 Warranty to be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. Warranty to include all parts, labor, travel time and expenses.

END OF SECTION

1.01 DESIGN DOCUMENTATION

.1 Design documentation for each system to include, as a minimum:
- .1 Narrative type of Sequence of Operation.
- .2 Control Description Logic (CDL).
- .3 Input/Output Summary Schedules.
- .4 Schematics.

1.02 EMCS LANGUAGE DESIGN CRITERIA

.1 Language: refer to Section 25 05 01 EMCS: General Requirements.

.2 Levels of EMCS Language
- .1 Level 1: alarm and operational messages to convey alarm conditions or operational messages.
- .2 Level 2: full names of equipment and control points. The various systems, their equipment and components and all control points are named in accordance with this section.
- .3 Level 3: system, equipment, component and control point descriptors: unique, alphanumeric identifiers derived from full names of corresponding system component and control point.
- .4 Level 4: commands: represent various computer functions and routines.
  - .1 Operational commands - relate to building operations and building system controls.
  - .2 Computer system commands - relate to computer maintenance, upgrading or development software used to improve and maintain the application software for the building site.
- .5 Level 5: machine language. Languages specific to each manufacturer's product, used internally to perform its functions and routines.

.3 Additional Equipment, Components and/or Control Points. Where additional equipment, components and/or control points are required on specific projects, the following procedures shall be adopted:
- .1 Full names of the equipment, component and control points shall be not more than 40 characters, including numerals.
- .2 SYSTEM descriptors shall be not more than 10 alphanumeric characters. INPUT and OUTPUT descriptors shall be not more than 10 alphanumeric characters. The letters shall be based upon the English language full name, and should, where possible, be the first letter of each word of the full name.

.4 The descriptor must be unique.

.5 Descriptors and expansions: table lists standardized system identifiers and point identifiers.

.1 Table:

Identifiers and Expansions

English Identifier (10 characters max)	English Expansion (40 characters max)
OAD	Outside air damper
OAT	Outside air temperature
OAH	Outside air humidity
OAV	Outside air volume
RAD	Return air damper
RAT	Return air temperature
RAH	Return air humidity
RASP	Return air static pressure
MAD	** Mixed air dampers **
MAT	Mixed air temperature
MAPSP	Mixed air plenum static pressure
** MAD shall be used for applications where outside air and return air dampers are controlled from one (1) only output signal.	
EAD	Exhaust air damper
PFPD	Pre-filter pressure drop
PFALM	Pre-filter pressure drop alarm
FFPD	Final filter pressure drop
FFALM	Final filter pressure drop alarm
HCVLV	Heating coil valve
HCVLVC	Heating coil valve control
HCVLVS	Heating coil valve status
BPD	Heating coil face and bypass damper
HCFA	Heating coil freeze alarm
CCVLV	Cooling coil valve
CCVLVC	Cooling coil valve control
CCVLVS	Cooling coil valve status
SVLV	Steam valve
SVLVC	Steam valve control
SVLVS	Steam valve status
SF#-C	Supply fan # control
SF#-S	Supply fan # status
SF#-VSD	Supply fan # VSD control
SF#-VSDF	Supply fan # VSD fault

SAV	Supply air volume
SAVC	Supply air volume control
SAT	Supply air temperature
SAH	Supply air humidity
SAVP	Supply air velocity pressure
SASP	Supply air static pressure
RF#-C	Return fan #control
RF#-S	Return fan # status
RF#-VSD	Return fan # VSD control
RF#-VSDF	Return fan # VSD fault
RAV	Return air volume
RAVC	Return air volume control
RAT	Return air temperature
RAH	Return air humidity
RAVP	Return air velocity pressure
RASP	Return air static pressure
EF#-C	Exhaust fan # control
EF#-S	Exhaust fan s# status
EXAT	Exhaust air temperature
EXAV	Exhaust air volume
Chiller #1:	
CH1F	Flow rate
CH1LWT	Leaving chilled water temperature
CH1LWP	Leaving chilled water pressure
CH1EWT	Entering chilled water temperature
CH1EWP	Entering chilled water pressure
CD1EWT	Entering condenser water temperature
CD1EWP	Entering condenser water pressure
CD1LWT	Leaving condenser water temperature
CD1LWP	Leaving condenser water pressure
CHP1F	Chilled water pump #1 flow rate
CHP1DP	Chilled water pump #1 discharge pressure
CHP1S	Chilled water pump #1 status

CP3C	Circulating pump #3 control
CP3F	Circulating pump #3 flow rate
CP3DP	Circulating pump #3 discharge pressure
CP3S	Circulating pump #3 status
HTA	High temperature alarm
LTA	Low temperature alarm
HTCO	High temperature cutout
LTCO	Low temperature cutout
HLA	High level alarm
LLA	Low level alarm
HLCO	High level cutout
LLCO	Low level cutout
HWF	Heating water flow rate
HWF	Heating water flow rate
HWRT	Heating water return temperature
STP	Steam pressure
STF	Steam flow rate
RM-T	Room temperature
RM-H	Room humidity
RM-SP	Room static pressure (add reference point)

Examples of specific space conditions:

RM-TNPER 2	Space temperature, North Perimeter, 2nd floor
RM-SPSPER I9	Space static pressure, South Perimeter, 19th floor
RM-HEINT 9	Space humidity, East Interior, 9th floor
AFS	Air Flow Switch
AFM	Air Flow Monitor
F	Flow
P	Pressure
ST	Supply temperature
RT	Return temperature
FA	Fire alarm
FTA	Fire trouble alarm
CW	Chilled water system
CD	Condenser Water System
HWH	Hot water heating system
RADN	Radiation system
CDR	Condensate return system
HPS	Steam - High pressure system

LPS	Steam - Low pressure system
DCW	Domestic cold water system
DHW	Domestic hot water system
DHWR	Domestic hot water system Recirculation
SANP	Sanitary sewage - pumped system
STMP	Storm water - pumped system
SPRD	Sprinkler - Dry pipe system
SPRW	Sprinkler - Wet pipe system
FSTP	Fire standpipe & hose system
VBA	Volume Box Control Assembly

1.03 I/O SUMMARY SCHEDULES

.1 General:
- .1 Have the EMCS contractor provide a complete I/O summary schedule similar to the one listed below, listing and describing all I/O's in detail. The standard schedule may be used provided all relevant information is provided.
- .2 PCU no: identifies the PCU to which all points in the I/O Summary Schedule are wired.
- .3 Building/Area: unique label given to each building forming part of a multi-building facility.
- .4 Area/System Label: unique label given to each area of the building or to each system.
  - .1 Column 1: Point no: I/O Summary Schedule reference number.
  - .2 Column 2: Point label: unique label for each point in the system. Point labels may be repeated for other buildings or systems.
  - .3 Column 3: Description: describes the point label in expanded terms.
  - .4 Column 4: Type: (eg. AI, AO, DI, DO).
  - .5 Column 5: Eng. Units: Describes the engineering units used (eg. for AI, AO: C, kPa, Amp Volt. For DI, DO: OFF, ON).
  - .6 Column 6: Access level: Defines the level of access for varying complexity of functions. Usually associated with password feature. Usually assigned value between 0 (lowest) and 4 (highest).
  - .7 Column 7: Sensor type: describes in 2 or 3words.

.8 Column 8: Assoc. Point: Identifies/ describes points for purposes of alarm suppression, software interlocks.
.9 Column 9: Type: defines the type of alarm (eg. CR = CRITICAL, CA = CAUTIONARY, M = MAINTENANCE).
.10 Column 10: DI/DO, NO/NC: defines the NORMAL condition of alarm. (NC = NORMALLY CLOSED. NO = NORMALLY OPEN).
.11 Column 11: Limits: Defines alarm levels (eg. L2 = Low alarm, Level2. H1 = High alarm, Level1).
.12 Column 12: Alarm Mess: Defines alarm message number. This number is related to pre-composed message detailing the problem and describing the required action.
.13 Column 13: Maint Mess: defines maintenance message number. This number as related to pre-composed message detailing the problem and describing the required action.
.14 Column 14: Set Point: Defines the design set-point of the control loop.
.15 Column 15: Dead band: defines the range above or below the set-point at which no change in output signal is to occur.
.16 Column 16: Dev alarm limit: defines the limit on deviation of the measured value from the set- point (sometimes also referred to as the "error limit").
.17 Column 17: NC/NO: defines NORMAL condition when de-energized. NC - NORMALLY CLOSED. NO = NORMALLY OPEN. DA/RA: defines the form of action. DA = direct acting. RA = REVERSE ACTING.
.18 Column 18: Contacts: NO/NC: defines NORMAL condition when de-energized. NC = NORMALLY CLOSED. NO = NORMALLY OPEN.
.19 Column 19: Delay Succ starts: defines the time limits (usually in seconds). To prevent overheating of motors or equipment from frequent re-starting.
.20 Column 20: Heavy motor delay: defines the time (usually up to 60seconds). To prevent heavy electrical load from simultaneous starting of large consumption equipment.
.21 Column 21: auto-reset: A = AUTOMATIC. M = MANUAL.
.22 Column 22: Programs:
    .1 Examples of Applications Programs include: Night set-back; optimum start/stop; demand limiting (load shedding).
    .2 Optimization routines (eg. chiller optimization, supply air temperature optimization, enthalpy control) should be described as part of CDL's.
    .3 Parameters for all application programs should be provided separately as part of the design

documentation (eg. the Systems Operation Manual).

.4 Note requirements for computer totalization, recording, print- out of accumulated value of a point over a period of time. If totalization depends upon a number of analog points, include for pseudo energy points.

.5 Run time totals: for calculation of operation of digital points.

.6 Optimum start/stop: Example: HVAC unit to start before scheduled occupancy, based upon HVAC unit capacity, heat loss, interior and exterior environmental conditions, etc.

Schedule:
INPUT/OUTPUT
PROJECT NO.
PROJECT NAME
POINT IDENTIFICATION

1	2	3	4	5	6	7	8	9	10	11
Point No.	Point Label	Descrip	Type	Eng Unit	Access Level	Sensor Type	Assoc Point	Type M,MCR	DI/DO NO/NC	Limits
12	13	14	15	16	17	18	19	20	21	22
Alarm Limit	Maint	Set-Point MO/MA	Dead band start	Dev alarm Delay	NO/NC DA/RA	Cont's NO/NC	Delay succ	Heavy motor	Auto reset	Prog

1.04 SEQUENCING OF OPERATION

.1 Refer to the Drawings.

END OF SECTION