SECTION 15900 - BUILDING MANAGEMENT SYSTEM AND HVAC EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL

A. The general project scope to provide controls and instrumentation for the HVAC systems:

1. All systems are to be an extension of the existing HACC BMS network.
2. Building level controller to be a Web Based system utilizing BACnet communications at all levels. System Level controls to be distributed DDC utilizing BACnet communication.
3. All control dampers to be provided by the BMS contractor, with the actuators furnished, installed and wired by the BMS contractor.
4. Provide web based graphical displays of all primary and secondary equipment as well as building floor plans showing equipment locations and space condition information.

B. The following is the scope of work for this contractor. With regards to the sequences of operation, the BMS contractor shall:

1. Provide Building Level DDC control system integrated to existing BMS server.
2. Provide Dual Duct VAV boxes with factory mounted controls.

1.2 RELATED DOCUMENTS

A. All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.

B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 15 Sections for details.

C. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.

D. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

1.3 QUALITY ASSURANCE

A. General:

1. The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.
2. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS.
3. No dealers, franchises or other suppliers other that factory owned branch offices of the controls manufacture shall be considered for execution of this project.
4. The BMS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.

1.4 SUBMITTALS

A. Shop Drawings, Product Data, and Samples:

1. The BMS contractor shall submit a list of all shop drawings with submittals dates within 60 days of contract award.
2. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.
3. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS work.
4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
5. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
6. The BMS Contractor shall correct any errors or omissions noted in the first review.
7. At a minimum, submit the following:

    a. Systems schematics, sequences and flow diagrams.
    b. Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
    c. Samples of Graphic Display screen types and associated menus.
    d. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
    e. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
    f. Details of all BMS interfaces and connections to the work of other trades.
    g. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.5 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals:

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:

   a. Table of contents.
   b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
   c. Manufacturers product data sheets or catalog pages for all products including software.
   d. System Operator's manuals.
   e. Archive copy of all site-specific databases and sequences.
   f. BMS network diagrams.
   g. Interfaces to all third-party products and work by other trades.

2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1.6 WARRANTY

A. Standard Material and Labor Warranty:

1. Provide a one-year labor and material warranty on the BMS.
2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.
3. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMS Contractor's normal business hours.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The control system shall be an extension of the existing Johnson Control System.

B. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network

connection shall not interrupt the execution of control strategies at other operational devices.

C. Systems shall utilize wireless communication where applicable for temperature sensing and field controller communication

D. Acceptable Manufacturers

1. Johnson Controls, Metasys Contact Scott Schmittel 717-712-1804

2.2 DDC SYSTEM CONTROLLERS

A. VAV Terminal Unit Controller (VMA):

1. The VMA shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units.
2. The VMA shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.
3. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
4. The VMA shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
5. Each VMA shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
6. The VMA shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
7. Each VMA shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
8. The VMA shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
9. VMA control setpoint changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
10. The VMA firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
11. The VMA shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
12. The VMA shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.

13. The VMA performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.

    a. Absolute temperature loop error.
    b. Signed temperature loop error.
    c. Absolute airflow loop error.
    d. Signed airflow loop error.
    e. Average damper actuator duty cycle.

14. The VMA shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

    a. Unreliable space temperature sensor.
    b. Unreliable differential pressure sensor.
    c. Starved box.
    d. Insufficient cooling.
    e. Insufficient heating.

15. The VMA shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.
16. The VMA shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.
17. The VMA shall be compatible with the U.S. EPA Energy Star Buildings recommendations for fan energy reduction via demand-based static pressure reset down to 2/3 of duct static pressure set point, "VSD 2/3 Reset."
18. Inputs:

    a. Analog inputs shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

        1) 0-10 VDC Sensors
        2) 1000ohm RTDs
        3) NTC Thermistors

    b. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."
    c. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

19. Outputs

    a. Analog outputs shall provide the following control outputs:

        1) 0-10 VDC

    b. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.
    c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.

2.3 FIELD DEVICES

A. Only the input/output devices to comply with the Sequence of Operation shall be utilized.

B. Input/Output Module:

1. The Input/Output Module provides additional inputs and outputs for use in the FEC.
2. The IOM shall communicate with the FEC using BACnet Standard protocol SSPC-135, Clause 9.

C. Networked Thermostat:

1. The Networked Thermostat shall be capable of controlling unitary HVAC system such as variable volume zoning systems.
2. The Networked Thermostat shall communicate using BACnet Standard protocol SSPC-135, Clause 9.

    a. The Networked Thermostat shall support remote read/write and parameter adjustment from the web based User Interfaceable through a Network Automation Engine.

D. Network Sensors:

1. The Network Sensors shall have the ability to monitor the following variables as required by the systems sequence of operations:

    a. Zone Temperature
    b. Zone humidity
    c. Zone setpoint

2. The NS shall transmit the zone information back to the controller using BACnet Standard protocol SSPC-135, Clause 9.
3. The Network Sensors shall include the following items:

    a. A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint.

b. An LED to indicate the status of the Override feature.
c. A button to toggle the temperature display between Fahrenheit and Celsius.
d. A button to initiate a timed override command

E. Many-To-One Wireless Room Temperature Sensor System:

1. The Many-To-One System Receiver (WRS Receiver) shall receive wireless Radio Frequency (RF) signals containing temperature data from multiple Wireless Room Temperature Sensors (WRS Sensors).
2. The WRS Receiver shall be capable of communication with WRS Sensors up to a distance of 200 Feet.
3. The WRS Sensors shall sense and report room temperatures to the WRS Receiver.

a. The WRS sensors shall be available with:

1) Warmer/Cooler Set Point Adjustment
2) No Set Point Adjustment
3) Set Point Adjustment Scale – 55 to 85º F.

b. The WRS sensors shall be assembled in NEMA 1 plastic housings.

2.4 INPUT DEVICES

A. General Requirements

1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.
2. All input device references to be understood as to be "where required to meet the intent of the sequences of operation"

B. Temperature Sensors

1. General Requirements:

a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	**Accuracy**
Room Temp	$\pm$ .5°F.
Duct Temperature	$\pm$ .5°F.
All Others	$\pm$ .75°F.

2. Room Temperature Sensors:

    a. Room sensors shall be constructed for either surface or wall box mounting.
    b. Room sensors shall have the following options when specified on the project plans:

        1) Setpoint reset slide switch providing a ±3 degree (adjustable) range.
        2) Individual heating/cooling setpoint slide switches.
        3) A momentary override request push button for activation of after-hours operation.
        4) Analog thermometer.

3. Room Temperature Sensors with Integral Display:

    a. Room sensors shall be constructed for either surface or wall box mounting.
    b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:

        1) Display room and outside air temperatures.
        2) Display and adjust room comfort setpoint.
        3) Display and adjust fan operation status.
        4) Timed override request push button with LED status for activation of after-hours operation.
        5) Display controller mode.
        6) Password selectable adjustment of setpoint and override modes.

4. Room Temperature and Humidity Sensors with Integral Display:

    a. Room sensors shall be constructed for either surface or wall box mounting.
    b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:

        1) Display room and outside air temperatures.
        2) Display room humidity.
        3) Display and adjust room comfort setpoint.
        4) Display and adjust fan operation status.
        5) Timed override request push button with LED status for activation of after-hours operation.
        6) Display controller mode.
        7) Password selectable adjustment of setpoint and override modes.

C. Differential Pressure Transmitters:

1. General Air and Water Pressure Transmitter Requirements:

    a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
    b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

2. Building Differential Air Pressure Applications (-1" to +1" w.c.):

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

1) -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application).
2) 4-20 mA output.
3) Maintain accuracy up to 20 to 1 ratio turndown.
4) Reference Accuracy: +0.2% of full span.

c. Acceptable Manufacturers: Johnson Controls and Setra.

3. Low Differential Air Pressure Applications (0" to 5" w.c.):

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

1) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
2) 4-20 mA output.
3) Maintain accuracy up to 20 to 1 ratio turndown.
4) Reference Accuracy: +0.2% of full span.

c. Acceptable Manufacturers: Johnson Controls and Setra.

4. Medium Differential Air Pressure Applications (5" to 21" w.c.):

a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:

1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
3) Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).

b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
c. Acceptable manufacturers: Johnson Controls and Setra.

D. Flow Monitoring:

1. Air Flow Monitoring shall be a thermal dispersion or multi-point, self-averaging pitot traverse station with integral air straightener-equalizer honeycomb cell, capable of continuously measuring fan discharges or ducted airflow with a certified accuracy of 2% or better when tested according to AMCA 610.

a. Fan Inlet Air Flow Measuring Stations:

1) Airflow measuring stations shall be manufactured by Air Monitor Corp., Tek-Air Systems, Inc., Ebtron, or Dietrich Standard.

b. Duct Air Flow Measuring Stations:

1) Acceptable manufacturers: Air Monitor Corp., Tek-Air, Ebtron, and Dietrich Standard.

2.5 OUTPUT DEVICES

A. Actuators:

1. General Requirements:

a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque. All damper and valve actuators that control in more than 2 positions (open/closed) shall be fully modulating.
b. Damper and valve actuators shall be electronic as specified in the System Description section.

2. All output device references to be understood as to be "where required to meet the intent of the sequences of operation".

3. Electronic Damper Actuators:

    a. Electronic damper actuators shall be direct shaft mount.
    b. Modulating and two-position actuators shall be provided as required by the sequence of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
    c. Acceptable manufacturers: Johnson Controls, Belimo.

4. Electronic Valve Actuators:

    a. Electronic valve actuators shall be manufactured by the valve manufacturer.
    b. Modulating and two-position actuators shall be provided as required by the sequence of operations.
    c. Acceptable manufacturers: Johnson Controls, Valve Solutions

B. Control Dampers:

1. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the Drawings.
2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.
5. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.
6. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.

C. Control Relays:

1. Control Pilot Relays:

a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
b. Mounting Bases shall be snap-mount.
c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
d. Contacts shall be rated for 10 amps at 120VAC.
e. Relays shall have an integral indicator light and check button.
f. Acceptable manufacturers: Johnson Controls, Lectro.

2.6 MISCELLANEOUS DEVICES

A. Dual Duct Variable Air Volume Boxes:

1. General:

a. Furnish and install Johnson Controls, TDS Series Flow Dual Duct Air Terminals of the sizes and capacities scheduled. Units shall be ETL listed. Terminal units shall be ARI certified and bear the ARI 880 seal.
b. The entire unit shall be designed and built as a single unit. Field-assembled components or built-up terminals employing components from multiple manufacturers are not acceptable.

2. Construction:

a. Terminals shall be constructed of not less than 22 gauge galvanized steel with a minimum G90 zinc coating, able to with-stand a 125 hour salt spray test per ASTM B-117. Stainless steel casings, or galvannealed steel casings with a baked enamel paint finish, may be used as an alternative. The terminal casing shall be mechanically assembled (spot-welded casings are not acceptable).
b. Casing shall be internally lined with 1/2" thick, 4 pound per cubic foot skin, dual density fiberglass insulation, rated for a maximum air velocity of 3600 f.p.m. In addition to using adhesive complying with NFPA 90A, the insulation shall incorporate a secondary mechanical fastener attached to the unit casing wall (clench nail). Adhesive as the only method of fastening the insulation to the casing is not acceptable. Maximum thermal conductivity shall be 0.24. Insulation must meet all requirements of ASTM Standards C1071,(fibrous glass duct lining insulation), G21,(Resistance of synthetic polymers to fungi), UL 181, (materials for the fabrication of air duct and air connector systems) and NFPA 90A, (Installation of air conditioning and ventilating systems). Raw insulation edges on the discharge of the unit must be covered with metal liner to eliminate flaking of insulation during field duct connections. Simple "buttering" of raw edges with an approved sealant is not acceptable.

c. Casing shall have full bottom access to gain access to the primary air valves and fan assembly. The casing shall be constructed in a manner to provide a single rectangular discharge collar. Multiple discharge openings are not acceptable. All appurtenances including control assemblies, control enclosures shall not extend beyond the top or bottom of the unit casing.

3. Sound:

a. The terminal manufacturer shall provide ARI certified sound power data for radiated and discharge sound. The sound levels shall not exceed the octave band sound power levels indicated on the schedule. If the sound data does not meet scheduled criteria, the contractor shall be responsible for the provision and installation of any additional equipment or material necessary to achieve the scheduled sound performance.

4. Hot Deck and Cold Deck Primary Air Valves:

a. The primary air valve shall consist of a minimum 22 gauge cylindrical body that includes embossment rings for rigidity. The damper blade shall be connected to a solid shaft by means of an integral molded sleeve which does not require screw or bolt fasteners. The shaft shall be manufactured of a low thermal conducting composite material, and include a molded damper position indicator visible from the exterior of the unit. The damper shall pivot in self lubricating bearings. The damper actuator shall be mounted on the exterior of the terminal for ease of service. The valve assembly shall include internal mechanical stops for both full open and closed positions. The damper blade seal shall be secured without use of adhesives. The air valve leakage shall not exceed 1% of maximum inlet rated airflow at 3" W.G. inlet pressure.

5. Primary Airflow Sensors:

a. Differential pressure airflow sensor shall traverse the duct using the equal cross sectional area or log-linear traverse method along two perpendicular diameters. Single axis sensor shall not be acceptable for duct diameters 6" or larger. A minimum of 12 total pressure sensing points shall be utilized. The total pressure inputs shall be averaged using a pressure chamber located at the center of the sensor. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 2.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. The sensor shall develop a differential pressure of 0.03" w.g. at an air velocity of < 450 FPM. Documentation shall be submitted which substantiates this requirement. Brass balancing taps and airflow calibration charts shall be provided for field airflow measurements.

PART 3 - EXECUTION

3.1 BMS SPECIFIC REQUIREMENTS

A. Graphic Displays:

1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list.
2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

B. Actuation/Control Type:

1. Primary Equipment:

a. Controls shall be provided by equipment manufacturer as specified herein.
b. All damper and valve actuation shall be electric.

2. Terminal Equipment:

a. Terminal Units (VAV) shall have electric damper actuation.
b. All Terminal Units shall be controlled with HVAC-DDC Controller).

3.2 INSTALLATION PRACTICES

A. BMS Wiring:

1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
2. Class 2 Wiring:

a. Class 2 wiring for sensors, actuators and communication buses shall be in conduit where exposed or inaccessible.
b. Class 2 wiring for sensors, actuators and communication buses shall be run using "open cable" wiring practices where concealed yet accessible. Open cable to be plenum rated where required.

3. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

B. BMS Line Voltage Power Source:

1. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.
2. Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

C. HVAC Input Devices – Genera1:

1. All Input devices shall be installed per the manufacturer recommendation.
2. Locate components of the BMS in accessible local control panels wherever possible.
3. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
5. Duct Temperature Sensors:

    a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
    b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
    c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

6. Space Sensors:

    a. Shall be mounted per ADA requirements.
    b. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

3.3 TRAINING

A. The BMS contractor shall provide the following training services:

1. One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.4 PROGRAMMING

A. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory free for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

C. Software Programming:

1. Provide programming for the system as per specifications and adhere to the strategy algorithms provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the BAS vendor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.

D. Operators' Interface:

1. The controls manufacturer shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third party software installation and integration required for successful operation of the operator interface.

3.5 CLEANING

A. The Contractor shall clean up all debris resulting from his or her activities daily. The Contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the General Contractor.

B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.

C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.6 FIELD QUALITY CONTROL

A. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BAS program shall be put online and commissioned. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy. Any discrepancies between the specification and the actual performance will be immediately rectified and re-commissioned.

B. After all BAS programs have been commissioned; the BAS vendor shall verify the overall system performance as specified. Tests shall include, but not be limited to:

1. Data communication, both normal and failure modes.
2. Impact of component failures on system performance and system operation.
3. Season changeover.
4. Global application programs and point sharing.
5. System backup and reloading.
6. System status displays.
7. Diagnostic functions.
8. Power failure routines.
9. All commissioning documents listed below shall be submitted for record.

    a. Test data sheets, listing all programmed software points.
    b. Sequence of operations verification sheets.
    c. Calibration sheets for test equipment, as needed.

10. After the above tests are complete and the system is demonstrated to be functioning as specified, the system shall be turned over to the Department.

3.7 TESTING AND DEMONSTRATION

A. The BAS vendor shall perform a complete test of the operator interface. Test duration shall be a minimum of 8hours on-site. Tests shall be made in the presence of the Owner or Owner's representative and the Professional.

B. A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The BAS vendor shall dedicate a minimum of 8 hours on-site with the Owner and his representatives for a complete functional demonstration and training of all the system requirements, including operation, adjustment, and maintenance. The training sessions shall be in six 4-hour sessions. This demonstration constitutes a joint acceptance inspection, and permits acceptance of the delivered system for on-line operation. Refer to Division 01 Section "Demonstration and Training."

3.8 SEQUENCE OF OPERATION

A. Cold Duct Damper:

1. The damper will modulate to provide cold air flow at or below maximum cold duct flow setpoint. Air flow setpoint will be determined from space temperature and cooling setpoint control loop. On a rise in space temperature cold air flow will increase. On a drop in space temperature cold air flow will decrease until the damper is closed.

B. Hot Duct Damper:

1. The damper will modulate to provide hot air flow at or below maximum hot duct flow setpoint. Air flow setpoint will be determined from space temperature and heating setpoint control loop. On a drop in space temperature hot air flow will

increase. On a rise in space temperature hot air flow will decrease until the damper is closed.

C. Total Airflow:

1. The total sum of hot deck and cold deck airflows shall never fall below the scheduled minimum air flow.

D. Hot and Cold Damper:

1. During the unoccupied mode of operation the sequence above will apply. However the box will setback and setup the space cooling and heating setpoints as well as reduce the minimum air flow requirements.

E. Discharge Air Temp Sensor:

1. A discharge air temp sensor is provided on each box for monitoring purposes.

END OF SECTION 15900