PART 1 - GENERAL

1.1 GENERAL

.1 The "provide" in this Division shall be interpreted as "supply, install, and connect".

.2 Energy Monitoring and Control System (BAS) shall include Direct Digital Control (DDC) of mechanical systems as specified for this project.

.3 Building Automation System (BAS) shall include the BAS as specified for this project.

1.2 DESCRIPTION OF SYSTEM

.1 Extend the existing Networked DDC Control System to meet the requirements specified for this project. The new and extended DDC products and services shall be fully compatible with the existing ~~TAC (Andover) Controls system~~ **Johnson Controls Metasys system.**

.2 **Existing Account Contact:**

Iain Hill
Account Executive
Johnson Controls Canada LP
CELL: 647-688-0702

.3 The extended Control System shall consist of but is not limited to the following:

.1 Laboratory Airflow Control System (LAFCS) as specified;

.2 Software required to implement a complete and operational system.

.3 Input and output control devices including sensors, actuators, conduit and wiring, as required to provide the operations specified.

1.3 QUALITY ASSURANCE

.1 The System Manufacturer shall match base building Building Automation System (BAS).

.2 The System Manufacturer must have maintained a local office within 400 kilometers of job site for at least 5 years with technical staff to provide technical information, routine and emergency maintenance on the system and all system components, and to provide training instructions to O&M staff.

.3 The System Manufacturer must have proven record of successful experience on projects of similar type and size.

.4 Submit the following information for review by Departmental Representative:

.1 Location of local office.

.2 Names and phone numbers of technical staff.

.3 Specification sheets for Master Control Units, Local Control Units and Terminal Control Units.

.4 Data communication network performance information including network protocols to be used, data rate, maximum number of nodes per Local Area Network (LAN).

1.4 CO-ORDINATION

.1 Co-ordinate work with Mechanical and Electrical Trades. Unless noted otherwise, provide all interface devices, control wiring, and controls as required to provide the control operation specified.

.2 Unless noted in Division 26, provide line voltage and low voltage control wiring for equipment specified in Division 25. Refer to Division 26 for power wiring, starters, disconnect switches, etc., to be provided for mechanical equipment.

.3 Provide all necessary power and dedicated circuits as required from local 120 volt branch circuits panel board for all Master Control Units. Install tamper locks on breakers of circuit panel.

.4 Unless noted otherwise, provide all other installation work required for the complete installation of BAS, including all interface devices, control and power wiring, controls and controlled devices.

1.5 LOCKABLE PANELS

.1 Provide lockable panels with key lock handle operators and hinged doors.

.2 Panels located in climate controlled environments to be NEMA 2 or 12 rating. Panels located in non-climate controlled environments to be NEMA 3R or 4 rating. Panels exposed to corrosive environments to be NEMA 4X rating.

.3 Equip all panels for Master Control Units with standard keyed-alike cabinet locks, keyed to same key.

1.6 NAMEPLATES

.1 Provide nameplates on all control items listed or shown in the submittal and approved control diagrams.

.2 Identify all panels and items mounted on panel face by laminated plastic nameplates 3 mm thick. Lettering shall be accurately aligned and engraved into the white core. Size of nameplates shall be 20 mm by 100 mm minimum. Lettering shall be minimum 5 mm high normal black lettering.

.3 Identify field sensors and controlled devices by plastic encased cards attached to the device by chain.

.4 Warning signage: provide each motor starter under remote automatic control (DO point on I/O Point Schedules) with signage warning of automatic starting under control of BAS. (i.e. "Caution - this equipment is under automatic remote control of BAS").

1.7 SHOP DRAWINGS

.1 Submit shop drawings and product data in accordance with Section 23 05 00. Submit control shop drawings within 15 days of Award of Contract.

.2 Shop drawings shall include:

.1 Description of software programs included.

.2 Specification sheets for each piece of equipment or control devices to be provided.

.3 Equipment and DDC Controllers location drawings.

.4 Mechanical control schematics.

.5 Sequence of operation for each mechanical system.

.6 DDC control point schedules.

1.8 INSTALLATION AND COMPLETION TESTS

.1 Installation and Calibration:

.1 Set control points and calibrate sensors immediately after installing controls.

.2 Completion Tests:

.1 After installation of each part of the system and completion of mechanical and electrical hood-up, perform tests to confirm correct installation and operation of equipment.

.2 Check and calibrate each AI using a calibrated digital thermometer, humidistat, velometer or transducer.

.3 Check each DI to insure proper settings and switching contacts.

.4 Check each AO to insure proper operation of valves and dampers. Verify tight closing, input and output signals.

.5 Check each DO to insure proper operation and lag time.

.6 Check all operating software.

.7 Check all application software. Provide samples of all logs and commands.

.8 Debug all software.

.9 Fine tuning and adjusting all control devices and make modifications as required to provide a fully operational BAS.

.10 Submit test report with checklist showing all input/output control points and all software programs.

.3 All reported results are subject to verification by the Departmental Representative.

1.9 SYSTEM STARTUP VERIFICATION TESTING

.1 Provide technical personnel and instrumentation to conduct startup verification and testing.

.2 Verification:

.1 Perform point-by-point verification of entire system.

.2 Verify the calibration of all AI devices individually.

.3 Verify the calibration of all DI devices individually.

.4 Verify all AO devices are functional, start and span are correct, direction and normal positions are correct.

.5 Verify that all DO devices operate properly and that the normal positions are correct.

.6 Verify the system sequences of operation. Simulate all modes of operation.

.7 Verify the stability of all DDC loops and optimum start/stop routines.

.8 Check each alarm separately.

.9 Verify interlocks and conditional control response.

.10 Simulate alarm conditions to check the initiating value of variable and interlock action.

.3 Complete and submit System Startup Verification Forms. Each item on the verification forms shall be signed off as verified (yes), or not verified (no) and actual date of verification. Forms to be signed by testing technician.

1.10 OPERATION AND MAINTENANCE MANUAL

.1 The manual shall be custom designed for this project and contain only information relevant to this project.

.2 The manual shall provide full and complete coverage of the following subjects:

.1 Operational Requirements: This document shall describe, in concise English terms, all the functional and operational requirements for the system and its functions that have been implemented.

.2 System Operation: Complete step by step procedures for operation of the system, including required actions at each operator station; operation of computer peripherals; input and output formats; and emergency, alarm, and failure recovery. Step-by-step instructions for system startup, back-up equipment operation, and execution of all system functions and operating modes shall be provided.

.3 Maintenance: Documentation of all maintenance procedures for each and all system component including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective module.

.4 Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as Test Procedures. A provision for the measurement or observation of results, based on the previously published Test Specification, forms the Test Reports.

.5 Configuration Control: Documentation of the basic system design and configuration with provisions and procedures for planning, implementing, and recording any hardware or software modifications required during the installation, test, and operating lifetime of the system.

1.11 TRAINING

.1 Provide the services of competent instructors who will provide instruction to designated personnel in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system specified. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach.

1.12 WARRANTY AND MAINTENANCE

.1 Provide all services; materials and equipment necessary for the maintenance of the Automatic Control Systems for a period of 12 months concurrent with the warranty period.

.2 Provide three minor inspections or as required by the manufacturer and one major inspection per year, and all service for the required maintenance. Major inspection shall be scheduled in April or November. A major inspection shall involve a point by point check and/or calibration. Provide dated database log to indicate executed point to point system check.

.3 Emergency Service: Departmental Representative will initiate service calls when there is indication that the Automatic Control System is not functioning properly. Provide qualified personnel available during the contract period to provide service to the "critical" overall control system components whenever required at no additional cost Contract. Furnish the Departmental Representative with a telephone number where the service personnel can be reached at all times. The service technician shall be on the job ready to service the control system within 4 hours after receiving a request for service. The work shall be performed continuously until the control system is back in reliable operating condition. This service shall be provided on a 24 hours basis 7 days a week.

.4 Upon completion of each inspection or emergency service, submit fully detailed report in writing to Departmental Representative.

PART 2 - PRODUCTS

2.1 BAS DATA COMMUNICATION NETWORK

.1 The Control Manufacturer shall design, supply, install and connect a data communication network to link all Terminal Control Units, Local Control Units, Master Control Units, and Operator Workstation.

.2 Local (field) Control Units (LCUs): Stand-alone such as: LAFCS, LCM and HPFC fully user programmable DDC Controllers that reside on BAS-BUS.

2.2 OWS SOFTWARE

.1 Provide to existing OWS, the software programs recommended by system manufacturer to update existing software, to permit command entry, information management, alarm management and database management functions for the new laboratory airflow

control system, Laboratory Air Contaminant Concentration System and High Plume Exhaust Fan System.

.2 Workstation operating system shall be multitasking and Windows 10 based.

.3 Workstation software shall include but not be limited to the following functions:

.1 Operator's commands and programming.

.2 Access control.

.3 Graphics software.

.4 Alarm management.

.5 Reports and logs.

.6 Database back-up and download.

.4 Refer to the specification for additional requirements of each function.

2.3 OPERATOR'S COMMANDS AND PROGRAMMING

.1 Provide software to enable non-programmer operator to perform global supervision tasks such as to view, and edit if applicable, the status of any object and property in the system.

.2 Operator shall be able to terminate automatic software control, initiate DO and AO manual commands, and return DO and AO manual commands to automatic software controls.

.3 Provide programming software at OWS to allow operator to create, edit, and download custom application programs to support MCUs and LCUs. On-line programming/configuration shall not interfere with normal system operation and control.

2.4 ACCESS CONTROL

.1 A minimum of 4 levels of access shall be supported:

.1 Level 0 No Password = Data Access and Display.

.2 Level 1 = Operator Overrides.

.3 Level 2 = Level 1 + Database Modification and Generation.

.4 Level 3 = Level 3 + Password Assignment: Addition / Modification.

.2 User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line. Default setting shall be 3 minutes.

2.5 GRAPHICS SOFTWARE

.1 Provide OWS with upgraded graphics software necessary to permit the operator to create, modify, delete, file, and recall all graphics. Operators shall be able to start and stop equipment or change set points from graphical displays.

.2 Utilize the graphics software to generate the custom Building Outline Drawings, Equipment and Sensors Location Diagrams, and Control Schematic Diagrams for this project.

.3 Operator shall be able to build graphic displays that include on-line point data from multiple MCU panels. Data shall be updated every 10 seconds or less.

.4 Windowing: the windowing environment of the OWS shall allow the user to simultaneously view several graphics at the same time.

2.6 ALARM MANAGEMENT

.1 Provide the software to notify the operator of the occurrence of an alarm condition. All alarm messages shall be displayed and printed. Alarm messages shall include as a minimum: location of alarm, time of occurrence, and type of alarm. Each point shall have its own message. Assignment of messages to a point shall be an operator editable function.

2.7 LAB CONTROL SYSTEM SPECIFICATION

.1 Refer to Section 25 50 00.

2.8 TEMPERATURE SENSORS AND TRANSMITTERS

.1 General: temperature sensors shall be RTD platinum type, unless otherwise noted.

.2 Temperature sensors shall be of the following types:

.1 Space RTD - suitable for wall mounting, with protective guard.

.2 Duct point RTD - suitable for insertion into air ducts at any angle, insertion length of 460 mm unless otherwise as noted on schedule or drawings.

.3 Mixed Air Averaging RTD: continuous filament with probe length of 6000 mm minimum. Maximum 6 mm cross section area per sensor. Probe to be bent, at field installation time, to a minimum radius of 100 mm at any point along the probe length without degradation in performance.

.3 Provide each sensor with a temperature transmitter having the following minimum specifications:

.1 Output signal of 4-20 mA into maximum of 500 ohm load.

.2 Combined nonlinearity, repeatability and hysteresis effects not to exceed ±0.5% of full scale output.

.3 Integral, zero and span adjustments.

.4 Temperature effect of ±1.0% full scale or less.

.4 Range of sensors to suit application and to be submitted with shop drawings.

2.9 HUMIDITY SENSORS AND TRANSMITTERS

.1 .Provide humidity sensors with the following minimum specifications:

.1 Operating range: 10-90% RH.

.2 Operating temperature: 0°C to 60°C.

.3 Accuracy: ±2% RH at 25°C.

.4 Response time: 60 seconds from 90% to 10% RH.

.2 Provide transmitters for all supplied relative humidity sensors with the following minimum specifications:

.1 Output signal of 4-20 mA or 0 to 10 VDC.

.2 Maximum output linearity error of ±1.0% of full scale output.

.3 Integral zero and span adjustments.

.4 Temperature effect of ±1.0% full scale or less.

.5 Drift: not to exceed 1% over 12 months.

2.10 AIR SYSTEM STATIC PRESSURE SENSORS AND TRANSMITTERS

.1 Sensors shall meet the following:

.1 Multipoint element with self-averaging manifold.

.2 Maximum pressure loss: 160 Pa at 10 m/s. (air stream manifold).

.3 Accuracy: ±1% of actual duct static pressure.

.2 Provide each sensor with a transmitter to meet the following requirements:

.1 Output signal: 4 - 20 mA linear into 500 ohm maximum load.

.2 Calibrated span: not to exceed 150% of duct static pressure at maximum flow.

.3 Accuracy: ±1.0% of full scale.

.4 Repeatability: within 0.5% of output.

.5 Linearity: within 1.5% of span.

.6 Deadband or hysteresis: 0.1% of span.

.7 External exposed zero and span adjustment.

.8 Range: 0 to 125 Pa static pressure downstream of VAV boxes and 0 to 373 Pa static pressure upsteam of VAV boxes, unless otherwise noted.

2.11 AIR SYSTEM VELOCITY SENSOR/TRANSMITTER

.1 Sensors shall meet the following requirements:

.1 Multipoint static and total pressure sensing element with self-averaging manifold, and with integral air equalizer and straightener section.

.2 Maximum pressure loss: 37 Pa at 10 m/s.

.3 Accuracy: +1% of actual duct velocity.

.2 Provide each sensor with a transmitter to meet the following requirements:

.1 Output signal: 4 - 20 mA or 0 - 10VDC linear into 500 ohm maximum load.

.2 Calibrated span: not to exceed 25% of duct static pressure at maximum flow.

.3 Accuracy: ±0.4% of span.

.4 Repeatability: within 0.1% of output.

.5 Linearity: within 0.5% of span.

.6 Deadband or hysteresis: 0.1% of span.

.7 External exposed zero and span adjustment.

.8 Air velocity range: 1 m/s to 10 m/s at 15°C.

2.12 PRESSURE/CURRENT TRANSMITTERS

.1 Provide pressure-to-current transmitters having the following minimum specifications:

.1 Internal materials of the transducer suitable for continuous contact with industrial standard instrument air, compressed air, water or steam as applicable.

.2 Output signal of 4-20 mA into a maximum of 500 ohm load.

.3 Output variations of less than 0.2% full scale for supply voltage variations of ±10%.

.4 Combined nonlinearity, repeatability and hysteresis effects not to exceed ±0.5% of full scale output over entire range.

.5 Integral zero and span adjustment.

.6 Temperature effect of ±1.5% full scale/50°C or less.

.7 Output short circuit and open circuit protection.

.8 Over-pressure input protection to a minimum of twice rated input.

.9 Pressure ranges to suit application.

2.13 DIFFERENTIAL PRESSURE TRANSMITTERS

.1 Provide differential pressure transmitters having the following minimum specifications:

.1 Internal materials to be suitable for continuous contact with the process material measured including compressed air, water, glycol, or steam as applicable.

.2 Output signal of 4-20 mA into maximum of 500 ohm load.

.3 Output variation of less than 0.2% full scale for supply voltage variations of ±10%.

.4 Combined nonlinearity repeatability and hysteresis effects not to exceed ±0.5% of full scale output over entire range.

.5 External exposed integral zero and span adjustment.

.6 Temperature effect of ±1.5% full scale/50°C or less.

.7 Output short circuit and open circuit protection.

.8 Over-pressure input protection to a minimum of twice rated input.

.9 Differential Pressure ranges to suit application.

2.14 PRESSURE SWITCHES

.1 Provide pressure or differential pressure switches for ranges as indicated on point schedule.

.2 Pressure sensing elements shall be bourdon tube, bellows or diaphragm type.

.3 Adjustable setpoint and differential.

.4 Pressure switches shall be snap action type rated at 120 volts, 15 amps AC or 24 volts DC.

.5 Sensor assembly shall operate automatically and reset automatically when condition returns to normal.

2.15 TEMPERATURE SWITCHES

.1 Provide High/Low temperature switches for ranges as indicated on point schedule.

.2 Temperature sensing element shall be liquid, vapour or bimetallic type.

.3 Adjustable setpoint and differential.

.4 Snap action type rated at 120 Volts, 15 amps or 24 V DC as required.

.5 Sensors shall operate automatically and reset automatically. Sensors used for freeze detection or fire detection shall be manually reset type.

.6 Temperature switches shall be of the following types:

.1 General Purpose Duct type - suitable for insertion into air ducts, insertion length of 457 mm.

.2 Thermowell type - with compression fitting for 20 mm NPT well mounting, length of 100 mm. Immersion wells shall be stainless steel.

.3 Freeze detection type - continuous element with insertion length of 6000 mm minimum, suitable for duct mounting to detect the coldest temperature in any 30 mm section.

.7 Temperature accuracy shall be ±1°C.

2.16 CURRENT/PNEUMATIC TRANSDUCERS

.1 Provide current to pneumatic transducers having the following minimum specifications:

.1 Input range of 4-20 mA or 0 to 10 VDC as suitable for interfacing with the FID digital-to-analog converter output subsystem.

.2 Directly proportioned output range of 20-104 kPa.

.3 Dustproof housing or panel mounted.

.4 Internal materials of the converter suitable for continuous contact with industrial standard instrument air.

.5 Combined nonlinearity, repeatability and hysteresis effects not to exceed +2% of full scale over the entire range.

.6 Integral zero and span adjustment.

.7 Temperature effect of +2.0% full scale or less.

.8 Maximum regulated supply pressure of 138 kPa or less.

.9 Provide air gauge on outlet.

.10 Air consumption: 0.008 scfm at 103 KPa supply.

2.17 CONTROL RELAYS

.1 Contacts rated at 5 amps at 120 V AC.

.2 Relays to be plug in type with termination base.

2.18 CURRENT TRANSDUCER

.1 Provide current transducers with range to match load being metered.

.2 Current transducers shall measure line current and produce a proportional signal in one of the following ranges.

.1 4-20 mA dc.

.2 0-1 V dc.

.3 0-10 V dc.

.4 0-20 V dc.

2.19 CURRENT SENSING RELAY

.1 Provide adjustable current-operated solid-state relays with integral zero leakage LED for switching AC or DC circuits.

.2 The contacts shall close when the current level sensed by the internal current transformer exceeds the trip point set by the multi-turn adjustment.

.3 Range of monitored AC current to suit application and to be submitted with shop drawings.

2.20 CONTROL DAMPERS

.1 Construction: Blades shall not exceed 200 mm wide or 1250 mm long. Modular maximum size 1250 mm wide x 1500 mm high. Multiple sections to have stiffening mullions and jack shafts.

.2 Materials:

.1 Frame: 2.3 mm (13 gauge) galvanized sheet steel.

.2 Blades: two sheets 0.5 mm (22 gauge) or 1.6 mm (16 gauge) galvanized steel.

.3 Bearings: oil impregnated sintered bronze. Provide additional thrust bearings for vertical blades.

.4 Linkage and shafts: zinc plated steel.

.5 Seals: Replaceable neoprene seals or stain-less steel spring on sides, top and bottom of frame and along all blade edges and blade ends.

.3 Performance:

.1 50 $L/s/m^2$ maximum allowable leakage against 1000 Pa static pressure.

.2 Temperature range: minus 50°C to 100°C.

2.21 DAMPER OPERATORS ELECTRONIC

.1 Provide direct coupled type electronic proportional damper operators where indicted or required.

.2 Spring return for "fail-safe" in Normally Open or Normally Closed position where required.

.3 Size operators to control dampers against maximum pressure or dynamic closing pressure whichever is greater.

.4 For modulating services, provide feedback circuit to indicate actuator position.

.5 Power Requirements 12 VA maximum at 24 V AC.

.6 Input signal: 2 to 10 VDC or 4 to 20 mA.

2.22 EXISTING CONTROLS

.1 Unless noted otherwise or approved by the Departmental Representative in writing, provide all new control devices required for a complete and working BAS System.

.2 Submit written requests to disconnect any controls and to obtain equipment down time. Only after receiving these requests shall such work be allowed to proceed.

.3 Be responsible for repair costs due negligence or abuse of existing equipment, or failure in reporting defective controls within 30 days of Award of Contract.

.4 Shop drawings shall show all signal levels, pressures, etc., where tying into existing control equipment.

.5 Where existing controls are not to be reused or not required, they shall be removed and placed in storage for future disposition as directed by Departmental Representative.

2.23 CONDUIT AND WIRE

.1 Use type FT6 plenum rated cable for low voltage BAS wiring in ceiling return plenum. Support FT6 cables in ceiling return plenum using cable straps and clamps screwed on to ceiling slab. Spacing to be 2 m maximum. Do not use ceiling suspension wires for fastening cables. Exact routings shall suit site conditions and shall be to the approval of the Departmental Representative.

.2 Use EMT conduit for wiring in mechanical, electrical, janitor rooms or equipment rooms.

.3 Unless noted otherwise, install network cable within building in EMT conduit and install network cable between buildings in buried PVC conduit. Provide conduits with spare capacity not less than 50%.

.4 Field wiring for each digital input and output shall be No. 20 AWG, stranded twisted pair. For multi-conductor wire having four or more conductors, wire size shall be not less than No. 22 AWG solid copper. Analog input shall be wired with shielded No. 20 AWG, stranded twisted pair, copper wire. Analog output shall be wired with 3 shielded No. 20 AWG stranded twisted copper wires.

.5 Where conduits pass through fire rated walls or floors, provide schedule 40 steel sleeves filled with fire stopping material and approved sealant around conduits to maintain fire rating integrity.

2.24 RESPONSIBILITY FOR QUANTITIES

.1 Provide correct lengths or sizes of conduit or correct types of wire or the correct number of DDC panels. No additional charges for these materials is acceptable.

2.25 WIRING IDENTIFICATION

.1 Provide numbered tape markings on all branch control wiring, and pneumatic tubing.

.2 At all junction boxes, splitters, cabinets and outlet boxes, maintain identification system.

.3 Use colour coded wires in communication cables, matched throughout system.

.4 Identify all power sources at each panel location.

2.26 CONDUIT IDENTIFICATION

.1 Colour code all Control System conduits.

.2 Coding to be located on all conduits and cables exposed after completion of construction in all locations including suspended accessible ceilings, tunnels and shafts.

.3 Coding to be plastic tape or paint at all points where conduit or cable enters wall, ceiling, or floor, and at 15000 mm intervals.

.4 Coding to be 25 mm wide, and fluorescent orange. Confirm colour with the Departmental Representative at commencement of the project.

2.27 MANUFACTURER'S AND CSA LABELS

.1 Manufacturers' nameplates and CSA labels to be visible and legible after equipment is installed.

PART 3 - EXECUTION

3.1 GENERAL

.1 All equipment shall be installed in according to manufacturers' published instructions.

.2 Provide programming for the system and adhere to the sequence of operation specified.

.3 Coordinate with work of Division 26 to provide required power feeds to BAS devices.

3.2 BUILDING AUTOMATION SYSTEM (BAS) NETWORK ARCHITECTURE

.1 Building Automation System (BAS) Network Architecture as shown on the Mechanical Drawings.

3.3 DDC INPUT/OUTPUT POINT SCHEDULE

.1 DDC Input/Output Point Schedule, as shown on the Mechanical Drawings.

.2 Naming convention: PWGSC Standardized Identifiers and Expansions of Building Names, System Names and Point Names shall be used for identification. Identifiers shall be not more than 10 alphanumeric characters, and Expansions shall not more than 40 characters.

.3 The Application Programs shall be assigned with the specified DDC points as indicated on the DDC Input/Output Schedule. In addition, the Application Program shall be assigned with the following point types:

.1 Alarm Program with: all space temperature AI points, all supply air temperature AI points, all supply air and return air humidity AI points, all air filter pressure drop AI points, all supply air static pressure AI points, all AI points of heating water supply and return temperature, all AI points of chilled water supply and return temperature, all DI points of fans and pumps.

.2 Auto Start/Stop Program with: all DO points of fans and pumps.

.3 Run Time Total Program with: all DO points.

.4 Heavy Equipment Delay Program with: all DO points of motors of 15 kw and larger.

.5 PID Control Program with: all AO points of control valves (except terminal heating control valves and radiation control valves) and control dampers (except terminal zone control dampers).

.6 Analog/PI Total Program with all AI or PI points of water meters and energy meters.

.4 All DI or DO points assigned with "alarm" and "run time total" programs shall be provided with "critical" and "maintenance" alarms. All AI or AO points assigned with "alarm" program shall be provided with "critical" and "cautionary" alarms.

3.4 INSTALLATION OF SENSORS

.1 Install sensors in accordance with the manufacturer's recommendations.

.2 Sensors used in mixing plenums shall be the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

.3 Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m of cross section area.

.4 All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.

.5 Outdoor air temperature sensors shall be installed on north wall, complete with sun shield at designated location.

.6 Building static pressure sensors: Pipe the low pressure port of the differential air static pressure sensor to the static pressure port located on the outside of the building through a high volume accumulator. Pipe the high pressure port to a location behind a thermostat cover.

.7 Supply duct static pressure sensor: Pipe the high pressure tap of the differential air static pressure sensor to the duct using a pitot tube. Pipe the low pressure port to a tee in the high pressure tap tubing of the corresponding building static pressure sensor.

3.5 INSTALLATION OF ACTUATORS

.1 Install actuators in accordance with the manufacturer's recommendations.

.2 Electronic dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low leakage dampers with seals, the actuator shall be mounted with a minimum 5 degree available for tightening the damper seals.

.3 Electronic Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

END OF SECTION