SECTION 250000 – BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 BIDDING REQUIREMENTS

A. General:

1. A system configuration diagram, which indicates the model, type, quantity, and location of the proposed BAS panels, and the schematic layout of the BAS Network Communications.

2. A breakdown of BAS contractors proposed cost including materials, markups, subcontractors, labor and training.

3. A complete input/output summary including cost per point broken out into major types. (i.e. A.I., A.O., B.I., BO., etc.)

4. Control schematics and sequence of operations including interface with any other control system and software functions that will be incorporated into the system.

5. Details of any major additions to front-end/operator interface hardware and software.

6. Total quote of project with written statement of any exceptions taken.

B. Failure to furnish any of the above items at the time bid packages are presented to General and the University shall result in the vendor’s bid being deemed non-responsive, and it shall be rejected without further consideration.

1.3 QUALITY ASSURANCE

A. All electrical components 25 volts and above shall be U.L. listed or labeled.

B. All equipment or piping used in the conditioned air stream, spaces or return air plenums shall comply with all applicable local building codes or requirements.
C. All wiring shall conform to the National Electrical Code (NEC).

D. Upon completion of the installation, the BAS contractor shall verify by demonstration to owner that the system is fully functional, installed in accordance with the plans and specifications, and calibrated within the operational limits specified. Acceptable documentation and test procedures shall be as approved on the initial project submittals. B.A.S. Contractor and James Madison University Building Automation Systems personnel will perform a complete point-by-point checkout to verify proper installation and operation, to include all control processes. The warranty period will not begin until completion of this checkout and correction of any problems found during this checkout and the graphics are completed and installed.

E. Material furnished under this Division shall be standard cataloged products of recognized manufacturers regularly engaged in the production of such material and shall be the latest design.

F. Materials shall be the best of their respective kinds. All materials shall be new. Work provided by the BAS contractor for each section of this specification shall be constructed and finished in every part in a substantial and workmanlike manner. Items necessary for the completion of the work and the successful operation of a product shall be provided even though not fully specified or indicated in each section.

G. Installation must be in accordance with the requirements of all local codes and authorities having jurisdiction.

H. The BAS contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the specification. Final installed software shall be of the manufacturer's latest available release level. All control performance criteria are specified in the Sequence of Operations section of the specification.

I. Provide $5,000.00 amount for training schools at the contractor's corporate training facility. Owner shall select the courses to be attended. The classes should be HVAC, BAS or Energy Related.

J. James Madison University shall be considered a preferred customer with or without a maintenance agreement with contractor. A two-hour response is expected for all service requests.

1.4 DEFINITIONS

A. The term "as indicated" means as shown on drawings by notes, graphics or schedules, or written into other portions of contract documents. Terms such as "shown", "noted", "scheduled" and "specified" have same meaning as "indicated", and are used to assist the reader in locating particular information.

B. The term "Provide" means furnish and install as part of the work covered in Division 25.
C. The term "Furnish" means furnish only for installation by other Divisions.

D. The term "Install only" means to install under the work of Division 25, equipment furnished by other Divisions, or by the Owner.

E. The term "Owner" when referenced herein shall be JAMES MADISON UNIVERSITY

F. BAS: The environmental monitoring and control system inclusive of all appurtenances required for control and monitoring of the mechanical, electrical, or other systems unless specifically exempted within this specification. This definition includes both hardware devices and software components that are integrated to form a working system. Ancillary components such as stand-alone gauges, thermometers, and other automatic temperature control devices are included unless exempted.

G. HVAC: Heating, Ventilating, and Air Conditioning Control System.

H. FIRST LEVEL CONTROLLER

1. First Level Controller and associated Second level Controller - Building controller with HOI and POI and communications capabilities between building SECOND LEVEL CONTROLLER controls and operator work station.

2. Siemens Building Technologies: PX/TX I/O Panels: First Level Controller and associated Second Level Controller - Building controller with individual point control modules and FOI and POI and communications capabilities between building SECOND LEVEL CONTROLLER controls and operator work station.

3. Exceptions to these products will need to be preapproved.

I. SECOND LEVEL CONTROLLER

1. SECOND LEVEL CONTROLLER: Second Level Control – Controller designed to control HVAC equipment. All points are programmable to the HVAC equipment being controlled. Controllers that have preprogrammed logic (application specific) are not acceptable. SECOND LEVEL CONTROLLER shall have POI interfaces and communications to FIRST LEVEL CONTROLLER's.

2. Siemens Building Technologies: XT I/O modules: Second Level Control - Controller with individual point control modules designed to control HVAC equipment. All points are programmable to the HVAC equipment being controlled. Controllers that have preprogrammed logic (application specific) are not acceptable. SECOND LEVEL CONTROLLER shall have POI interfaces and communications to FIRST LEVEL CONTROLLER's.

There are not exceptions to these products.
J. AWS: Apogee Work Station – This is Siemens Building Technologies front-end system.

K. COI: Communications port for operator interface. (i.e. RS-232 or RS-485)

L. FOI: Filed operator interface. Device used for field access to controller databases (Cat 5 Port).

M. POI: Portable operator interface (Lap Top Computer).

1.5 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:
   1. Division 23 Section "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
   2. Division 25 Section "Sequences of Control" for requirements that relate to this Section.
   3. Division 28 Sections for additional conduit requirements for all electronic safety and security systems specified under Division 28.

C. Work Under Other Sections:
   1. All wells, valves, taps, dampers, flow stations, etc. furnished by the BAS manufacturer shall be installed under Section “Hydronic Piping.”
   2. The following shall be provided under Division 25 specifications sections:
      a. 120V power to BAS panels and devices with circuits indicated on the drawings. Refer to “Coordination” paragraph below.
      b. Wiring of power feeds to disconnect switches and starters.
      c. Wiring from disconnect switches and starters to electric motors.
      d. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished under this section of the specifications.

1.6 ABBREVIATIONS

A. AI: Analog In

B. AO: Analog Out

C. BI: Binary In

D. BO: Binary Out

E. BAS: Building Automation System.

F. CT: Current transformer/transmitter
G. Cond.: Condition
H. DDC: Direct digital control.
I. I/O: Input/output.
J. IT: Information Technology.
K. IS: Information Systems.
L. LAN: Local Area Network.
M. MS/TP: Master-slave/token-passing
N. NAC: Network area controllers.
O. NE: Not equal to
P. PC: Personal computer.
Q. PID: Proportional plus integral plus derivative.
R. PPM: Parts per million.
S. RTD: Resistance temperature detector.
T. SS: Start Stop
U. S: Status
V. OWS: Operator Work Station
W. VFD: Variable Frequency Drive
X. WAN: Wide-Area Network

1.7 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
   2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
   3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. **Object Scan**: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. **Alarm Response Time**: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. **Program Execution Frequency**: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. **Performance**: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. **Reporting Accuracy and Stability of Control**: Report values and maintain measured variables within tolerances as follows:

   a. **Water Temperature**: Plus or minus 1 deg F.
   b. **Water Flow**: Plus or minus 5 percent of full scale.
   c. **Water Pressure**: Plus or minus 2 percent of full scale.
   d. **Space Temperature**: Plus or minus 1 deg F.
   e. **Ducted Air Temperature**: Plus or minus 1 deg F.
   f. **Outside Air Temperature**: Plus or minus 2 deg F.
   g. **Dew Point Temperature**: Plus or minus 3 deg F.
   h. **Temperature Differential**: Plus or minus 0.25 deg F.
   i. **Relative Humidity**: Plus or minus 5 percent.
   j. **Airflow (Measuring Stations)**: Plus or minus 5 percent of full scale.
   k. **Airflow (Terminal)**: Plus or minus 10 percent of full scale.
   l. **Air Pressure (Space)**: Plus or minus 0.01-inch wg.
   m. **Air Pressure (Ducts)**: Plus or minus 0.1-inch wg.
   n. **Carbon Dioxide**: Plus or minus 50 ppm.
   o. **Electrical**: Plus or minus 5 percent of reading.

1.8 **SYSTEM DESCRIPTION**

A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

B. Control system includes interface to the following:

1. Division 28 sections on Electronic Safety and Security Systems. Provide interface outputs for selective annunciation and monitoring (i.e. alarm status).
2. Building clock control system specified in Division 27 Section "GPS Wireless Clock System."
3. Building lighting control system specified in Division 26 Section "Lighting Control Devices."
4. Fire alarm system specified in Division 28 Section "Digital Addressable Fire Alarm."

1.9 **WARRANTY**

A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year beginning on the date of Substantial Completion.
B. Services, materials, and equipment shall include but not be limited to:
1. The adjustment, required testing, and repair of the system including all computer equipment, transmission lines, transmission equipment, sensors and control devices.
2. On-line support services shall be provided as follows:
   a. The local BAS representative shall have the capability to monitor and control the facility’s building automation system via a remote connection.
   b. If the problem is not resolved by local support, the national office of the building automation system manufacturer, having the same dialup capability, shall also provide online support.

1.10 SUBMITTALS

A. Pre-submittal meeting: The Contractor performing work under this Section of the specifications shall attend a meeting for coordinating the control system with major pieces of equipment including rooftop units; HVAC packaged pumping system, chillers and boilers. The meeting shall be held on the project site in the contractor’s trailer or other location acceptable to the Contractor. The Contractor shall be responsible for arranging the meeting. Submittals shall be essentially complete at the time of the meeting so detailed coordination items can be discussed.

B. Submit ten (10) complete sets of documentation in the following phased delivery schedule:
1. Schedule of dampers including size, leakage, and flow characteristics.
2. Schedule of valves including leakage and flow characteristics.
3. Product Data: Include manufacturer’s technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Include each control device labeled with setting or adjustable range of control.
4. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Include the following:
   a. System schematics, including:
      1) Written sequences of operation
      2) Listing of connected data points, including connected control unit and input device.
         a) point names
         b) point addresses
      3) Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
      4) Details of control panel faces, including controls, instruments, and labeling.
      5) Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
      6) Trunk cable schematic showing programmable control unit locations and trunk data conductors.
      7) System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
      8) System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
C. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:
   1. Maintenance instructions and lists of spare parts for each type of control device.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5. Calibration records and list of set points.

D. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

E. Upon project completion, submit operation and maintenance manuals, consisting of the following:
   1. Index sheet listing contents in alphabetical order.
   2. Manufacturer’s equipment parts list of all functional components of the system.
   3. CD-ROM of system schematics including wiring diagrams.
   4. Sequence of operations
   5. As-built interconnection wiring diagrams.
   7. Trunk cable schematic showing remote electronic panel locations and all trunk data.
   8. List of connected data points, including panels to which they are connected and input device (sensors, thermostat, etc.)
   9. Software and firmware operational documentation. Include the following:
      a. Software operating and upgrade manuals.
      b. Program software backup: On a magnetic media or compact disc, complete with data files.
      c. Device address list.
      d. Printout of software application and graphic screens.
      e. Software license required by and installed for DDC workstations and control systems.
   10. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.
   11. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

F. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system. Submit a schedule of airflow measuring devices indicating compliance with specified accuracy at minimum and maximum airflow rates. Submit installation, operation and maintenance documentation.
1.11 QUALITY ASSURANCE

A. The BAS system shall be designed and installed, commissioned, and serviced by a manufacturer’s authorized installer.

B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those indicated for this Project and with a record of successful in-service performance.

C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, governing radio frequency electromagnetic interference and shall be so labeled.

F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

1.12 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory-mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.13 COORDINATION

A. Control Wiring: The BAS manufacturer shall be responsible for all BAS and temperature control wiring for a complete and operable system. All wire and cable shall be plenum-rated and shall be in accordance with Division 26 specification sections and all local, state and national codes and ordinances.

B. Where plenum-rated BAS cable is routed in concealed, accessible spaces, the cable may be run in the cable trays or in J-Hooks provided under this section of the specifications. Where plenum-rated BAS cable is routed in exposed or inaccessible areas, it shall be run conduit provided under this section of the specifications.

C. Power Wiring:
   1. Power wiring indicated (device and circuit designation indicated) on the drawings shall be provided under Division 26.
2. The BAS manufacturer shall be responsible for power wiring not indicated (device or circuit designation not indicated) on the Drawings. It shall be the BAS manufacturer’s responsibility to review the Contract Documents to determine the extent of power wiring included in Division 26 and to provide additional power wiring as required. Work shall be in accordance with Division 26 specifications and all local, state and national codes and ordinances.

3. Where the contractor performing work under this section requires an additional circuit for power wiring to a device or panel under paragraph 2 above, an RFI shall be issued requesting approval to use an available circuit in the nearest panel. Once approval is granted, all wiring and conduit from the breaker to the device or panel shall be provided under this section of the specifications.

D. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. All conduits shall be concealed within walls and above ceilings unless indicated otherwise.

E. Coordinate installation of conduit to avoid cutting of finished surfaces.

F. Coordinate equipment with Division 28 Section "Common Work Results for Electronic Safety and Security" for building security control detection system and selective annunciation and monitoring only (i.e. ‘status alarms’).

G. Coordinate equipment with Division 27 Section "GPS Wireless Clock System" to achieve compatibility with equipment that interfaces with that system.

H. Coordinate equipment with Division 26 Section "Lighting Control Devices" to achieve compatibility with equipment that interfaces with that system.

I. Coordinate equipment with Division 28 Section "Digital Addressable Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

J. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

K. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

L. Coordinate equipment with Division 26 Section “Switchboards” to achieve compatibility with power monitoring and metering devices in that equipment.
PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. The intent of this specification is to provide a complete distributed, stand-alone DDC controls system with electric actuation. The FIRST LEVEL CONTROLLER and SECOND LEVEL CONTROLLER controllers shall be selected so that each units operation is controlled by an individual level controller. Each unit operation, such as chiller plant, boiler plant, or air handling unit shall be controlled by a single SECOND LEVEL CONTROLLER. All control devices, including valves, dampers, sensors, transducers and related appurtenances, shall be provided, furnished, or installed if furnished under another section or division of the specification. The system shall perform the functions described by the specified sequence of operation. Control loops shall be implemented using direct digital control (DDC) methods that provide proportional integral derivative (PID) control algorithms. All pneumatic control piping and all control wiring required to accomplish the sequence of operation is to be included.

B. Under no circumstance shall multiple SECOND LEVEL CONTROLLERS be employed to control a single piece of equipment due to the limitation of a single controller's input/output capability. If the specified sequence of operation for a single equipment system requires more input/output capability than is available within a SECOND LEVEL CONTROLLER the control shall be supported using an FIRST LEVEL CONTROLLER.

2.2 ACCEPTABLE MANUFACTURERS

A. Siemens Industry, Inc.

2.3 HARDWARE REQUIREMENTS

A. FIRST LEVEL CONTROLLERS:

1. General:

   a. The HVAC controls system shall include one or more FIRST LEVEL CONTROLLER configured as described herein. The FIRST LEVEL CONTROLLER must be capable of stand-alone operation, and/or network operation as required. Manufacturers shall use First Level Controllers as defined, Siemens- FIRST LEVEL CONTROLLER.

2. Operating Environment:

   a. All controllers shall be capable of normal operation in any environment that ranges from 32 to 122 degrees F. (0 to 50 degrees C.) with 0 to 90 percent relative humidity. Hazards like extreme airborne dust, explosive or corrosive vapors, and other similar conditions shall require all controllers to be located in a more
favorable environment or protected by a suitable enclosure that is environmentally maintained within the identified limits.

3. Power Line Requirements:
   a. Each FIRST LEVEL CONTROLLER shall be designed to require a power line input of 110 to 120 VAC, 60 Hertz. Each controller shall have fuse protection on the AC input line.
   b. Each circuit shall be a dedicated circuit with properly sized breaker to each controller. This circuit shall energize no other devices. Power for FIRST LEVEL CONTROLLER shall be provided by Division 26.
   c. Each circuit shall be equipped with a power line filter. See owner for recent model selection.

4. Locations:
   a. A FIRST LEVEL CONTROLLER shall be provided in all main mechanical rooms. Main Mechanical Rooms are defined as any single room having control of two or more of the following systems or any two or more of the same systems in a single room: Chiller, Chilled water, Cooling Tower, Converter, Hot Water system of any type, Air Handling Unit, Heating and Ventilation Unit.

5. Extra points:
   a. Each FIRST LEVEL CONTROLLER shall have a minimum of 10 spare points to be used by the owner at a later date. These points shall include 2 binary in 2 out, 4 analog in, and 2 analog out. This point is negotiable on a case by case basis. To take exception BAS contractor must have written authorization from University BAS representative.

6. Identification
   a. Each FIRST LEVEL CONTROLLER shall be labeled and all components within each panel shall be labeled.

B. SECOND LEVEL CONTROLLERS:

1. General:
   a. SECOND LEVEL CONTROLLER shall be field programmable microprocessor based, electronic controllers incorporating direct digital control technology. These controllers shall be capable of performing their assigned control and energy management functions as standalone units or as part of a comprehensive network of SECOND LEVEL CONTROLLER linked via a data trunk to an FIRST LEVEL CONTROLLER. Each SECOND LEVEL CONTROLLER shall be capable of performing energy management functions including, but not limited to supply air and water reset, economizer, duty cycling, chiller optimization, morning cool-down and warm-up, unoccupied setback, and real-time scheduling.
2. **Input/Output Support:** Contractor shall support all devices, points and sequence of operation listed in this specification.

a. **SECOND LEVEL CONTROLLER** shall use the manufacturer’s standard sensors, transducers, and other input/output devices. Digital to Analog and Analog to Digital conversion precision within the controller shall provide a minimum of 12 bits accuracy. Controllers shall accept electrical and pneumatic inputs/outputs of the standard range identified.

b. Each **SECOND LEVEL CONTROLLER** shall support the following Input/Output types:
   1) Universal Analog Inputs
   2) 1000 ohm Platinum RTD, 1000 ohm Balco RTD, 0/11 VDC, 4/20 mA, and non-supervised circuit as a contact input.
   3) Pulse Analog Inputs (Pulse Width Modulation - PWM) 
      10 Hz @ 40-60% duty cycle pulse rate maximum.
   4) Contact Inputs
      Class A and Class B supervised circuits.
   5) Velocity Sensor Inputs (Air Flow)
      Range 0 to 1.5” wc at 2830 FPM
   6) Analog Outputs
      0/10 VDC, 4/20 MA
   7) Contact Outputs with Override Switches
      SPDT; 3.0 Amps @ 24 VAC/DC; 1.0 Amp @ 120 VAC/DC; 0.5 Amp @ 240 VAC/DC.
   8) Digital Triac Outputs
      On/Off, Floating or PWM, 0.5 Amp @ 24 VAC.
   9) Digital FET Outputs
      On/Off, Floating or PWM, 1 Amp @ 24 VAC/DC.

3. **Operating Environment:**

a. Each **SECOND LEVEL CONTROLLER** shall be capable of normal operation in any environment that ranges from 32 to 122 degrees F. (0 to 50 degrees C.) With 0 to 90 percent relative humidity. Hazards like extreme airborne dust, explosive or corrosive vapors, and other similar conditions shall require the **FIRST LEVEL CONTROLLER** to be located in a more favorable environment or protected by a suitable enclosure that is environmentally maintained within the identified limits.
4. Power Line Requirements:
   a. Each SECOND LEVEL CONTROLLER shall be designed to require a power line input of 110 to 120 VAC, 60 Hertz. Each controller shall have fuse protection on the AC input line.
   b. Each circuit shall be a dedicated circuit with properly sized breaker to each controller. This circuit shall energize no other devices. Power for SECOND LEVEL CONTROLLER shall be provided by Division 26.
   c. Each circuit shall be equipped with a power line filter. See owner for recent model selection.

5. Agency Listings:
   a. Each SECOND LEVEL CONTROLLER shall be UL 864, NFPA 92A (Smoke Purge) listed, and designed to meet requirements of IEEE C62.41 (Category A).
   b. Each SECOND LEVEL CONTROLLER shall be FCC Part 15, Class A approved.

6. Extra Points - each SECOND LEVEL CONTROLLER shall have 8 extra points defined as 2 analog in, 2 analog out, 2 binary in and 2 binary out. This does not apply to every SECOND LEVEL CONTROLLER's if more than one is same location.

7. Locations: All areas that are not specified as main mechanical room.

8. Each SECOND LEVEL CONTROLLER shall be labeled and all components within the panel shall be labeled.

C. Field Operator Interface (FOI):

1. The BAS contractor shall provide a Terminal to access building information on all FIRST LEVEL CONTROLLERS (If more than one FIRST LEVEL CONTROLLER is in a mechanical room only one terminal is needed.)
2. The BAS contractor shall provide a communication drop that connects the user to The BAS network at each SECOND LEVEL CONTROLLER. (If more than one SECOND LEVEL CONTROLLER is in a mechanical room only one drop is needed)

D. Site Communications: Provide all fiber optic equipment and interfaces necessary to communicate on vendor specific fiber network provided by the University.

E. Input/Output Devices: Contractor shall be responsible for all devices necessary to interface with all hardware points listed in this specification or added to this specification by change order. All devices input and output controllers shall be tagged with moisture proof label.
1. Temperature Sensors:

a. Temperature sensors shall be provided for space, duct, fluid, and outside air sensing which are compatible with the digital controllers. All temperature sensors shall be accurate to ± 0.5% of the range of the sensor.

b. All sensors in water or steam lines shall be installed in wells.

c. The sensors shall be housed in enclosures appropriate for the application. As a minimum five types shall be available:

1) Molded plastic unit suitable for wall mounting to sense room space temperatures.

2) Metal duct mounted single point unit suitable for mounting in air ducts.

3) Metal duct mounted averaging element type unit suitable for mounting in air ducts, with elements of 8' or 17' length as required to traverse the entire duct width. In mixed air and coil discharge applications, and wherever averaging type sensors are indicated, single point sensors will not be acceptable.

4) Metal outside air unit with sun-shield and housing suitable for mounting outdoors. Outside air sensors shall be mounted on the Northwest side of the building, near the eave, in such a manner that the sensor housing shall never be in direct sunlight or where effected by heat from the building structure.

5) Brass or stainless steel metal thermo well unit suitable for mounting in pipes to sense chilled and hot water temperatures. Wells shall be of suitable length to allow the best temperature sensing for the application.

d. All temperature sensor housings within each mechanical room shall have label permanently attached to them. Label shall contain an identifier that matches the way it is identified on the wiring diagrams (i.e., DAT).

e. Low limit thermostats for detection of low temperature in the duct shall have 20' elements, located as indicated. If any portion of the element senses a temperature below its setting, the contact shall open. The thermostat shall be hardwired to shut down the respective fan independently of the alarm to the DDC.

f. Elements for averaging type temperature sensors and low limit thermostats shall be carefully installed in a serpentine fashion using specially designed turning clips, and arranged so as to cover the entire duct cross sectional area. At no point should the spacing of the capillary tube exceed eighteen (18) inches.

2. Differential and Static Pressure Sensors:
a. Pressure Sensors: Sensor shall be Setra or equal with accuracy of +0.3% of span.

3. Current sensing relays:
   a. Current sensing relays shall be adjustable, provided for positive status of AHU’s, HW and CW circulating pumps and exhaust fans. Trip set point shall be 1% of range. Relays shall be sized for the horsepower rating of the equipment served.

4. CO2 sensors:
   a. Duct mounted CO2 sensors shall be Vaisala Carbocap carbon dioxide transmitter for duct mounting complete with: 24 VDC or 24 VAC input power; selectable 0 to 20 mA, or 0 to 10 VDC output signal corresponding to 0 to 2000 PPM CO2. Model number: GMD20, or equivalent Vaisala transmitter.
   b. Carbocap carbon dioxide transmitter for wall mounting complete with: 24 VDC or 24 VAC input power; selectable 0 to 20 mA, or 0 to 10 VDC output signal corresponding to 0 to 2000 PPM CO2. Model number: GMW20, or equivalent Vaisala transmitter.

5. Domestic Water & Cooling Tower Exclusion Flow Meters
   a. Badger Recordall® Compound Series Meters Unit shall be specifically designed for use in potable cold water, up to 120 deg F and working pressures up to 150 psi. Meters shall be sized for capacities indicated. Unit shall be all bronze case with companion flanges and bronze top cover plate with internal screws, spindles and shaft of stainless steel. Rotor shall be polyphenylene. Unit shall have accuracy registration of 100% +/- 1-1/2% within flow range of 5 to 700 gpm. Pressure drop shall not exceed 1.4 psi at 350 gpm. Unit shall be factory equipped with Kent IRT integral transmitter (4-20ma for connection to the BAS) with visual rate indicator and totalizer. Flow meters shall be calibrated on-site after installation by the factory representative. BAS Contractor shall provide letter from factory representative attesting that meters have been field calibrated and are operating correctly. BAS vendor shall monitor both sides of meter, as compound meter is specified.

   1) BAS contractor shall be responsible for installation of all piping, valves, and labor necessary to install water meter as specified. BAS contractor shall not be responsible for this installation and parts if this work is specified in mechanical contractors obligations. BAS contractor shall coordinate.
   b. Provide, install and program a KEPtrol F/C dual input flow-monitoring computer. Model # KFC8A3A2C3

6. KW Demand Meter (Electric meters under electrical contractor Div. 26)
a. All power meters must be capable of providing but not limited to the following information.
   1) KW
   2) KWH
   3) Monthly Reset of KWH
   4) AB Voltage
   5) AC Voltage
   6) BC Voltage
   7) A, B, C Voltage
   8) A - Amps
   9) B - Amps
   10) C - Amps
   11) Peak Demand

   Note: All meters are to be tied into the BAS system and to have real time readings.

7. Points (General)
   a. All points shall reside in a panel in same room as HVAC equipment.
   b. All points for a given system shall reside in same panel structure.
   c. All points within a Mechanical Room shall terminate in that room.

8. Relays
   a. Relays shall have an LED to give indication of position of the relay.
   b. Relays shall be mounted in an accessible location.

F. Control Valves & Dampers

1. Control Valves
   a. All modulating straight through water valves shall be provided with equal percentage contoured throttling plugs. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve's position. Valves shall be factory rated to withstand the pressures encountered. Valves shall have stainless steel stems and spring loaded ring packing. Water valves shall be sized for 3 psi maximum pressure drop. Valves shall have replaceable seats and discs.

   b. All modulating straight through steam coil valves shall have linear characteristics for 90% of the closing stroke and equal percentage for the final 10%. Valves shall have stainless steel stems, spring loaded ring packing. Valves two inches and smaller shall be screwed type, and larger valves shall be flanged. Valves shall have replaceable seats and discs.
c. Unitary valves shall be straight through or three way with high pressure connections suitable for copper pipe and rated for 200 psig. Stems shall be polished stainless steel and packing shall be ethylene propylene suitable for both chilled water and 250 degf hot water services. Straight through valves shall have back seat feature, to allow packing to be replaced without draining system.

d. All water valve bodies shall have the same pressure characteristics as the pipe in which it is installed.

2. Control Dampers

a. Provide all necessary dampers for project unless specifically stated in other division of specifications that dampers are with units. Dampers shall have a leakage of less than 0.5% when closing against four inches wg static pressure. The frame and blades shall be constructed of galvanized steel and shall be designed so that a given percentage of operator travel will provide approximately the same percentage throttle of flow. Seals shall be provided on blade edges and the top, bottom, and sides of the frames. Damper shafts shall have oil impregnated bronze bushings.

b. Damper actuators shall be Belimo and of sufficient size to operate there respective dampers effectively.

2.4 SOFTWARE REQUIREMENTS

A. Software Revisions

1. Provide all latest software revision upgrades available. This shall apply until expired warranty date. Provide all software necessary to program and communicate with all devices provided.

B. Input/Output Support

1. The operator, through the OWS, FIRST LEVEL CONTROLLER, and SECOND LEVEL CONTROLLER shall be capable of overriding the programmed control sequence to manually operate the outputs for system checkout. All sequences of operation shall be demonstrated through this simulation technique. All SECOND LEVEL CONTROLLER controllers shall be stepped through their sequence to verify system operation. During the maintenance routine, the controllers shall be capable of selectively disabling inputs and outputs without affecting the operations of the remaining inputs and outputs. A point trend log for maintenance and trouble shooting of the system shall be capable of printing at OWS. All space thermostat set points shall be programmable from a global command to select a specific set point with one command from the operator workstation.

C. Graphics Generation
1. A complete color graphic shall be provided for each mechanical system (AH Unit, Chiller, Converter, etc.) and floor plans for each floor. All information shall be displayed in a real time dynamic fashion. All new graphics provided shall be in a similar style as existing system graphics on campus.
   
a. Mechanical Systems: Each mechanical system shall have an associated color graphic that shows all appropriate real time information and alarm conditions. Color banding shall be used to indicate sensed temperatures. Color selections for graphics shall be provided by the owner.

D. Programming Requirements
1. Each VAV, CAV or similar type device point name shall include the associated AHU number.

2. Each AHU, RTU or similar type equipment shall have a detailed description of all the areas it serves as well as where the unit is physically located.

3. All lead lag standby setups including chillers, pumps and boilers shall be able to be switched by changing the state of a single point.

4. All zone temperature sensors that include a local temperature range adjustment will have that adjustment ability disabled by default. The enable/disable point for the adjustment shall be mapped to the head end.

2.5 DDC EQUIPMENT

A. Existing Operator Workstations: All BAS interface software should be installed on the campus existing head end computers located in the Building and Ground Office. Provide at least two hard copies on CD or DVD of all software required for interface.
1. Application Software:
   a. I/O capability from operator station.
   b. System security for each operator via software password and access levels.
   c. Automatic system diagnostics; monitor system and report failures.
   d. Database creation and support.
   e. Automatic and manual database save and restore.
   f. Dynamic color graphic displays with up to 10 screen displays at once.
   g. Custom graphics generation and graphics library of HVAC equipment and symbols.
   h. Alarm processing, messages, and reactions.
   i. Trend logs retrievable in spreadsheets and database programs.
   j. Alarm and event processing.
   k. Object and property status and control.
   l. Automatic restart of field equipment on restoration of power.
   m. Data collection, reports, and logs. Include standard reports for the following:
      1) Current values of all objects.
      2) Current alarm summary.
3) Disabled objects.
4) Alarm lockout objects.
5) Logs.

n. Custom report development.
o. Workstation application editors for controllers and schedules.
p. Maintenance management.

B. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide either modulating signal, low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
7. Universal I/Os: Provide software selectable binary or analog outputs.

C. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

2.6 DDC CONTROLLERS

A. No controller shall be loaded to more than 80%. IE: A controller with 20 available points shall be loaded with 16 points or less.

B. DDC controllers shall be stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of the contract documents. Each controller shall support a minimum of two (2) LAN Device Networks.
C. Each DDC controller shall have sufficient memory to support its own operating system and databases, including:
   1. Control processes
   2. Energy management applications
   3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
   4. Historical/trend data for points specified.
   5. Maintenance support applications.
   7. Operator I/O.
   8. Dial-up communications.

D. Each DDC controller shall support any combination of industry standard inputs and outputs.

E. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

F. DDC controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, Ethernet connections, printers, or terminals.

G. Each DDC controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

H. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

I. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 days.
   1. Upon restoration of normal power, the DDC controller shall automatically resume full operation without manual intervention.
   2. Should DDC controller memory be lost for any reason, the system shall automatically reload the DDC controller via the local RS-232C port, via telephone line dial-in or Ethernet from the existing network workstation PC.

J. Provide a separate DDC controller for each RTU or other HVAC system. It is intended that each unique system be provided with its own point resident DDC controller.
2.7 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

A. General:
   1. The software programs specified in this Section shall be provided as an integral part of
      DDC Controllers and shall not be dependent upon any higher-level computer for
      execution.

B. Control Software Description:
   1. The DDC Controllers shall have the ability to perform the following pre-tested control
      algorithms:
      a. Two-position control
      b. Proportional control
      c. Proportional plus integral control
      d. Proportional, integral, plus derivative control
      e. Automatic tuning of control loops

C. DDC Controllers shall have the ability to perform any or all the following energy management
   routines:
   1. Time-of-day scheduling
   2. Calendar-based scheduling
   3. Holiday scheduling
   4. Temporary schedule overrides
   5. Start-Stop Time Optimization
   6. Automatic Daylight Savings Time Switchover
   7. Night setback control
   8. Enthalpy switchover (economizer)
   9. Peak demand limiting
   10. Temperature-compensated duty cycling
   11. Trending

D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to
   automatically perform calculations and special control routines.

E. Alarm management shall be provided to monitor and direct alarm information to operator
devices. Each DDC Controller shall perform distributed, independent alarm analysis and
filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic
and prevent alarms from being lost. At no time shall the DDC Controllers ability to report
alarms be affected by either operator or activity at a PC workstation, local I/O device or
communications with other panels on the network.

F. A variety of historical data collection utilities shall be provided to manually or automatically
sample, store and display system data for points as specified.

2.8 APPLICATION SPECIFIC CONTROLLERS (ASC)
A. Each DDC Controller shall be able to extend its performance and capacity using remote application specific controllers (ASCs) through LAN Device Networks.

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of ASCs as a minimum:
   1. Terminal Equipment Controllers
      a. Terminal Box (VAV box controllers) should have a differential pressure transmitter (transducer) accuracy of 0.015-inches w.g. or less.

C. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.

D. Terminal Equipment Controllers:
   1. Provide for control of each piece of equipment, including, but not limited to, the following:
      a. Terminal Units
      b. Exhaust fans

2.9 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters and Resistance Temperature Detectors and Transmitters:
   1. Accuracy: Plus or minus 0.5 deg F at calibration point.
   2. Wire: Twisted, shielded-pair cable.
   3. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
   4. Averaging Elements in Ducts: 36 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.
   5. Insertion Elements for Liquids: Brass or stainless steel socket with minimum insertion length of 2-1/2 inches.
   6. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Set-Point Adjustment: Exposed warmer/cooler adjustment. Range of adjustment capable at zone sensor shall be programmable through the BAS.
      b. Set-Point Adjustment (Common spaces, restrooms, corridors, stairs, storage/receiving): Concealed.
      c. Set-Point Indication: Exposed.
      d. Thermometer: LCD display of room temperature for monitoring purposes only.
      e. Thermometer (Common spaces, restrooms, corridors, stairs, storage/receiving): Concealed.
      f. Color: Manufacturer’s standard.
      g. Orientation: Vertical.
7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
8. Specific Sensor Type Locations: In corridors, lobbies, stairs, restrooms/toilets, & common area locations, provide blank stainless-steel cover plate sensors with insulated back and security screws.

C. Humidity Sensors: Capacitance or bulk polymer resistance type.
1. Accuracy: 5 percent full range with linear output.
2. Room Sensor Range: 20 to 80 percent relative humidity.
3. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Color: Manufacturer’s standard.
   b. Orientation: Vertical.
4. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 0 to 185 deg F.
5. Duct-Mounted: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

D. Pressure Transmitters/Transducers:
1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input and temperature-compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: 0- to 0.25-inch wg.
   d. Duct Static-Pressure Range: 0- to 5-inch wg.
2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential. Accuracy shall be +/- 5% of range.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

E. Current Sensing Switch:
1. Sensor supply voltage and supply current shall be induced from monitored conductor. Contact rating shall be 0.2 amperes at 30 volts DC/AC. Trip set point shall be adjustable to +/-1% of range. Current sensing switch wiring shall not be polarity sensitive.

F. Liquid Level Sensors:
1. Liquid level sensors shall have ½” accuracy calibrated to detect water in temperature range from 60°F to 80°F. Output signal shall be 4 to 20 mA. Sensor material shall be stainless steel or other non-corrosive material.

2.10 STATUS SENSORS

A. Status Inputs for Fans: Current sensing relay
B. Status Inputs for Pumps:  Current sensing relay

C. Status Inputs for Electric Motors:  Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac):  Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor:  3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches:  Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator:  Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches:  Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.11 FLOW MEASURING STATIONS

A. Duct Airflow Station:
   1. Qualifications: The manufacturer shall have a minimum of ten years experience producing products of this type.
   2. Acceptable Manufacturers:  Subject to compliance with requirements, provide products by Ebtron Inc.  Unless otherwise noted model numbers shall be as follows:
      a. Model GTx116-PC for ducts and plenums.
      b. Model GTx116-F for fan inlet applications.
   3. Alternative Manufacturers:  Alternative manufacturers may be submitted as a substitution in accordance with Division 1 specification requirements.  Superior performance or lower cost to the owner must be provided.  Acceptance shall be at the sole discretion of the Architect.
   4. Special Warranty: In addition to other required warranties, provide 3 years on parts from the date of unit shipment.
   5. Delivery, Storage and Handling: All handling and storage procedures shall be per manufacturer’s recommendations.  Airflow measuring devices shall be kept clean and dry, protected from weather and construction traffic.
6. Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.

7. The measurement device shall consist of one or more sensor probe assemblies and a single, remotely mounted, microprocessor-based transmitter. Each sensor probe assembly shall contain one or more independently wired sensor housings. The airflow and temperature readings, calculated for each sensor housing, shall be equally weighted and averaged by the transmitter prior to output. Pitot tubes and arrays are not acceptable. Vortex shedding flow meters are not acceptable.

8. Sensor Probe Assemblies:
   a. Sensor housings shall be manufactured of a U.L. listed engineered thermoplastic.
   b. Sensor housings shall utilize two hermetically sealed, bead-in-glass thermistor probes to determine airflow rate and ambient temperature. Devices that use “chip” or diode case type thermistors are unacceptable. Devices that do not have two thermistors in each sensor housing are not acceptable.
   c. Sensor housings shall be calibrated at a minimum of 16 airflow rates and have an accuracy of +/-2% of reading over the entire operating airflow range.
   d. Each sensor housing shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
   e. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
   f. Operating temperature range for the sensor probe assembly shall be -20° F to 160° F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).
   g. Each temperature sensor shall be calibrated at a minimum of three temperatures and have an accuracy of +/-0.15° F over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
   h. Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
   i. Each sensor assembly shall not require matching to the transmitter in the field.
   j. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.

9. Duct and Plenum Sensor Probe Assemblies:
   a. Sensor housings shall be mounted in an extruded, 6063 aluminum tube probe assembly.
   b. Thermistor probes shall be mounted in sensor housings using an epoxy resin.
   c. All thermister probe wires shall be contained within the aluminum tube probe assembly.
   d. The number of sensor housings provided for each location shall be as follows:
      1) Area (sq.ft.) Sensors
      2) <2 4
      3) 2 to <4 6
      4) 4 to <8 8
5) 8 to <16 12
6) >=16 16
e. Probe assembly mounting brackets shall be constructed of 304 stainless steel.
    Probe assemblies shall be mounted using one of the following options:
    1) Insertion mounted through the side or top of the duct
    2) Internally mounted inside the duct or plenum
    3) Standoff mounted inside the plenum
f. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated.

10. Fan Inlet Sensor Probe Assemblies:
    a. Sensor housings shall be mounted on 304 stainless steel blocks.
    b. Mounting rods shall be field adjustable to fit the fan inlet and constructed of
       nickel-plated steel.
    c. Mounting feet shall be constructed of 304 stainless steel.
    d. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated.

11. Transmitters:
    a. The transmitter shall have a 16-character alphanumeric display capable of
       displaying airflow, temperature, system status, configuration settings and
       diagnostics. Configuration settings and diagnostics shall be accessed through a
       pushbutton interface on the main circuit board. Airflow shall be field configurable
       to be displayed as a velocity or a volumetric rate.
    b. The transmitter shall be capable of:
       1) Independently monitoring and averaging up to 16 individual airflow and
          temperature readings.
       2) Displaying the airflow and temperature readings of individual sensors on the
          LCD display.
    c. The transmitter shall have a power switch and operate on 24 VAC (isolation not
       required). The transmitter shall use a switching power supply fused and protected
       from transients and power surges.
    d. All interconnecting pins, headers and connections on the main circuit board, option
       cards and cable receptacles shall be gold plated.
    e. The operating temperature range for the transmitter shall be -20° F to 120° F. The
       transmitter shall be protected from weather and water.
    f. The transmitter shall be capable of communicating with the BAS using one of the
       following interface options:
       1) Linear analog output signal: Field selectable, fuse protected and isolated, 0-
          10VDC and 4-20mA (4-wire)
       2) RS-485: Field selectable BACnet-MS/TP, ModBus-RTU and Johnson
          Controls N2 Bus
       3) Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, ModBus-
          TCP and TCP/IP
       4) LonWorks Free Topology
    g. The transmitter shall have an infrared interface capable of downloading individual
       sensor airflow and temperature data or uploading transmitter configuration data to
       a handheld PDA (Palm or Microsoft Pocket PC operating systems).
    h. The measuring device shall be UL listed as an entire assembly.
    i. The manufacturer’s authorized representative shall review and approve placement
       and operating airflow rates for each measurement location indicated. A written
report shall be submitted to the architect should any measurement location not meet the manufacturer’s placement requirements.

12. Installation: Install in accordance with manufacturer’s instructions at locations indicated. A written report shall be submitted to the architect if any discrepancies are found.

13. Adjusting: Duct and plenum devices shall not be adjusted without the Architect’s approval.

2.12 THERMOSTATS

A. Available Manufacturers:
   3. Tekmar Control Systems, Inc.

B. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

   1. Label switches "FAN ON-OFF" or "FAN HIGH-LOW-OFF" or "FAN HIGH-MED-LOW-OFF."
   2. Mount on single electric switch box.

C. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
   1. Automatic switching from heating to cooling.
   2. Preferential rate control to minimize overshoot and deviation from set point.
   3. Set up for four separate temperatures per day.
   4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
   5. Short-cycle protection.
   6. Programming based on every day of week.
   7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
   8. Battery replacement without program loss.
   9. Thermostat display features include the following:
      a. Time of day.
      b. Actual room temperature.
      c. Programmed temperature.
      d. Programmed time.
      e. Duration of timed override.
      f. Day of week.
      g. System mode indications include "heating," "off," "fan auto," and "fan on."

D. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

E. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical
rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.

F. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

G. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

H. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

I. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

J. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

K. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig, and cast housing with position indicator and adjusting knob.
2.13 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
2. Dampers: Size for running torque calculated as follows:
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
   c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
   e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
   f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
6. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
7. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
8. Temperature Rating: Minus 22 to plus 122 deg F.
9. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
2.14 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

C. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Thermostatic Operator: Liquid-filled integral sensor with integral remote adjustable dial.

2.15 DAMPERS

A. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.16 SMOKE DETECTORS

A. Smoke detectors shall be furnished under Division 28 and installed under this Section.

B. Wiring from smoke detectors to fire alarm system shall be under Division 28.

C. Wiring from smoke detectors to mechanical equipment shall be under this Section.
2.17 UNINTERRUPTIABLE POWER SUPPLY (UPS)

A. Available Manufacturers:
   1. APC
   2. Tripp lite
   3. Liebert Corporation; a division of Emerson.

B. Provide UPS sized for a run time of 10 minutes at full load, but no smaller than 300 W 7ah to keep all DDC controls on emergency generator running between transfer switch activation.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

A. Provide a designated project manager who will be responsible for the following:
   1. Construct and maintain project schedule
   2. On-site coordination with all applicable trades and subcontractors
   3. Authorized to accept and execute orders or instructions from owner/architect
   4. Attend project meetings as necessary to avoid conflicts and delays
   5. Make necessary field decisions relating to this scope of work
   6. Coordination/Single point of contact.

3.2 EXAMINATION

A. Verify that power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.3 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified in Section 23 section “Sequences of Control.”

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices next to light switch(es) when space is available with top of device at 48 inches above finished floor. Where space next to light switch(es) is not available, align device vertically with light switch and locate device with top at 40 inches above the finished floor.
1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

F. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

G. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

H. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

I. Control Wiring:
   1. All wiring, regardless of the voltage, required for the proper installation and operation of the BAS as described herein shall be furnished and installed by the BAS Contractor.
      a. All wiring shall be numbered or labeled at both ends.
   2. All electrical work shall be installed in complete accordance with the NEC and all local codes.
   3. All wiring in mechanical and electrical equipment rooms and in other areas where exposed and all power wiring to controllers shall be installed in EMT. Wiring exposed in existing occupied areas shall be installed in wiremold, neatly run parallel to the building lines and as near as possible to ceiling height.
      a. 120vac wiring to energize outboard gear devices will be fused inside the panel. Under no circumstances will the FIRST LEVEL CONTROLLER or SECOND LEVEL CONTROLLER have to be deenergized to deenergize outboard gear devices.
   4. Wiring qualifying as limited energy circuits according to the NEC may be run without conduit where concealed (but accessible) above lay-in acoustic tile ceilings. All limited energy circuits installed without conduit shall utilize cables specifically listed by UL and labeled as being suitable for the intended service. In addition, cables installed in ceilings that serve as environmental air plenums shall be specifically listed and labeled for plenum service. Cables installed without conduit must be neatly bundled, secured to the building structure (attachment to ceiling grid wires, threaded rod, or other equipment hangers or straps is not acceptable) and run parallel to the building lines.

J. All safeties such as freezestats, firestats, smoke detectors, etc. shall be hard wired to stop their respective equipment and return all controlled devices to their normal positions.

K. Control Relays and Current Sensing Relays, EP, PE, Etc: All control Relays and current sensing relays, EP’s, PE’s, etc., shall be located in a readily accessible location, and in a
proper type enclosure and that location shall be noted on control drawings. Installing these devices in pull boxes or in non-accessible locations will not be acceptable.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
7. Check temperature instruments and material and length of sensing elements.
8. Check control valves. Verify that they are in correct direction.
9. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.
3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
   a. Check analog inputs at 0, 50, and 100 percent of span.
   b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
   c. Check digital inputs using jumper wire.
   d. Check digital outputs using ohmmeter to test for contact making or breaking.
   e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
   a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
   b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
   a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
   b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
   b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.
C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.6 TRAINING

A. Provide 8 hours of training for Owner’s designated operating personnel. Training shall include:
   1. Explanation of drawings and operation & maintenance manuals
   2. Walk-through of the job to locate control components
   3. Operator workstation and peripherals
   4. Operation of Portable computer
   5. DDC controller and ASC operation/function
   6. Operator control functions including graphic generation and field panel programming
   7. Explanation of adjustment, calibration and replacement procedures

B. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Manufacturer. If necessary additional training will be contracted by the Owner at a later date.

C. Coordinate with Owner if video recording documentation of training is required.

END OF SECTION 250000