

**SECTION 230900  
BUILDING AUTOMATION SYSTEM**

**PART 1 - GENERAL**

**1.01 SCOPE OF WORK**

- A. The Facility Management and Control System (FMCS) Contractor shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control as herein specified. The system shall include all required computer software and licenses, hardware, controllers, sensors, transmission equipment, system workstations, local panels, conduit, wire, installation, engineering, database and setup, supervision, commissioning, acceptance test, training, warranty service and, at the owner's option, extended warranty service. System shall be Delta Controls by Atkinson Electronics.
- B. The system shall only employ BACnet communications in an open architecture with the capabilities to support a multi-vendor environment. The software package shall be sold and promoted by at least three independent controls manufacturers. It shall include the provisions to load and execute the toolsets of each of the three manufacturers including commissioning, configuring and programming of each manufacturer's equipment. The system shall be capable of integrating third party systems and utilizing the following standard protocols.
  - 1. BACnet communication according to ASHRAE standard ANSI/ASHRAE 135-2001 shall be the communication protocol for the FMCS.
  - 2. OPC server communications according to OPC Data Access 2.0 and Alarms and Events 1.0.
  - 3. Modbus communication for integration to third party devices.
- C. The FMCS shall be web based and shall provide total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet.
- D. The FMCS shall demonstrate, with (3) proof sources, integration with HVAC industry open standard protocols, including BACnet, ModBus, OPC and Internet standard SQL database and HTTP / HTML / XML text formats.
- E. The FMCS shall communicate to third party systems on this project including VFD's, boilers, ERV systems, transfer switches, and other building management related devices using any of the open, interoperable communication protocols referenced in Paragraph D.
- F. The FMCS shall be able to be monitored and controlled at the designated FMCS control Console at the site. All alarms shall annunciate and be displayed on the designated FMCS control console by owner.
- G. All materials and equipment used shall be standard components, regularly manufactured with standard part numbers and owner's manuals for this and/or other systems. One of a kind, third party or custom integrations devices designed especially for this project will not be allowed.
- H. The four pipe fan coil units serving the condos shall be provided with a Google Nest Learning Thermostat and independently controlled. The BMS shall not interface with these units.

## 1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Drawings and general provisions of the Contract, including General and supplementary Conditions and Division 1 specification sections, apply to work of this section.
- B. Products furnished but not installed under this section:
  - 1. Valves, flow switches, flow sensors, thermowells and pressure taps to be installed under Division 23.
  - 2. Automatic dampers to be installed under Division 23.
- C. Coordination with electrical:
  - 1. Installation of all line voltage power wiring by Division 26.
  - 2. Each motor starter provided under Division 26, shall be furnished with individual control power transformer to supply 120 volt control power and auxiliary contacts (one N.O. and one N.C.) for use by this section.

## 1.03 QUALITY ASSURANCE

- A. The system shall be furnished, engineered, and installed by the manufacturers' locally authorized representative. The controls contractor shall have factory-trained technicians to provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.
- B. At the time of bid, all BCS Application Specific Controllers and Programmable Equipment Controllers shall be listed as follows:
  - 1. Underwriters Laboratory UL 916
  - 2. FCC Regulation, Part 15, Class B

## 1.04 SUBMITTALS

- A. Submit electronic PDF documentation in the following phased delivery schedule for review:
  - 1. Valve and damper schedules
  - 2. Equipment data cut sheets
  - 3. System schematics, including:
    - a. sequence of operations
    - b. point names
    - c. point addresses
    - d. point to point wiring
    - e. interface wiring diagrams
    - f. panel layouts
    - g. system riser diagrams
  - 4. Software flow charts or logic diagrams or code as used by control manufacturer.
  - 5. AutoCAD® compatible as-built drawings
- B. 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, disk of system schematics, including wiring diagrams
3. Description of sequence of operations
4. As-Built interconnection wiring diagrams
5. User's documentation containing product, system architectural and programming information
6. Trunk cable schematic showing remote electronic panel locations, and all trunk data
7. List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
8. Conduit routing diagrams
9. Copy of the warranty/guarantee
10. Operating and maintenance cautions and instructions
11. Recommended spare parts list

## **PART 2 - PRODUCTS**

### **2.01 ACCEPTABLE MANUFACTURERS\**

- A. Delta Controls Inc by Atkinson Electronics or approved equal
- B. The Facility Management Control System (FMCS) shall be comprised of a network of interoperable, stand-alone digital controllers. The FMCS shall incorporate BacNet MSTP485 or Ethernet in all unitary, terminal and other device controllers. The system shall include:
- C. Programmable Equipment Controllers (PEC's) for control of primary mechanical systems and distributed system applications. Controllers shall be fully programmable to create custom control solutions.
- D. Network Area Controllers (NAC's) for distributed system applications, databases and networking functions.
- E. Application Specific Controllers (ASC's) for control of VAV terminal units, fan coil terminal units, unit vent terminal units, heat pump units and other terminal equipment.
- F. Graphical User Interface (GUI), which includes the hardware and software necessary for a user to interface with the control system and devices.
- G. The controller network shall use twisted pair wiring or loop. The PEC and ASC network shall communicate at a minimum 78Kbps using BACnet. The GUI and NAC shall reside on an Ethernet backbone.
- H. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices.

### **2.02 NETWORK AREA CONTROLLER (NAC)**

- A. The Network Area Controller (NAC) shall provide the interface between the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:
  1. Calendar functions
  2. Scheduling
  3. Trending
  4. Alarm monitoring and routing

5. Time synchronization
  6. Integration of BACnet and MODBUS networks
- B. The NAC shall provide multiple, concurrent user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
- C. The NAC shall support standard Web browser access via the Intranet/Internet. It shall be capable of supporting multiple users, expandable to fifty.
- D. The NAC shall provide alarm recognition, storage, routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
1. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
  2. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:
    - a. To alarm
    - b. Return to normal
    - c. To fault
  3. Provide for the creation of an unlimited number of alarm classes for the purpose of routing types and or classes of alarms, i.e. security, HVAC, Fire, etc.
  4. Provide timed (schedule) routing of alarms by class, object, group, or node.
  5. Provide alarm generation from binary object "runtime" and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- E. Alarms shall be annunciated in any of the following manners as user defined:
1. Screen message text
  2. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
    - a. Day of week
    - b. Time of day
    - c. Recipient
  3. Pagers via paging services that initiate a page on receipt of email message
  4. Graphic with flashing alarm object(s)
  5. Printed message, routed directly to a dedicated alarm printer
  6. Cell phones
- F. The following shall be recorded by the NAC for each alarm (at a minimum):
1. Time and date
  2. Location (building, floor, zone, office number, etc.)
  3. Equipment (air handler #, accessway, etc.)
  4. Acknowledge time, date, and user who issued acknowledgement.
- G. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.

- H. A log of all alarms shall be maintained by the NAC and/or a server and shall be available for review by the user.
- I. Provide a “query” feature to allow review of specific alarms by user defined parameters.
- J. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- K. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.
- L. Data Collection and Storage
  - 1. The NAC shall have the ability to collect data for any property of any object and store this data for future use.
  - 2. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
    - a. Designating the log as interval or deviation.
    - b. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
    - c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
    - d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
    - e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
  - 3. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.
  - 4. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
  - 5. All log data shall be available to the user in the following data formats:
    - a. HTML
    - b. XML
    - c. Plain Text
    - d. Comma or tab separated values
  - 6. The NAC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:
    - a. Archive on time of day
    - b. Archive on user-defined number of data stores in the buffer (size)
    - c. Archive when buffer has reached its user-defined capacity
- M. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1. Time and date
  2. User ID
  3. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.
- N. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
1. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.
  2. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

## 2.03 PROGRAMMABLE EQUIPMENT CONTROLLERS (PEC)

- A. Programmable Equipment Controllers (PEC's) shall be stand-alone, multi-tasking, real-time digital control processors.
- B. The PEC's shall communicate via native BacNet communication according to ASHRAE standard ANSI/ASHRAE 135-2001.
- C. The PEC must communicate peer-to-peer with all of the network application specific, programmable controllers and third party BacNet devices.
- D. The PEC software database must be able to execute all of the specified mechanical system controls functions. The programming software shall be able to bundle software logic to simplify control sequencing. All values, which make up the PID output value, shall be readable and modifiable at a workstation or portable service tool. Each input, output, or calculation result shall be capable of being shared/bound with any controller or interface device on the network.
- E. Provide programming, engineering, and configuration tools used for the project duly licensed to the owner for owner's use.
- F. PEC's shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- G. A single process shall be able to incorporate measured or calculated data from any and all other PEC's on the network. In addition, a single process shall be able to issue commands to points in any and all other PEC's on the network.
- H. Each PEC shall support firmware upgrades without the need to replace hardware.
- I. Each PEC shall continuously perform self-diagnostics, which include communication diagnosis and diagnosis of all components.
- J. In the event of the loss of normal power, there shall be an orderly shutdown of all PEC's 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 72 hours.
  1. Upon restoration of normal power, the PEC shall automatically resume full operation without manual intervention.

2. All PEC's control programming and databases must be stored in Flash memory, therefore eliminating data loss, down time and re-load time.
- K. Provide a separate PEC for each AHU or other HVAC system such that the inputs, calculations, and outputs shall reside on a single controller.

#### 2.04 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each Application Specific Controller (ASC) shall operate as a stand-alone BacNet compliant controller capable of performing its specified control responsibilities independent of other controllers in the network. Each ASC shall be a minimum 16-BIT microprocessor based, multi-tasking, multi-user, real time digital control processor.
- B. Controllers shall include all inputs and outputs necessary to perform the specified control sequences. Analog and digital outputs shall be industry standard signals such as 0-10V and 3-point floating control allowing for interface to a variety of industry standard modulating actuators. The ASC inputs and outputs shall consist of industry standards types. Inputs shall be electrically isolated from outputs, communications and power.
- C. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the network is not acceptable, whose network failure may cause building or equipment damage or failure.
- D. The ASC must be mounted remotely from the room sensor. ASC's, that are wall mounted with integral room sensors, are not acceptable.
- E. The control program shall reside in the ASC. The application program and the configuration information shall be stored in non-volatile memory with no battery back-up required.
- F. After a power failure the ASC must run the control application using the current set points and configuration. Reverting to default or factory setpoints are not acceptable.

#### 2.05 GRAPHICAL USER INTERFACE SOFTWARE (GUI)

- A. Command of points from multiple manufacturers shall be transparent to the operator.
- B. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The GUI software shall run on a Windows XP or newer 32-bit operating system. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line FMCS alarms and monitoring information. If the software is unable to display several different types of displays at the same time, the FMCS contractor shall provide at least two operator workstations at each location specified.
- C. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:
  1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures and streaming video.
  2. Provide programming, engineering, and configuration tools used for the project duly licensed to the owner for the owner's use.

3. A gallery of HVAC and automation symbols shall be provided, including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and symbols. The user shall have the ability to add custom symbols to the gallery as required.
  4. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
  5. Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
  6. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
    - a. Schedule times will be adjusted by mouse command using a graphical slider, without requiring any keyboard entry from the operator.
    - b. Holidays shall be set by mouse command using a graphical calendar, without requiring any keyboard entry from the operator.
  7. Commands to start and stop binary objects shall be done by mouse command from the pop-up menu. No entry of text shall be required.
  8. Adjustments to analog objects, such as set points, shall be done by mouse command using a graphical slider to adjust the value. No entry of text shall be required.
- D. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
1. Create, delete or modify control strategies
  2. Add/delete objects to the system
  3. Tune control loops through the adjustment of control loop parameters
  4. Enable or disable control strategies
  5. Generate hard copy records or control strategies on a printer
  6. Select points to be alarmable and define the alarm state
  7. Select points to be trended over a period of time and initiate the recording of values automatically
- E. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- F. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.
- G. All graphic displays shall be provided using web browser client as specified in 2.7.
- H. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.



- I. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

## 2.06 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer® or Netscape Navigator®. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Web page access and control shall be from system Network Area Controllers, or the Workstation.
- C. The Web browser shall provide the same system view, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- D. The Web browser client shall support at a minimum, the following functions:
  - 1. User log-on identification and password security shall be required and implemented using Java authentication and encryption techniques to prevent unauthorized access. If an unauthorized user attempts access, a blank web page shall be displayed.
  - 2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
  - 3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
  - 4. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client machine are not acceptable.
  - 5. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
  - 6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    - a. Modify in a graphical manner, common application objects, such as schedules, calendars, and set points. Schedule times will be adjusted by mouse command using a graphical slider, without requiring any keyboard entry from the operator. Holidays shall be set by mouse command using a graphical calendar, without requiring any keyboard entry from the operator.
    - b. Commands to start and stop binary objects shall be done by mouse command right-click of the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
    - c. View logs and charts
    - d. View and acknowledge alarms

7. The system shall provide the capability to specify a user's home page (as determined by the log-on user identification). From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

## 2.07 PROJECT SPECIFIC WEB PAGES

- A. Home page shall include a campus layout of the individual buildings at the site. Once an individual building is selected the following minimum web-based tree structure shall be provided:
  1. Documents Page: The document page shall include the O&M and Systems Manuals for the control system in PDF format along with AutoCAD drawings for each drawing provided in the control system O&M Manual. This document page shall include links between the control diagrams and associated data sheet in PDF format, such that the system user shall be able to click on the control device and retrieve, in PDF format, the factory O&M sheets associated with that device.
  2. Station Functions:
    - a. Logging separate sheet of station functions for a particular selected building shall be the viewing of one or more logs or the creation of logs in which any value at any point, or the mode of any point, shall be selected via the web to be trended against any other point with an adjustable frequency in seconds, minutes, hours, or days.
    - b. The alarm acknowledgement via the web shall allow the viewing and acknowledgement of the alarms.
    - c. Audit log shall be provided via the web to show the operator actions as well as other audit logs as specified in section 2.5 Network Area Controller (NAC) paragraph "M" Data Collection and Storage.
  3. Floor Plans:
    - a. AutoCAD drawings of floor plans shall be provided in the control system such that via the web the user shall be able to turn layers on and off on the mechanical floor plans. These floor plans shall also include an overlay of the temperature control as-built wiring for the project showing thermostat locations, communication runs, transformer locations, controller locations, etc.
    - b. Floor Display Summaries: the operator shall be able to select floor plans displaying the following formats:
      - 1) All zone temperatures
      - 2) All zone heating percentages
      - 3) All zone cooling percentages
      - 4) All zone room names and numbers (Owner shall provide a list of zone names desired)
      - 5) All zones CFM delivered
    - c. Upon selecting a graphical floor plan layout the web page shall show all the zone temperature sensor locations on the floor. By clicking on the zone temperature location, an individual Heat Pump graphic shall be displayed with the following attributes:

- 1) A manual menu that shall allow the operator to manually set the air flow set point, space temperature set point, damper position, cooling percentage, heating percentage, and zero the box.
- 2) A 24 hour log chart that shows space temperature history, flow history, and allows the operator to build custom charts by comparing this log to other associated selectable logs.
- 3) A display of the Heat Pump discharge temperature, space temperature, and space temperature set point.
- 4) A bar graph that shows current air floor set point, percentage of heating and cooling in a thermometer-like fashion and changes color based on heating or cooling mode.
- 5) The occupancy status, room name and heating/cooling mode shall also be shown.

4. Systems:

- a. On selecting the systems menu, a tree structure shall allow the operator to select the boilers, control valves, pumps, heat pumps, closed circuit cooler, ERV's, etc. systems associated with that building. See points lists for specifics. Each system in the points list shall be treated as a branch of the tree above.
- b. All devices that provide dynamic function in the primary equipment, i.e., fans, pumps, coils, dampers shall be dynamic in nature showing their operating status/percentage of capacity by movement on the web page.
- c. The set points for the various control loops shall be adjustable via the web page. Individual controlled devices, i.e., valves, dampers, and fans shall be controlled via the web page and be stopped or started or placed in a command state or percentage of value output.
- d. Logging and trending shall be provided to meet the commissioning, measurement and verification section of the specifications.

2.08 FIELD DEVICES

- A. Provide automatic control valves, automatic control dampers, thermostats, clocks, sensors, controllers, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published information, designed and constructed as recommended by manufacturer.
- B. Temperature Sensors
  1. Temperature Sensors: Temperature sensors shall be linear precision elements with ranges appropriate for each specific application.
  2. Space (room) sensors shall be available with setpoint adjustment and override switch.
  3. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be installed according to manufacture recommendation and looped and fastened at a minimum of every 36 inches.
  4. Sunshields shall be provided for outside air sensors.
  5. Thermo-wells for all immersion sensors shall be stainless steel or brass as required for the application.
- C. Humidity Sensors: Humidity sensors shall be of the solid-state type using a capacitance-sensing element. The sensor shall vary the output voltage with a change in relative humidity. Humidity sensors shall have a minimum range of 10% to 90%  $\pm 5\%$  and 30% to 70%  $\pm 3\%$  accuracy.

- D. Pressure Sensors: The differential pressure sensor shall be temperature compensated and shall vary the output voltage with a change in differential pressure. Sensing range shall be suitable for the application with linearity of 1.5% of full scale and offset of less than 1% of full scale. Sensor shall be capable of withstanding up to 150% of rated pressure without damage.
- E. CO<sub>2</sub>/TVOC SENSORS: The CO<sub>2</sub> sensor shall be a non-dispersive infrared sensor. The diffusion gas chamber in the sensor shall incorporate a gold plated, reflective light pipe or waveguide surrounded by a permeable teflon based hydrophobic diffusion filter that prevents particulate and water contamination of the sensor. The sensor shall incorporate elevation correction adjustment and have an accuracy of plus or minus 50 ppm or 5% (7% for levels over 1500 ppm) at temperatures of 60-90 Degrees F (15-32 Degrees C). The TVOC Sensor shall incorporate Metal Oxide Semiconductor technology. The calibration range shall be 0-50 ppm using isobutylene gas. It shall have an accuracy of plus or minus 2 ppm (as isobutylene), it shall detect VOCs, such as methanol, vaporized solvents, methane, nitromethane and methylene chloride. The resolution shall be 1ppm and a minimum response time of 30 seconds. For ease of installation, the sensors shall have a detachable base with all field wiring terminals on base.
- F. Switches and Thermostats
  - 1. The FMCS Contractor shall furnish all electric relays and coordinate with the supplier of magnetic starters for auxiliary contact requirements. All electric control devices shall be of a type to meet current, voltage, and switching requirement of their particular application. Relays shall be provided with 24 VAC coils and contacts shall be rated at 10 amps minimum.
  - 2. Duct Smoke Detectors: Duct smoke detectors shall be supplied by others with an integral auxiliary contact to be used by the FMCS contractor to provide a digital input to the FMCS.
  - 3. Low Temperature Detection Thermostats: Thermostats shall be the manual reset type. The thermostat shall operate in response to the coldest one-foot length of the 20-foot sensing element, regardless of the temperatures at other parts of the element. The element shall be properly supported to cover the entire downstream side of the coil with a minimum of three loops. Separate thermostats shall be provided for each 25 square feet of coil face area or fraction thereof.
  - 4. Differential Pressure Switches: Pressure differential switches shall have SPDT changeover contact, switching at an adjustable differential pressure setpoint.
  - 5. Current Sensing Relays: Motor status indications, where shown on the plans point list shall be provided via current sensing relays. The switch output contact shall be rated for 30 VDC, .15 amps.
  - 6. Flow Switches: Motor status indications, where shown on the plans point list, shall be provided via flow switches. Flow switches shall be of the paddle type equipped with SPDT contacts to establish proof of flow.
  - 7. The sensors shall be constructed of materials that resist corrosion due to the presence of salt or chemicals in the air; all non-painted surfaces shall be constructed of stainless steel. The electronics enclosure shall be NEMA 1.
  - 8. The monitor/controller shall be the VOLU-flo/OAM as manufactured by Air Monitor Corporation, Santa Rosa, California or equal by Ebtron.
- G. Control Valves
  - 1. General: Control Valves up to 4 inches shall be globe or characterized ball valves and shall be sized for a 3 to 5 PSI pressure drop. Valves shall be packless, modulating, electrically or magnetically actuated, with a control rangeability of 100 to 1. These valves shall have equal percentage flow characteristics in relationship to valve opening.

2. ½ Inch to 4 Inch: Valves shall be equipped with handwheel, or manual position mounted dial adjacent to valve, to allow manual positioning of valve in absence of control power. (Valves with a rangeability of less than 200 to 1 shall utilize two valves in a 1/3 – 2/3 parallel arrangement in order to achieve control rangeability).
  3. 4 Inches to 6 Inches: Valves for heating shall be globe valves modulating electrically actuated, 2-way or 3-way as required, with a rangeability of 50 to 1. Valve body shall be flanged and shall be equipped with a handwheel, or manual position dial mounted adjacent to the valve, to allow manual positioning of the valve in the absence of control power. Valves for cooling shall be butterfly with a rangeability of 25 to 1.
  4. Butterfly Valves: 2-way and 3-way butterfly valves shall be cast iron valve body, with stainless steel stem, and available with disc seal for bubble-tight shut off.
- H. Damper Actuators: Actuators shall be of the push-pull or rotary type of modulating, 3-point floating, or 2-position control as required by the application. The actuator shall use an overload-proof synchronous motor or an electric motor with end switches to de-energize the motor at the end of the stroke limits. Control voltage shall be 24 VAC, 0-20 VDC, or 4-20 ma as required. Actuators shall be available with spring return to the normal position when required. Actuators shall have a position indicator for external indication of damper position. Actuators shall have manual override capability without disconnecting damper linkage.

I. CONTROL DAMPERS

1. Motorized dampers, unless otherwise specified elsewhere, shall have damper frames using 13 gauge galvanized steel channel or 1/8" extruded aluminum with reinforced corner bracing. Damper blades shall not exceed ten (10) inches in width or 48" in length. Blades are to be suitable for high velocity performance. Damper bearings shall be as recommended by manufacturer for application. Bushings that turn in the bearing are to be oil impregnated sintered metal. All blade edges and top and bottom of the frame shall be provided with replaceable, butyl rubber or neoprene seals. Side seals may be spring-loaded stainless steel. The seals shall provide a maximum of 1% leakage at a wide open face velocity of 1500 FPM and 4: W.C. close-off pressure. The damper linkage shall provide a linear flow or equal percentage characteristic as required. Provide Ruskin or equal.
2. Control dampers shall be parallel or opposed blade type as scheduled on drawings or outdoor and return air mixing box dampers shall be parallel blade, arranged to direct air streams towards each other. All other dampers may be parallel or opposed blade types.

**PART 3 - EXECUTION**

3.01 PROJECT MANAGEMENT

- A. Provide a project manager who shall, as a part of his duties, be responsible for the following activities:
1. Coordination between the Controls Contractor and all other trades, Owner, local authorities and the design team.
  2. Scheduling of manpower, material delivery, equipment installation and checkout.
  3. Maintenance of construction records such as project scheduling and manpower planning and AutoCAD or Visio for project co-ordination and as-built drawings.
  4. Coordination/Single point of contact.

3.02 INSTALLATION METHODS

- A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division-16 sections of these specifications.
- B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices.
- C. All wiring, low and line voltage subject shall be run in conduit (minimum ¾"). Line and low voltage wiring shall be run in separate conduits.
- D. All Controllers, Relays, Transducers, etc., required for stand-alone control shall be housed in a NEMA 1 enclosure with a lockable door.

### 3.03 SYSTEM ACCEPTANCE

- A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.
- B. Field Equipment Test Procedures: DDC control panels shall be demonstrated via a functional end-to-end test. Such that:
  - 1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operation verified.
  - 2. All analog input channels shall be verified for proper operation.
  - 3. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.
  - 4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.
  - 5. Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.
  - 6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.
- C. As-Built Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply six complete as-built drawing sets, together with AutoCAD® diskettes to the owner.
- D. Operation and Maintenance Manuals: Submit four copies of operation and maintenance manuals. Include the following:
  - 1. Manufacturer's catalog data and specifications on sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.
  - 2. An operator's manual that will include detailed instructions for all operations of the system.
  - 3. An operator's reference table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
  - 4. A copy of the warranty/guarantee.

5. Operating and maintenance cautions and instructions.

#### 3.04 WARRANTY/GUARANTEE

- A. The control shall be warranted to be free from defects in both material and workmanship for a period of one (1) year of normal use and service. This warranty/guarantee shall become effective the date the owner accepts or receives beneficial use of the system as defined by Utah state law.

END OF SECTION 23 09 00