

1 General

1.1 RELATED SECTIONS

- .1 Section 01 91 13 – General Commissioning (Cx) Requirements.
- .2 Section 21 05 01 – Common Work Results – Mechanical.

1.2 SUBMITTALS

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures and 25 05 02 - EMCS: Submittals and Review Process.
- .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 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 - Closeout Submittals.
 - .4 Recommend additional changes and/or modifications deemed advisable in order to improve performance, environmental conditions or energy consumption.

1.3 DESIGN REQUIREMENTS

- .1 Confirm with Departmental Representative that Design Criteria and Design Intent are still applicable.
- .2 Commissioning personnel to be fully aware of and qualified to interpret Design Criteria and Design Intent.

1.4 COMMISSIONING

- .1 Do commissioning in accordance with Section 01 91 13 - General Commissioning (Cx) Requirements.
- .2 Carry out commissioning under direction of Departmental Representative. Provide Departmental Representative advance notice of commissioning and opportunity to witness it.
- .3 Correct deficiencies, re-test to requirements of Departmental Representative.
- .4 Acceptance of tests will not relieve Contractor from responsibility for ensuring that complete systems meet every requirement of Contract.
- .5 Load system with project software.
- .6 Departmental Representative reserves right to test system to verify operation.

1.5 COMPLETION OF COMMISSIONING

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

1.6 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

2.1 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 2 months prior to tests.

3 Execution

3.1 PROCEDURES

- .1 Test each system independently and then in unison with other related systems.
- .2 Commission each system and integrated systems using procedures prescribed by the Departmental Representative.
- .3 Debug system software.
- .4 Optimize operation and performance of systems by fine-tuning PID values and modifying CDLs as required.
- .5 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.

3.2 FIELD QUALITY CONTROL

- .1 Pre-Installation Testing.
 - .1 General: consists of field tests of equipment just prior to installation.
 - .2 Testing to be on site unless prior permission received from Departmental Representative.

- .3 Configure major components to be tested in same architecture as designed system. Include BECC equipment and 2 sets of Building Controller's including MCU's, LCU's, and TCU's.
 - .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 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 and to BECC.
 - .7 After setting, test zero and span in 10 % increments through entire range while both increasing and decreasing pressure.
 - .8 Transmitters above 0.5 % error will be rejected.
 - .9 DP switches to open and close within 2% of setpoint.
- .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.
 - .3 Final Startup Testing: Upon satisfactory completion of tests, perform point-by-point test of entire system. Provide:
 - .1 Technical personnel capable of re-calibrating field hardware and modifying software.
 - .2 Commissioning to commence during final startup testing.
 - .3 O&M personnel may assist in commissioning procedures as part of training.
 - .4 Commission systems considered as life safety systems before affected parts of the facility are occupied.
 - .5 Operate systems as long as necessary to commission entire project.

- .6 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 thirty (30) day test demonstrate that operating parameters (setpoints, 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 thirty (30) consecutive twenty four (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 The Departmental Representative reserves the right to verify reported results.

3.3 ADJUSTING

- .1 Final adjusting: upon completion of commissioning set and lock devices in final position and permanently mark settings.

3.4 DEMONSTRATION

- .1 Demonstrate to the 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 Section 01 79 00 - Demonstration and Training.

END OF SECTION

1 General

1.1 REFERENCED SECTIONS

- .1 Section 21 05 01 - Common Work Results – Mechanical.
- .2 Section 25 05 01 - EMCS: General Requirements.
- .3 Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

1.2 REFERENCES

- .1 Not Used.

1.3 SUBMITTALS

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures and this section.
- .2 Submit preliminary design document within 5 working days after tender closing and before contract award, for review by Departmental Representative.
- .3 Shop Drawings to consist of three (3) hard copies and 1 soft copy of design documents, shop drawings, product data and software.
- .4 Hard copy to be completely indexed and coordinated 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 *.pdf format, structured using menu format for easy loading and retrieval on OWS.

1.4 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.

1.5 PRELIMINARY SHOP DRAWING REVIEW

- .1 Submit preliminary shop drawings within 30 working days of award of contract and include 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, 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 centre, 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.

1.6 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 Setpoints, 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 system 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 and 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.

1.7 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 programmer to attend meeting.
- .3 Departmental Representative retains right to revise sequence or subsequent CDL prior to software finalization without additional costs.

2 Products

2.1 NOT USED

- .1 Not Used.

3 Execution

3.1 NOT USED

.1 Not Used.

END OF SECTION

1 General

1.1 RELATED SECTIONS

- .1 Section.21 05 01 - Common Work Results – Mechanical

1.2 SUBMITTALS

- .1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures and 25 05 02 - EMCS: Submittal and Review Process.
- .2 Record Documents to be in in English.
- .3 Provide soft copies and hard copies in hard-back, 50 mm 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.

1.3 AS-BUILTS

- .1 Provide 1 copy of detailed shop drawings generated 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 Departmental Representative.
- .3 Provide before acceptance three (3) hard and one (1) electronic copies incorporating changes made during final review.

1.4 O&M MANUALS

- .1 Custom design O&M Manuals (both hard and electronic 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 three (3) hard and one (1) electronic 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 Specific functions of design philosophy and system.
 - .3 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.
 - .4 Explicit description of hardware and software functions, interfaces and requirements for components in functions and operating modes.
 - .5 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 Operation of computer peripherals, input and output formats.
 - .2 Emergency, alarm and failure recovery.
 - .3 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.
 - .4 General and specific instructions for the maintenance and operation of automatic and adjustable controls.
 - .5 Seasonal settings and changeovers.
 - .6 Document the limits of adjustment of manual controls.
- .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's, 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, and fully commented source listing of applicable driver/handler.
- .10 Preventative Maintenance (PM) Schedule.

2 Products

2.1 NOT USED

- .1 Not Used.

3 Execution

3.1 NOT USED

- .1 Not Used.

END OF SECTION

1 General

1.1 REFERENCES

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

1.2 SUBMITTALS

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

2 Products

2.1 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.
- .2 Sizes: 25 x 67 mm minimum.
- .3 Lettering: minimum 7 mm high, black.
- .4 Inscriptions: machine engraved to identify function.

2.2 NAMEPLATES FOR FIELD DEVICES

- .1 Identify by plastic encased cards attached by plastic tie.
- .2 Sizes: 50 x 100 mm minimum.
- .3 Lettering: minimum 5 mm high produced from laser printer in black.
- .4 Data to include: point name and point address.
- .5 Companion cabinet: identify interior components using plastic enclosed cards with point name and point address.

2.3 NAMEPLATES FOR ROOM SENSORS

- .1 Room sensors to have no manufacturers label on them.

2.4 ABOVE CEILING EQUIPMENT IDENTIFICATION

- .1 Where control devices (valves, dampers, panels, relays, junction boxes, etc) are installed above accessible ceilings, adhesive red / white discs shall be installed on the ceiling spline or access door frame directly below the device(s). Red discs shall be 19 mm diameter, white disc to be 6 mm diameter. In no case shall a device be installed in a ceiling space that is not considered accessible.

3 Execution

3.1 NAMEPLATES AND LABELS

- .1 Ensure that manufacturer's nameplates, CSA labels and identification nameplates are visible and legible at all times.
- .2 Install labels to manufacturer's instructions unless noted otherwise in this specification.
- .3 Lamicoid identification to be mechanically fastened to equipment with screws or chains.
- .4 Identification to be in both English and French.

3.2 EXISTING PANELS

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

END OF SECTION

1 General

1.1 RELATED SECTIONS

- .1 Section 21 05 01 – Common Work Results - Mechanical.
- .2 Section 25 05 02 – EMCS Submittals and Review Process
- .3 Section 25 05 54 – EMCS: Identification.
- .4 Section 26 05 01 – Common Work Results - Electrical
- .5 Section 26 05 20 – Wire and Box Connectors 0-1000 V
- .6 Section 26 05 21 – Wires and Cables (0-1000 V)

1.2 REFERENCES

- .1 American National Standards Institute (ANSI).
 - .1 ANSI C12.7, Requirements for Watt-hour Meter Sockets.
 - .2 ANSI/IEEE C57.13, Standard Requirements for Instrument Transformers.
- .2 American Society for Testing and Materials International, (ASTM).
 - .1 ASTM B148, Standard Specification for Aluminum-Bronze Sand Castings.
- .3 National Electrical Manufacturer's Association (NEMA).
 - .1 NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- .4 Air Movement and Control Association, Inc. (AMCA).
 - .1 AMCA Standard 500-D, Laboratory Method of Testing Dampers for Rating.
- .5 Canadian Standards Association (CSA International).
 - .1 CSA-C22.1-2012, Canadian Electrical Code, Safety Standard for Electrical Installations.

1.3 SUBMITTALS

- .1 Submit shop drawings and manufacturer's installation instructions in accordance with Section 01 33 00 - Submittal Procedures, Section 21 05 01 – Common Work Results, Mechanical, and Section 25 05 02 – EMCS Submittals and Review Process.

1.4 ACCEPTABLE CONTROLS CONTRACTOR

- .1 Controls & Equipment Ltd.

2 Products

2.1 GENERAL

- .1 Control devices of each category to be of same type and manufacturer.
- .2 Operating conditions: -10 – 44 degrees C with 10 - 90 % RH (non-condensing) unless otherwise specified.

- .3 Terminations: use standard conduit box with slot screwdriver compression connector block unless otherwise specified.
- .4 Transmitters and sensors to be unaffected by external transmitters including walkie talkies.
- .5 Account for hysteresis, relaxation time, maximum and minimum limits in applications of sensors and controls.
- .6 Devices installed in user occupied space not exceed Noise Criteria (NC) of 35. Noise generated by any device must not be detectable above space ambient conditions.
- .7 Cutting and Patching: Restore work areas and existing works outside areas of demolition to match condition of adjacent, undisturbed areas.

2.2 SOLID STATE RELAYS

- .1 General:
 - .1 Relays to be socket or rail mounted.
 - .2 Relays to have LED Indicator
 - .3 Input and output Barrier Strips to accept 14 to 28 AWG wire.
 - .4 Operating temperature range to be -20 degrees C to 70 degrees C.
 - .5 Relays to be CSA Certified.
 - .6 Input/output Isolation Voltage to be 4000 VAC at 25 degrees C for 1 second maximum duration.
 - .7 Operational frequency range, 45 to 65 HZ.
- .2 Input:
 - .1 Control voltage, 3 to 32 VDC.
 - .2 Drop out voltage, 1.2 VDC.
 - .3 Maximum input current to match AO (Analog Output) board.
- .3 Output.
 - .1 AC or DC Output Model to suit application.

2.3 TEMPERATURE SENSORS

- .1 General: except for heat pump control to be resistance or thermocouple type to following requirements:
 - .1 Thermocouples: to be limited to temperature range of 200°C and over.
 - .2 RTD's: 100 ohm at 0°C (plus or minus 0.2 ohms) platinum element with strain minimizing construction, 3 integral anchored leadwires. Co-efficient of resistivity: 0.00385 ohms/ohm°C.
 - .3 Sensing element: hermetically sealed.
 - .4 Stem and tip construction: copper or type 304 stainless steel.
 - .5 Time constant response: less than 3 seconds to temperature change of 10°C.
 - .6 Immersion wells: NPS 3/4, (brass) or stainless steel spring loaded construction, with heat transfer compound compatible with sensor and

ABS housing with conduit entrance. Insertion length as required, min.
20% of pipe diameter complete with 6.25mm s.s. probe.

- .2 Sensors:
 - .1 Room type: wall mounting 1500mm above the finished floor, in slotted type covers having brushed stainless steel finish, with guard (where indicated). Element 10-50 mm long with ceramic tube or equivalent protection. Accuracy shall be 0.5°C. Wall mounted box (100 x 50mm) by Division 16.
 - .2 General purpose duct type: suitable for insertion into ducts at any angle, insertion length 460 mm or as indicated to suit duct dimensions.
 - .1 0.25" stainless steel probe of length between one-third and two-thirds of the duct width.
 - .2 Thermistor or RTD compatible with BMS, sealed in probe with three part moisture protection system.
 - .3 BMS shall report the monitored temperature with an accuracy of 0.5°C.
 - .4 Duct mounted ABS plenum rated housing with conduit entrance.
 - .3 Averaging duct type: continuous filament with minimum immersion length 6.10 m Bend probe at field installation time to 100mm radius at any point along probe without degradation of performance.
 - .1 Probe length of 3.66m minimum or 3.25 m per m² 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 shall report the monitored temperature with an accuracy of 1.0°C.
 - .5 Duct mounted ABS plenum rated housing with conduit entrance.
 - .6 Suitable supports at all bends and at intermediate points to prevent movement in the air systems.

2.4 DIFFERENTIAL PRESSURE SENSORS - INTEGRAL WITH TERMINAL UNIT CONTROLLERS

- .1 Provide as part of the terminal unit controller, a differential pressure transducer for the monitoring of the terminal unit air flow rate. The differential pressure transducer shall meet, at minimum, the following requirements:
 - .1 If shall monitor the differential pressures generated by a multi-point averaging device, such as a cross flow sensor located in the primary air duct or at the discharge of the terminal unit. The terminal unit manufacturer shall provide the multi-point averaging sensors. Co-ordinate with the terminal unit manufacturer for range of pressure differential.
 - .2 The pressure differential transducers shall be a compatible component of the terminal unit unitary controller (or supplied by the BMS Contractor). The terminal unit manufacturer as part of the factory installation shall provide tubing from these sensors to the multi-point averaging devices.
 - .3 The differential pressure sensor shall be mounted in the terminal unit enclosure or on the terminal unit, depending on space availability. The differential transducer shall monitor the flow rates with an accuracy of $\pm 5\%$ in the flow range of 100 to 1000 metres per minute.
 - .4 Provide a one-micron filter on the pressure differential sensor if it monitors a moving air stream.

- .5 The output from the differential pressure transducer shall be compatible with the unitary controller. The unitary controller must convert the analog signal using the square root extraction formula to output the velocity.

2.5 CONTROL VALVES

- .1 Size, flow characteristic and factor (Cv) to match existing.
- .2 Leakage rate ANSI class IV, 0.01% of full open valve capacity.
- .3 Packing easily replaceable.
- .4 Stem, Type 316 stainless steel.
- .5 Plug and seat: brass unless noted otherwise.
- .6 Disc, replaceable, material to suit application.
- .7 Minimum shut-off pressure equals maximum circulating pump shut-off pressure.
- .8 NPS 2 and under:
 - .1 Screwed National Pipe Thread (NPT) tapered female connections.
 - .2 Valves to ANSI Class 250, valves to bear ANSI mark.
 - .3 Rangeability 50:1 minimum.

2.6 Control Valves with Electronic Actuators

- .1 Body to be two-way as indicated on the drawings or required for application.
- .2 Screwed body style to be available in 125# or 250# class as required for hot water. Material to be bronze.
- .3 Action: normally open for fail-safe.
- .4 Globe type valve body materials to include replaceable EMPT disc, bronze seat, stainless steel stem, and multiple EMPT V-ring packing. Ports are to be female NPT.
- .5 Operating temperature to 250°F.
- .6 Actuator to be powered with 24V AC controlled from two-position, proportional control signal (0-10V AC), 4-20 ma) or tri-state.
- .7 Actuator must be UL listed, CSA certified.
- .8 Manual crank for opening and manually positioning valve for service. Must lock actuator in place at any position. Position indication readable from ten feet away.
- .9 NEMA 2 housing. Ambient temperature ratings -30°C to 50°C.

2.7 WIRING

- .1 In accordance with CSA-C22.1-2012, Canadian Electrical Code, Safety Standard for Electrical Installations.
- .2 Wiring must be continuous without joints.
- .3 Sizes:
 - .1 Field wiring to digital device: #18 AWG copper, 105°C, 300V.
 - .2 Analog input and output: shielded #18 minimum copper, 105°C, 300V.

3 Execution

3.1 INSTALLATION

- .1 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.
- .2 Install field control devices in accordance with manufacturers recommended methods, procedures and instructions.
- .3 Controllers, valves, and relays: install in NEMA I enclosure or as required for specific applications. Provide for electrolytic isolation in cases when dissimilar metals make contact.
- .4 Support field-mounted panels, transmitters and sensors on pipe stands or channel brackets.
- .5 Fire stopping: provide space for fire stopping in accordance with Section 07 84 00 – Fire-stopping. Maintain fire rating integrity.
- .6 Electrical:
 - .1 CSA-C22.1-2012, Canadian Electrical Code, Safety Standard for Electrical Installations.
 - .2 Refer to control schematics included as part of control design on drawings. Trace existing control wiring installation and provide updated wiring schematics including additions, deletions to control circuits for review by the Departmental Representative before beginning Work.
 - .3 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.
 - .4 Install all wiring in EMT conduit: Make final connection to field devices using flexible metal conduit. Install conduit in accordance with CEC 12-1999 through 12-1014 and 12-1400 through 12-1410.
 - .1 Provide complete conduit system to link Building Controllers, field panels and OWS(s).
 - .2 Maximum conduit fill not to exceed 40%.
 - .3 Design drawings do not show conduit layout.
 - .5 Communications wiring to be in separate EMT.

- .6 Do not run exposed conduits in normally occupied spaces unless otherwise indicated or unless impossible to do otherwise. Departmental Representative to review before starting Work..
- .7 Repair surfaces damaged during execution of Work.
- .8 Turn over to Departmental Representative existing materials removed from Work not identified for re-use.

3.2 PANELS

- .1 Arrange for conduit and tubing entry from top, bottom or either side.
- .2 Wiring and tubing within panels: locate in trays or individually clipped to back of panel.
- .3 Identify wiring and conduit clearly.

3.3 IDENTIFICATION

- .1 Identify field devices in accordance with Section 25 05 54 - EMCS: Identification.

3.4 TESTING AND COMMISSIONING

- .1 Calibrate and test field devices for accuracy and performance in accordance with Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

END OF SECTION