SECTION 23 09 00

HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

1.2 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. Related Sections include the following:

1. Division 26 Section "Fire Alarm" for fire and smoke detectors mounted in HVAC systems and equipment.

2. 230993 -Sequence of Operation

1.3 DEFINITIONS

A. ATC: Automatic Temperature Control.

B. BMS: Building Management System.

C. CFM: Cubic Feet per Minute.

D. CMMS: Computerized Maintenance Management System.

E. DDC: Direct-digital controls.

F. FAS: Fire Alarm System.

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

H. LAN: Local area network.

I. LCD: liquid Crystal Display.

J. MER: Mechanical Equipment Room.

K. MS/TP: Master-slave/token-passing.

L. PICS: Protocol Implementation Conformance Statement.

M. PID: Proportional Integral Derivative.

N. POT: Portable Operators Terminal.

O. VAV: Variable air volume.

P. VFD: Variable Frequency Drive.

1.4 SYSTEM DESCRIPTION

A. Control system consists of sensors, indicators, acuators, final control elements, interface equipment, other apparatus and accessories to control mechanical systems. The entire system shall be BACnet, open protocol all web interfaced. The web server shall be provided by this contractor and include all protocols to assure a complete and functioning web based interfaced system.

B. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories and software connected to distributed controllers operating in multi-user, multitasking environment on token-passing network and programmed to control mechanical systems. All systems and components shall have wireless access.

C. Control system includes the following:

1. Building lighting control system specified in Division 26 Section "Network Lighting Controls."

2. Fire alarm system specified in Division 26 Section "Fire Alarm."

1.5 WORK INCLUDED

A. The control system shall tie into the existing Honeywell system. Provide necessary panels for new controls. Provide new graphics at existing front-end for new scope of work.

B. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all global controllers, logic controllers, and all input/output devices. Items of work included are as follows:

1. Provide a submittal that meets the requirements below for approval.

2. Coordinate installation schedule with the mechanical contractor and Construction Manager

3. Provide installation of all panels and devices unless otherwise stated.

4. Provide power for panels and control devices from a source designated by the electrical contractor.

5. Provide all low voltage control wiring for the DDC system using plenum rated cable or wire and conduit where exposed and/or as installed all mechanical or electrical spaces

6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.

7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.

8. Provide testing, demonstration and training as specified below.

9. Provide connections to lighting relay panels, room occupied/unoccupied sensors and coordinate control with Electrical Contractor.

10. Provide connections for all monitoring of all owner power metering and coordinate requirements with Electrical Contractor.

1.6 SUBMITTALS

A. 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. All such documents shall be in PDF format with no exceptions.

1. Each control device labeled with setting or adjustable range of control.

B. 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. All such documents, including drawings, shall be in PDF format with no exceptions. All drawings and control wiring diagrams will be in 11" x 17" format. Submittal shall include the following as a minimum:

1. Schematic flow diagrams showing fans, pumps, chillers, boilers, cooling towers, air handling units, coils, dampers, valves, instrumentation and control devices.

2. Of special note-
The shop drawing package and flow diagrams shall also contain complete schematics, wiring diagrams and control sequences for equipment such as boilers, chillers, variable frequency drives, lighting relay panels, etc. that have internal control sequences that might not be directly controlled by the BMS but are part of the overall BACnet system even though those particular control devices aren't supplied by the BMS Contractor.

3. Specification sheets of sensors, transmitters, controllers, actuators, relays, switches, and miscellaneous control devices.

4. Wiring Diagrams: Power, signal, and control wiring for all systems and components.

5. Symbol and abbreviation list for control diagrams.

6. Details of control panel faces, including controls, instruments, and labeling.

7. Schedule of dampers including size, leakage, and flow characteristics.

8. Schedule of valves including leakage and flow characteristics, GPM, pressure drop, and CV at a minimum.

9. All input/output (I/O) device submittals shall indicate the unique identifier listed in these Sections.

10. Complete system, device, equipment and operational sequence of operations for all building/infrastructure systems regardless of what contractor and/or supplier might have supplied such systems as long as connected to the BMS these sequences shall be part of and included in the submitted sequences.

11. Pads, foundations, anchorages, supports and attachments to the building structure where required for the installation of the work shall be shown in layout and in detail with sizes, dimensions, materials and methods of construction noted.

12. All shop drawings used by field personnel for the installation of equipment shall bear an Engineer's approval stamp.

13. Architectural floor plans indicating proposed locations of all wall-mounted devices (i.e. DDC units, control panels, sensors, thermostats, etc.) and mechanical drawings indicating proposed locations of all temperature, flow, and pressure transmitters.

14. Field quality-control test reports.

15. Operation and maintenance data.

16. Qualification Data and Project Manager Resume for firms and from persons specified in "Quality Assurance" Article.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.

B. 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.

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

D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

E. All portions of the system must be of the same manufacturer and must be designed, furnished, installed, commissioned and serviced by manufacturer-approved, factory-trained employees.

F. Single source responsibility of supplier shall be the complete installation and proper operation of the BMS and control system and shall include debugging and proper calibration of each component in the entire system.

G. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory, and all necessary test and diagnostic equipment.

H. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

I. BMS shall comply with UL 916 PAZX and UL 864 UDTZ and be so listed at the time of bid.

J. All system components shall be fault-tolerant. System shall include:
   1. Satisfactory operation without damage at 110% and 85% of rated voltage and at 3 Hertz variation in line frequency.

   2. Static, transient and short-circuit protection on all inputs and outputs.

   3. Protection for communication lines against incorrect wiring, static transients and induced magnetic interference.

   4. Network-connected devices to be AC coupled or equivalent so that any single device failure will not disrupt or halt network communication.

   5. All real time clocks and data file RAM to be battery-backed for a minimum 100 hours and include local and remote system low battery indication.

K. The BMS Contractor shall employee a Project Manager dedicated to this project who shall be regularly engaged in the installation and maintenance of the BMS systems specified under this section and shall meet the following qualifications:
   1. A minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of BMS systems similar in size and complexity to this project.

2. A minimum of ten (10) years experience installing the control system of the manufacturer that they work for.

3. Shall be a certified-to-install, direct representative/direct employee of the control system manufacturer.

4. The system manufacturer/installer shall submit resumes to the Construction Manager of the proposed experienced project manager, meeting the above qualifications, for this work from beginning of control installation until final completion. The project manager is responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager, and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion. If the BMS manufacturer/contractor wishes to change the project manager, the construction manager and/or owner's representative must be notified immediately and both the new project manager and the previous project manager shall spend 3 consecutive business days together on-site performing a project management switchover. No excerptions shall be allowed.

L. Comply with all current governing codes, ordinances, and regulations including UL, NFPA, the local Building Code, NEC, etc.

M. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to Primary Control Panels, Secondary Control Panels, personal operator workstations, and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters

1.8 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 unit manufacturer.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 26 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 26 Section "Enclosed Controllers" and Sections 230514-"Enclosed Controllers" and 230515 "Variable-Frequency Motor Controllers" to achieve compatibility with motor starters and annunciation devices.

D. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with relay panels and controls.

1.10 EXTRA MATERIALS

A. Maintenance Materials: One thermostat adjusting key.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

1. Honeywell

2.2 CONTROL PANELS

A. Central Master Control Panels: Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide multicolor graphic displays, schematically showing system being controlled.

B. Local Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

1. Fabricate panels of 0.06" thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.

2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.

3. Door-Mounted Equipment: Flush-mount on hinged door manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.

4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

C. Alarm Panels: Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted in hinged-cover enclosure.

1. Alarm Condition: Indicating light flashes and horn sounds.

2. Acknowledge Switch: Horn is silent and indicating light is steady.

3. Second Alarm: Horn sounds and indicating light is steady.

4. Alarm Condition Cleared: System is reset and indicating light is extinguished.

5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.3 PRIMARY CONTROL PANEL HARDWARE

A. Spare Capacity

1. All Primary Control Panels shall be installed with 10% spare points (of each type) and 10% spare memory capacity for future connections. The type of spare point capacity shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:

   a. Expansion modules
   b. Sensor/actuator
   c. Field wiring/tubing

B. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation. All panels shall be BACnet open protocol web based/wireless.

C. Each Primary Control Panel shall, at a minimum, be provided with:

1. Appropriate NEMA rated metal enclosure.

2. An integral real-time clock.

3. A 32bit, stand-alone, multi-tasking, multi-user, real-time 48MHz digital control microprocessor module.

4. Primary Network wireless communication module for primary network communications.

5. Memory module (72MB, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system

and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.

6. Data collection/ Data Trend module sized for 10,000 data samples.

7. Power supplies as required for all associated modules, sensors, actuators, etc.

8. Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

9. Monitoring of the status of all HOA switches and all variable frequency drives. The status of the HOAN switch shall be available as a BMS wireless data point and all variable frequency drives shall be trend logged (kWh) and totalized.

10. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.

11. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

12. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.

13. Graduated intensity LEDs or analog indication of value for each analog output.

D. The web operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. These override switches shall be operable whether the panel processor is operational or not. Provide HOA switch for each digital output, including spares. Provide hand/auto switch and gradual positioning potentiometer for each analog output, including spares.

E. Each Primary Control Panel shall continuously perform self-diagnostics on all hardware modules and network wireless communications. The Primary Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

F. Each Primary Control Panel shall provide DIN RAIL UPS's to support the real-time clock and all memory and programs for a minimum of 100 hours. UPS's shall send a signal to BMS when on-battery, low batter, or replace battery is sensed.

G. Each Primary Control Panel shall support firmware upgrades without the need to replace hardware.

H. Each controller shall support a minimum of 3 directly connected associated secondary networks.

I. Primary control panels shall provide at least two EIA-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. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

J. Provide one primary control panel minimum to each AHU, AC unit, chilled water system and for each floor zone, area and/or as required to maintain the minimum spare points.

K. Immunity to power and noise.

1. Controller shall be able to operate at 90% - 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2. Operation shall be protected against electrical noise of 5 -120Hz and from keyed radios up to 5W at 3ft.

3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V

b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8kV air discharge, 4kV contact.

c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1kV power

d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)

4. Isolation shall be provided at all Primary Controller's AC input terminals to suppress induced voltage transients consistent with:

a. IEEE Standard 587 1980

b. UL 864 Supply Line Transients

c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.4 PRIMARY CONTROL PANEL SOFTWARE

A. Furnish the following applications software to form complete wireless operating system for building and energy management as described in this specification.

B. Provide all necessary software for a complete operating system as required. All software shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

C. All points, panels and programs shall be identified by a 30 character name and a 16 character point descriptor. The same names shall be displayed at both the Primary Control Panel(s) (via portable terminal, printer or modem) and via the web browser for complete system wide wireless access, display, control and monitoring.

D. All digital points shall have a user-defined, two-state status indication with 8 characters minimum (e.g. Summer, Enabled, Disabled, Abnormal).

E. System Security:

1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.

3. Primary Controllers shall be able to assign to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.

4. User Log On/Log Off attempts shall be recorded.

5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

F. Each Primary Control Panel shall, at a minimum, be provided with software for:

1. Two-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.

2. Limiting the number of times each piece of equipment may be cycled within any one-hour period.

3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. Upon the resumption of power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

4. Priority load shedding (All zones).

5. Energy management routines including time of day scheduling, room occupied/unoccupied, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

6. Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.
   a. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

   b. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.

   c. Any process shall be able to issue commands to points in any and all other controllers in the system via the BACnet, open protocol web based system.

   d. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

   e. The custom control programming feature shall be documented via English language descriptors.

   f. Each controller shall support text comment lines in the operating program to allow for quick troubleshooting, documentation and historical summaries of program development.

   g. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.

7. Generate and receive automatic and manual operator messages and advisories.

8. Comment lines for all programs.

9. Distributed, independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of six priority levels shall be provided for each point.

10. Automatically accumulate and store run-time hours for all digital points.

11. Automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for all analog and pulse input type points

G. Trend data shall be stored at the Primary Control Panels and automatically uploaded to the PC workstation. Uploads shall occur based on user-defined intervals, manual commands, or automatically when the trend buffer is 80% full. All trend data shall be available for use in any 3rd party personal computer applications located in the BMS.

H. Primary Control Panels shall be able to assign password access and control priorities to each system individually. The logon password (at any PC workstation(s) or POT) shall enable the operator to monitor, adjust and/or control only the systems, programs, primary control panel, and/or secondary control panels that the operator is authorized for. All other systems, programs, primary and secondary control panels shall not be displayed at the PC workstation, POT, or modem. Passwords and priority levels for each system, program, primary control panel and secondary control panel shall be fully programmable and adjustable.

I. Primary Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Primary Control Panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Primary Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The system web browser shall allow complete communication/feedback/control capabilities.

J. 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.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

a. Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

5. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

K. Scheduling:

1. Provide a comprehensive menu driven program to automatically start and stop designated object or group of objects in the system according to a stored time.

2. It shall be possible to define a group of objects as a custom event (Le. meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.

3. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and stop within that group.

4. The operator shall be able to define the following information:

a. Time, day

b. Commands such as on, off, auto, and so forth.

c. Time delays between successive commands.

d. There shall be provisions for manual overriding of each schedule by an appropriate operator.

5. It shall be possible to schedule calendar-based events up to one year in advance based on the following:

a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, pre-cool/pre-heating (warm-up) and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.

b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on

the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

L. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

M. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

N. Enthalpy switchover (economizer). The Primary Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air enthalpy falls below changeover set point the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on enthalpy and will be able to override the economizer cycle and return to minimum outside air operation at any time.

O. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and PID gains shall be user-selectable.

P. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

Q. Staggered Start:

1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order, in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.

2. Upon the resumption of power, each Primary Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

R. Totalization:

1. Run-Time Totalization. Primary Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.

2. Consumption totalization. Primary Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points. This shall include all motors/devices controlled by Variable Frequency Drives.

3. Event totalization. Primary Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all

points. The event totalization feature shall be able to store the records associated with events before reset.

S. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points for a minimum of 5 years.

1. DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group and communication to the network. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of I minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.

b. Trend data shall be stored at the DDC Controllers and automatically uploaded to the web browser wireless network. Uploads shall occur based upon user-defined interval, manual command or automatically when the trend buffers are 80% full. All trend data shall be available for use in any 3rd party personal computer applications located on the MLN.

c. DOC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for a minimum of 36 operator-selected PID control loops. Provide capability to view or print trend and tuning reports.

1) The controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.

2) Loop tuning shall be capable of being initiated either locally at the DOC Controller, from a network workstation, or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

T. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

U. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for all analog and digital pulse input type points.

V. DDC Controllers shall count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, and monthly basis for all points. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events or five years before reset, whichever is greater.

W. Each Primary DDC Controller shall have enough memory to buffer and store all trend and alarm data for that primary controller during a network outage (16 MB minimum for each primary DDC Controller).

2.5 SECONDARY CONTROL PANEL HARDWARE

A. Each Secondary Control Panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each secondary control panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

B. Each Primary Controller shall be able to communicate with secondary controllers over the Secondary Network to control terminal equipment only.

C. The use of Secondary Network controllers with custom program applications to control AHU's, water systems, etc. is not acceptable.

D. Each secondary controller shall include all point inputs and outputs necessary to perform the specified control sequences. The secondary controller shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs may be utilized either for two-state, modulating, floating, or proportional control, allowing for additional system flexibility.

E. Provide a Secondary Control Panel for each of the following types of equipment (if applicable):

1. Constant Air Volume (CAV) boxes.

2. Duct-mounted coils.

3. Space/room humidifiers.

4. Variable Air Volume (VAV) Boxes (Supply).

5. Room Pressurization.

6. Other terminal equipment

F. Each Web Interfaced Secondary Control Panel shall, at a minimum, be provided with:

1. Appropriate NEMA rated enclosure.

2. A stand-alone real-time digital control microprocessor module.

3. Secondary network communications ability.

4. Power supplies as required for all associated modules, sensors, actuators, etc.

5. Input/output points as required.

6. Software as required for all sequences of operation, logic sequences, and energy management routines. Relay logic is not acceptable.

7. A portable operator terminal connection port.

8. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.
9. Local LED status indication for each digital input and output.

10. Each controller measuring air volume shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

11. Each controller measuring air volume shall include a differential pressure transducer.

12. Lighting control.

13. Fan relay for cabinet unit heaters.

G. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

H. Control Algorithms. The controller shall receive its real-time data from the Primary Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

I. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

J. Calibration. Each VAV box controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

1. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

K. Each Secondary Control Panel shall continuously perform self-diagnostics on all hardware and secondary network communications. The Secondary Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication to the system.

L. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the Universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of Universal outputs, provide a minimum of 50% spare outputs of each type via additional point termination boards or controllers. Analog outputs shall be industry standard signals such as 24VAC floating control, allowing for interface to a variety of modulating actuators. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable.

M. Provide each secondary control panel with sufficient memory to accommodate point databases, operating programs, local alarming, and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM, and PROM, or a minimum of 72hr battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPS's) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

N. The secondary control panels shall be powered from a 24VAC source provided by this contractor and shall function normally under an operating range of 18 -28VAC (-25% -17%), allowing for power source fluctuations and voltage drops. Install plenum data line and sensor cable in accordance with local code and NEC. The BMS Contractor shall provide a dedicated power source and separate isolation transformer for each controller to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° -122°F (0° -50°C) and 10% -95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The BMS Contractor shall provide 24VAC power to the terminal units by utilizing:

1. The building line voltage power trunk and installing separate isolation transformers for each controller.

2. Dedicated line voltage power source and isolation transformers at a central location and installing 24VAC power trunk to supply multiple ASC's in the area.

O. Environment. The controllers shall function normally under ambient conditions of 320-122°F (00-500 C) and 10% -95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

P. Immunity to noise. Operation shall be protected against electrical noise of 5 -120Hz and from keyed adios up to 5W at 1m (3ft).

2.6 SECONDARY CONTROL PANEL SOFTWARE

A. Provide all necessary software for a complete operating system as required. All software shall reside in each Secondary Control Panel. Secondary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

B. Secondary control panel software configured for CAV or VAV control algorithms shall include provisions for manual and automatic calibration of attached differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

C. Each secondary controller shall perform its primary control function independent of primary controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the primary control panel time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) control for all applications. All PI parameters shall be field-adjustable by the user via a portable operator's terminal.

D. Secondary control panels shall support pressure independent terminal boxes including VAV cooling only, VAV with hot water reheat, induction VAV with hot water reheat and CV with hot water reheat. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

2.7 PERSONAL COMPUTER OPERATOR WORKSTATION SOFTWARE

A. General

1. Provide software which includes the following:

a. Scheduling and override of building operations.

b. Collection and analysis of historical data.

c. Editing, programming, storage, and downloading of controller databases, programs, and parameters.

d. Microsoft Office 2012 as a minimum.

e. A 32-bit, multi-tasking Microsoft Windows NT 4.0/Windows XP environment that allows the user to run several applications simultaneously. Other Windows applications shall run simultaneously with the BMS software including, but not limited to, Word, Excel, Access, etc.

f. Provide a user interface that shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.

g. The operator shall be able to drag and drop information between applications (e.g. click on a point in the alarm screen and drag it into the dynamic trend graph screen to initiate a dynamic trend).

h. Operator specific password access protection shall allow the user to limit workstation control, display, and data base manipulation capabilities for each object in the system. An object shall be defined as any input or output point, setpoint, system program, etc. The operator privileges shall "follow" the operator to any workstation or Primary Control Panel that the operator logs on to. Provide a minimum of 1000 passwords.

i. Operators will be able to perform only those commands on the objects available based on their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.

j. An audit trail report to track system object changes that shall record operator initiated actions. These actions shall include, but not be limited to, changes made by a particular person, changes made to a specific piece of equipment, and/or changes made during a designated time frame. The changes shall be printed and archived for future reference either on command or automatically, at the operator's option. The operator activity tracking data shall be stored in a tamper proof buffer.

k. Software shall allow the operator to perform commands including, but not limited to:

    1) Start up and shutdown of equipment.

    2) Setpoint adjustment.

    3) Add/modify/delete time programming.

4) Enable/disable process execution.

5) Lock/unlock alarm reporting.

6) Enable/disable totalization and/or trending.

7) Override PID loop setpoints.

8) Enter temporary override schedules.

9) Define holiday schedules.

10) Change time/date.

11) Automatic daylight savings time adjustments.

12) Enter/modify analog warning and alarm limits.

l. Reporting

1) Reports shall be generated and directed to CRT displays, printers, or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

A general listing of all points in the network.

List of all points currently in alarm.

List of all points currently in override status.

List of all disabled points.

List of all points currently locked out.

DDC Controller trend overflow warning.

List all weekly schedules.

m. Scheduling

1) Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide schedules for 365 days in advance.

2) Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.

3) Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all points that can be commanded residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.

n. Collection and Analysis of Historical Data

1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data shall be stored on hard disk for future diagnostics and reporting.

2) Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred directly to an off-the-shelf spreadsheet package such as Excel. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.

3) Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both historical and/or real-time dynamic point data. A minimum of 10 points shall be viewed simultaneously on a single graph. The user may pause the graph and take "snapshots" of screens to be stored on the hard disk for future recall and analysis. Displays shall include an 'X' axis indicating elapsed time and a 'V' axis indicating a range scale in engineering units for each point. The 'V' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'V' axis. All 'V' axis data shall be color-coded to match the line color for the corresponding point.

4) Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.

5) Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling

times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

o. Dynamic Color Graphic Displays

1) All workstation(s) shall be provided with color graphics. All workstation(s) software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

2) Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS. Provide scaled floor plans indicating equipment location, service, and system data as required.

3) Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems, and hot water systems to optimize system performance analysis and speed alarm recognition.

4) MMC Compliance manager and MMC lead HVAC supervisor shall sign-off on all Honeywell EBI graphic changes.

5) The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

6) Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

7) The windowing environment of the PC operator workstation(s) shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

8) Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays via an off the shelf graphics package similar to MicroGraphix Designer.

9) Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, YAY, etc.) and electrical symbols.

10) Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points that aids the operator in the analysis of the facility.

11) Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers, PC workstation(s), and networks.

12) Provide a separate dynamic display page of each HVAC System (AHU, chiller, boiler, hot water pump and loop, etc.), electrical, and/or plumbing system connected to the BMS.

13) Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

14) Provide an additional (10) separate dynamic, graphic display pages at each workstation as required by the operating staff to further assist in daily system operations.

15) Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

16) The graphic integration shall include the downloading, reformatting and creation of all other systems and graphics currently monitored by this existing American Energy Management System.

2. System Configuration and Definition

a. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

b. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add, delete, or modify any system object including Primary Control Panel(s), operator workstations(s), Secondary Control Panels, reporting definitions, control loops, energy management applications, time and calendar-based programming, totalization, historical data trending, custom control processes, graphic displays, operator passwords, alarm messages, etc.

c. Definition of operator device characteristics for individual points, applications, and control sequences shall be performed using instructive prompting software.

d. Programming shall be performed with the BMS system online and shall not interfere with BMS system operation.

e. Inputs and outputs for any process shall not be restricted to a single Primary Control Panel, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

f. Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation(s) are on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Primary Control Panel. Similarly, changes made at the Primary Control Panels shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

g. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

2.8 REMOTE NOTIFICATION PAGING SYSTEM:

A. Workstations shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.

B. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices that can receive messages from the system.

C. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.

D. Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.

E. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.

F. Message detail shall be configurable on a per user basis.

G. During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.

H. Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.

I. Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.

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B. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add, delete, or modify any system object including Primary Control Panel(s), operator workstations(s), Secondary Control Panels, reporting definitions, control loops, energy management applications, time and calendar-based programming, totalization, historical data trending, custom control processes, graphic displays, operator passwords, alarm messages, etc.

C. Definition of operator device characteristics for individual points, applications, and control sequences shall be performed using instructive prompting software.

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G. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

2.10 SENSORS

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

B. Temperature Sensors

1. Resistance Temperature Detectors: Platinum. Temperature sensors shall be platinum resistance temperature detectors (RTD) with the following characteristics. Thermistor sensors are NOT an acceptable substitute,

regardless of accuracy. Platinum RTDs may be installed with a transmitter if the controller cannot accept a direct platinum RTD input. It is not acceptable to claim that the controller cannot accept an RTD sensor. The project will be bid and installed with a controller that accepts RTD sensors or the voltage or current input of a platinum RTD used in conjunction with a transmitter. NO EXCEPTIONS. Thermistors used alone may be submitted as a deduct price for the owner's consideration.

2. Accuracy: Plus or minus 0.2°F.

3. Wire: Twisted, shielded-pair cable.

4. Insertion Elements in Ducts: Single point, 18" long flexible; use where not affected by temperature stratification or where ducts are smaller than 9sq ft..

5. Averaging Elements in Ducts: 12' to 25' long, rigid; use where prone to temperature stratification or where ducts are larger than 9sq ft; length as required.

6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2" (64mm)
7. Space sensors: Provide recessed space temperature sensors in lieu of thermostats for all public areas, including all entry vestibules, lobbies, corridors, toilet rooms, etc.

    a. Color: White, except on metal surfaces (tubes or mullions) shall be brushed aluminum.

    b. Orientation: Vertical.

    c. Space temperature sensors shall be recessed with flush mounted covers.

    d. Insulating Bases: For thermostats located on exterior walls.

    e. Adjusting Key: As required for calibration and cover screws.

    f. Security Sensors: Stainless-steel cover plate with insulated back and security screws.

8. Aspirating Space Sensors:

    a. Concerted with aspirating sensor for spaces with no surface for the sensor.

C. Room Humidity Sensors: Bulk polymer sensor element.

1. Accuracy: 1% full range with linear output.

2. With locking cover matching room thermostats, span of 0 to 100%RH.

3. Output: 4 -20mA.

4. The sensor shall be a Kele model HW1K or pre-approved equal.

D. Duct and Outside Humidity Air Sensors: Bulk polymer sensor element

1. Accuracy: 1% full range with linear output.

2. With element guard and mounting plate, span of 0 to 100% RH.

3. Output: 4 -20mA.

4. The sensor shall be a Kele model HD1 K, Kele model H01 K, or pre-approved equal.

E. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

1. Accuracy: 1% of full scale with repeatability of 0.1 %.

2. Output: 4 -20mA.

3. Building Static-Pressure Range: 0-0.25" wg (0-62 Pa).

4. Duct Static-Pressure Range: 0-5" wg (0-1243 Pa).

5. Provide a Setra M264 or pre-approved equal.

F. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4-20mA.

1. Two-wire capacitance.

2. NEMA 4X enclosure.

3. Rated for 0 to 1OO%RH and -400-185°F.

4. Dual component housing with a moisture barrier completely isolating the electronic circuitry from the field wiring and calibration terminals.

5. Operates with a 10 -55VDC power supply.

6. Zero and span adjustments.

7. Accuracy shall be ± 0.075% of calibrated span.

8. Setra 209 Series or pre-approved equal.

G. Damper Endswitches

1. Provide a heavy-duty switch with plug-in, oil tight, watertight, and NEMA 3 construction (unless exposed to outside air type conditions). Shall be rated to operate from -40° -212°F (-40° -100°C). Shall have a side rotary switch for

use with interchangeable levers. Shall have LED position and operation indicators. Shall be Omron, D4A series or pre-approved equal.

H. Equipment operation sensors as follows:

1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 -5" wg (0 -1243 Pa) for fans not served with variable frequency drives.

2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 -60psig (55 -414 kPa) for pumps not served with variable frequency drives.

3. Status Inputs for Electric Motors: Split-core current switch, adjustable and set to 175% of rated motor current.

I. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2-to 1O-V dc, feedback signal.

J. Water-Flow Switches: Pressure-flow switches of bellows-actuated non-mercury type or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vapor proof type.

K. Water Differential Pressure Switches: Chilled water and hot water application. Hermetically sealed SPDT contacts; stainless steel bourdon tube (or bellows) sensing element; fixed deadband; setpoint shall be at about midpoint of operating range; electrical rating of 5A at 120VAC; manual adjustable setpoint; vibration resistant; weatherproof enclosure; snap-acting switch type.

L. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die-cast aluminum housing, adjustable setpoint, and minimum 5A switch rating at 120VAC, SPDT switches, and the switch pressure range shall be suited for the application. Provide Dwyer or equal. Switch shall be automatic reset type.

M. OR and Isolation Room Differential Pressure Monitors

1. Shall be TSI model RPM20 with audible and visual alarm. Monitor shall include optional door switches to prevent alarm if any door is left in the open position.

2. Monitor to include optional analog output to DDC system for room pressure differential as well as low pressure alarm.

2.11 THERMOSTATS

A. 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, 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.

B. Room Thermostat Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Exposed.

2. Set-Point Indication: Exposed.

3. Thermometer: Exposed.

4. Color: Match space temperature sensors.

5. Orientation: Match space temperature sensors or brushed aluminum where installed on metal surfaces.

C. Room thermostat accessories include the following:

1. Insulating Bases: For thermostats located on exterior walls.

2. Thermostat Guards: Locking; heavy-duty, transparent plastic; mounted on separate base Metal wire, tamperproof Locking, solid metal, ventilated, for mechanical/electrical equipment rooms.

3. Adjusting Key: As required for calibration and cover screws.

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

E. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, double-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. Setpoint shall be adjustable. Switch shall be manual reset type.

1. Bulb Length: Minimum 20ft.

2. Quantity: One thermostat for every 20sq ft of coil surface and a minimum of three (3) loops all properly supported.

F. Electric High-Limit Duct Thermostat: Snap-acting, single-pole, double-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.

1. Bulb Length: Minimum 20ft.

2. Quantity: One thermostat for every 20sq ft of coil surface and a minimum of three (3) loops all properly supported.

G. Freeze protection thermostats:

1. Serpentine sensors across the entire face of the cooling coil at a ratio of 12 in. of sensor per every one (1) sq. ft. of coil, regardless of coil size / area and all supported and fastened at a minimum of every 36 inches across the entire face area.

2.12 HUMIDISTATS

A. Duct-Mounted Humidistats: Electric insertion, 2-position type with adjustable 2% throttling range, 20 to 80% operating range, single-or double-pole contacts.

2.13 RELAYS

A. Current Sensing Relay

1. Provide and install current sensors for all motor status points. Current sensor shall combine a status sensor for monitoring positive status, and a command relay for starting or stopping motors in a single package. Current sensor shall be split core, two-wire, loop powered, and sized for expected amperage. Unit shall be UL listed. Provide status LEDs for current sensed below setpoint, current sensed above setpoint, and loop power failure. The current sensor output shall be N.O., solid state, and rated for 0.1A at 30 VAC/DC. The relay output shall be N.O., and rated for 5A resistive, 3A inductive at 30VDC, 240VAC. Current sensor with command relay shall be a Hawkeye model H938 or pre-approved equal. Provide and install current sensing switches for all constant speed motors. Switches shall be split core design for clamp-on installation. Switches shall be matched to the voltage and current rating of the motors.

2.14 LEAK DETECTOR

A. Leak detector shall have mounting feet with legs adjustable up to 1-Y2", gold-plated water detection probes, adjustable height, a green LED to indicate power, a red LED to indicate water detected, SPDT alarm contacts. The enclosure shall be cast aluminum, weatherproof with adjustable legs. The leak detector shall operate between 11 and 27 VAC/DC.

2.15 FAN INLET RING AIRFLOW MEASURING STATION

A. Provide Piezometer ring air flow measuring stations mounted on the fan inlet cone throat and inlet cone static pressure tap capable of continuously measuring the air volume of the respective fan.

B. The fan inlet airflow traverse probes shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probes and internally connected to their respective averaging manifolds. Sensor shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.

C. The fan inlet airflow traverse probes shall have symmetrical averaging signal takeoffs, and shall be of aluminum construction with hard anodized finish with galvanized steel mounting hardware.

D. The fan inlet ring air flow measuring station shall not impact fan performance or contribute to fan generated noise levels. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 5% of actual flow over a fan operating range of 6 to 1 capacity turndown.

E. The fan inlet ring air flow measuring station shall be the Piezometer as manufactured by Twin City Fans or pre-approved equal.

F. The fan inlet ring airflow measuring station shall be provided by the air handling unit manufacturer as called out in section 237314 Custom Indoor Air Handling Unit. Provide transducers as required.

2.16 OUTSIDE AIR MONITOR

A. Provide airflow/temperature measurement devices (ATMD) where indicated on the plans.

B. Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

1. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.

2. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.

3. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.

4. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.

5. Each transmitter shall have a 16-character minimum alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.

6. Pitot tubes and arrays are not acceptable.

7. Vortex shedding devices are not acceptable.

C. All Sensor Probes

1. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.

2. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).

3. Airflow accuracy shall be +/-2% of Reading over the entire operating airflow range.

   a. 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.

4. Temperature accuracy shall be +/-0.15°F over the entire operating temperature range of -20°F to 160°F.

5. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
6. Each sensor probe 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.

7. Each sensor assembly shall not require matching to the transmitter in the field.

8. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

D. Duct and Plenum Probes

1. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.

2. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

   a. Insertion mounted through the side or top of the duct.

   b. Internally mounted inside the duct.

3. The number of sensor housings provided for each location shall be as follows:

Duct or Plenum Area (sq. ft)	Total # Sensors / Location
<2	4
2 to <4	6
4 to <8	8
8 to <16	12
>=16	16

4. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

E. Transmitters

1. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.

2. The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.

3. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).

   a. The transmitter shall use a switching power supply fused and protected from transients and power surges.

   b. The transmitter shall use "watch-dog" circuitry to assure reset after power disruption, transients and brown-outs.

4. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

5. The operating temperature range for the transmitter shall be -200 F to 1200 F. The transmitter shall be installed at a location that is protected from weather and water.

6. The transmitter shall be capable of communicating with other devices via:

   a. RS-485: Field selectable BACnet-ARCNET, BACnet-MSrrP or Modbus-RTU

      1) BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.

F. The ATMD shall be UL listed as an entire assembly.

G. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.

1. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

H. The monitor/controller shall be the GP1 as manufactured by Ebtron or pre-approved equal.

2.17 AUTOMATIC CONTROL VALVES

A. All automatic control valves shall meet the following requirements:

1. Fully proportioning.

2. Capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements.

3. Maximum pressure drop: 3 psi.

4. Close against the maximum differential pressure of the system.

5. Body pressure rating and connection type construction shall conform to piping and fittings in which the valve is to be installed and to the valve schedules.

6. Two-way modulating chilled water and hot water, three-way blending/mixing and bypass valves shall have equal percentage flow characteristics.

7. Control valves 2" and smaller shall be ball valves with stainless steel stem and ball. Valves shall be Belimo, Warren, or pre-approved equal.

8. Control valves 2-1/2" and larger shall be butterfly valves as specified in this section.

9. All 2-position control valves must be line size.

2.18 BUTTERRFLY CONTROL VALVES

A. All control valves 2-1/2" and larger, where shown on the drawings or specified herein, shall be high performance butterfly type with lug ends and shall be furnished with electric actuators.

B. The valve shall meet the following minimum requirements:

1. Valve body: Carbon steel.

2. Valve disc: 316 stainless steel.

3. Valve shaft: 17-4ph stainless shaft.

4. Valve seat: RTFE

5. Bubble-tight closure at 285psi or the required differential pressure across the disc

6. Maximum system operating temperature: minimum of 250°F.

7. Valves shall be full-bodied, full lug type only (Wafer type or semi-lugged valves will not be permitted).

8. Valves shall be bolted from both ends of the flanges.

9. Valve shall be manufactured by Belimo, Tyco/Keystone, Jamesbury, Bray or pre-approved equal.

C. All valve actuators shall be electric type and shall meet the following minimum requirements:

1. Input: Modulating actuators require 4 -20mA or 0 -10VDC.

   a. VAV box valve actuators shall be floating type.

2. Gear housing material: Cast iron with double reduction type gear reduction consisting of worm and helical gearing.

3. Worm gear: Alloy bronze.

4. Worm: Alloy steel.

5. Helical gears: heat-treated steel.

6. Steal materials shall be Viton.

7. Temperature rating shall be -200-150°F.

8. Actuator shall be provided with a manually operated handwheel for overriding the spring and actuator position. Actuators shall have an integral toggle switch to allow the actuator power to be de-energized and the valve to be manually positioned by a hand wheel, or other such positioning device temporarily. This contractor shall provide an external toggle switch for all actuators which do not include an integral switch.

9. Actuator shall include a speed control device (adjustable) to prevent the valve from too rapid a closure rate.

10. Actuator shall have an external position indicator.

11. Actuator motor shall meet the following minimum requirements:

    a. Singlephase, 115V type.

b. Nominal duty of 15min.

c. Dynamic torque nominal 20% of start torque.

d. Class B standard insulation.

e. Maximum current of 3A.

f. 120VAC heater (for outdoor applications).

g. Limit switch shall be gear driven.

h. Snap-acting switch with 16 contacts rated at 600V 6A resistive.

i. 60A inrush at 120VAC.

12. Actuator shall be manufactured by Limitorque, Tyco/Keystone, Bray or pre-approved equal.

2.19 DAMPERS

A. Dampers: AMCA-rated design; 0.125" minimum, extruded aluminum thermal break frames with hat channel for duct mounting; damper blades shall not be less than 0.075" extruded aluminum with high density polyurethane CFC free foam insulation with maximum blade width of 6 inches.

B. Blades shall be secured to 1/2" diameter, zinc-plated axles using zinc-plated hardware, with nylon 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. Blades shall be thermally insulated low leakage with thermal breaks.

C. Operating Temperature Range: From -700-200°F.

D. For standard applications, include Ruskiprene II edging.

E. For low-leakage applications, use parallel-or opposed-blade design depending upon application (mixing: parallel/ shut-off: opposed blade) with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 1OCFM/sq ft of damper area, at differential pressure of 4" wg when damper is being held by torque of 50 in x Ibf; when tested according to AMCA 500D.

F. Dampers used in a two-position application shall be parallel blade design. Dampers used in a modulating application shall be opposed blade design. Dampers shall be provided with end switches.

G. All dampers used for smoke control/unit isolation type dampers with all electric actuators, shall be UL listed for smoke control service. Dampers for UL listed service shall be type SD50 as manufactured by Ruskin or approved equal.

H. All Dampers shall be type CDTI-50BF as manufactured by Ruskin or Approved equal.

2.20 ACTUATION

A. All actuation shall be electric. Pneumatic actuation is not acceptable. All actuators for smoke control/unit isolation service shall be UL listed for such services.

B. Incremental Electronic Actuator for Terminal Equipment Valve and/or Damper Actuation

1. Incremental actuators shall be allowed for terminal equipment only.
2. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.
3. Actuators shall be manufactured by Belimo.
4. Actuators shall be equipped with a permanent manual adjustment.
5. Minimum Torque: 35" lb.
6. Operating Voltage: 24VAC.
7. Input Signal: 3 wire floating, 0 -10VDC, or 4 -20mA.
8. Frequency: 50 -60Hz.
9. Power Consumption: 1.5VA maximum.
10. Spring Return Time: 20sec maximum.
11. Spring return position should be field adjustable with a switch.
12. Nominal Force: 90lb Minimum.
13. Stroke: 7/3211 (5.5mm) maximum.
14. For use when the maximum media temperature is 230°F.

C. Valve Actuation

1. Valve actuators shall:
   a. Be quiet in operation
   b. Provide smooth modulation at design flow and pressure conditions.
   c. Be capable of operating in sequence with other valves and/or damper actuators when required by the sequence of operation.

d. Be sized to close against a differential pressure equal to the design pump head plus 15%. Where pressure and flow combinations exceed ratings for commercial valves and actuators, industrial class valves and actuators shall be provided.

e. Valve actuators shall fail-safe in either the normally open or normally closed position in the event of power failure or signal failure. Fail Safe positions are as follows:

1)	Air-Handling Unit Preheat Valves	Normally Open
2)	Air-Handling Unit Cooling Valves	Normally Closed
3)	Air-Handling Unit Heating Valves	Normally Open
4)	Duct-mounted Heating Coil Valves	Normally Closed
5)	Radiation Valves	Normally Open
6)	Unit Heater Valves	Normally Open
7)	Cabinet Unit Heater Valves	Normally Open

2. Electric Valve Actuation

a. Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.

b. Actuators shall be equipped with a permanent manual override hand wheel and visual and electronic stroke indicators.

c. Operating Voltage: 24VAC.

d. Input Signal: 0-10VDC, 4-20mA.

e. Power Consumption: 18VA maximum (valves 2" and under), 28VA maximum (valves 2-1/2" -4")

f. Spring Return Time: 15 seconds maximum

g. Spring return position should be field adjustable with a switch.

h. Stroke: 3/4" (20mm) maximum (valves 2" and under), 1-1/2" (valves 2-1/2"-4")

i. For use when the maximum media temperature is 300°F.

D. Damper Actuation

1. Damper actuators shall have external adjustable stops to limit the stroke in either direction.

2. All damper actuators shall have sufficient power to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.

3. Actuators shall be sized with a torque greater than 150% of the design damper torque.

4. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not buried in the wall construction. All damper actuators serving UL rated dampers shall be also UL listed as part of the assembly.

5. Damper actuators shall fail-safe in either the normally open or normally closed position in the event of power failure or signal failure. Fail Safe Positions are as follows:

   a. Outside Air Dampers — Normally Closed

   b. Return Air Dampers — Normally Open

   c. Exhaust Air Dampers — Normally Closed

6. Electric Damper Actuation for Modulating and Two Position Damper Actuation

   a. Provide proportional, electronic, direct-coupled spring return actuators for all automatic dampers used for modulating service. Each actuator shall be equipped with a brushless DC motor, self-centering shaft coupling, metal housing, permanent manual override, visual stroke indicators, and built in adjustable start and span controls with the following specifications:

      1) Operating Voltage: 24VAC

      2) Input Signal: 0-10VDC, 4 -20mA (modulating), on/off (two position)

      3) Frequency: 50-60Hz

      4) Power Consumption: 9VAMaximum 2.23 CONTROL CABLE

      5) Spring Return Time: 15secs Maximum

      6) Spring return position should be field adjustable with a switch.

      7) Minimum Torque: 144" Ib

      8) Angular Rotation

2.21 CONTROL CABLE

A. BACKBOARDS

1. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches for panel and control mounting. Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry."

B. RS-232 CABLE

1. Standard Cable: NFPA 70, Type CM.

   a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.

   b. Polypropylene insulation.

   c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.

   d. PVC jacket

   e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.

   f. Flame Resistance: Comply with UL 1581.

2. Plenum-Rated Cable: NFPA 70, Type CMP. Note: Partial Plenum Return Project

   a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.

   b. Plastic insulation.

   c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.

   d. Plastic jacket.

   e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire

   f. Flame Resistance: Comply with NFPA 262

C. RS-485 CABLE

1. Standard Cable: NFPA 70, Type CM or Type CMG.

   a. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.

   b. PVC insulation.

   c. Unshielded.

   d. PVC jacket.

e. Flame Resistance: Comply with UL 1581.

2. Plenum-Rated Cable: NFPA 70, Type CMP. Note: Partial Plenum Return Project

a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.

b. Fluorinated ethylene propylene insulation.

c. Unshielded.

d. Fluorinated ethylene propylene jacket.

e. Flame Resistance: NFPA 262, Flame Test.

PART 3 - EXECUTION

3.1 CONTROL CABLE

A. Control wiring and cabling Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.

2. Smoke-Developed Index: 50 or less.

3. Plenum rated cable above and in all ceiling return plenums

B. All control wiring and cabling associated with and part of the smoke evacuation system shall be installed in rigid conduit without exception.

C. All control wiring and cabling in the Central Utility Plant, Wet Mechanical Rooms, Penthouses, tunnels and any other spaces where exposed shall be installed in rigid conduit without exception.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. PATHWAY:

1. Support of Open Cabling: NRTL labeled for support of Control cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

a. Support brackets with cable tie slots for fastening cable ties to brackets.

b. Lacing bars, spools, J-hooks, and D-rings.

c. Straps and other devices.

F. CONTROL-CIRCUIT CONDUCTORS

1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN in raceway, complying with UL 83 and UL 44.

2. Class 2 Control Circuits: Stranded copper, (1) Type THHN-THWN, in raceway (2) [power-limited cable, concealed in building finishes Le. above ceiling in walls] complying with UL 83 and UL 44.

3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

G. IDENTIFICATION PRODUCTS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.

b. HellermannTyton.

c. Kroy LLC.

d. Panduit Corp.

2. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

3. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

H. INSTALLATION OF PATHWAYS

1. Comply with TINEIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

2. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

3. Install manufactured conduit sweeps and long-radius elbows if possible.

4. Pathway Installation in Equipment Rooms:

a. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.

b. Secure conduits to backboard if entering room from overhead.

c. Extend conduits 3 inches above finished floor and seal/caulk to be air tight.

d. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

5. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

I. INSTALLATION OF CONDUCTORS AND CABLES

1. Comply with NECA 1.

2. General Requirements for Cabling:

a. Comply with TINEIA-568-B.1.

b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

c. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

d. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

e. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSIITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.

f. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

g. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

h. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

J. CONTROL-CIRCUIT CONDUCTORS

1. Minimum Conductor Sizes:

a. Class 1 remote-control and signal circuits, No 14 AWG.

b. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.

c. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

K. FIRESTOPPING AND AIR SEALING

1. Comply with requirements in Division 07 Section "Penetration Firestopping."

2. Comply with TIAIEIA-569-A, Annex A, "Firestopping."

3. Comply with BICSI TDMM, "Firestopping Systems" Article.

4. All penetrations at any and all air handling equipment, casings, plenums or other such air distribution I air delivery devices shall have grommet seals and be 100% air sealed.

L. GROUNDING

1. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

2. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

M. IDENTIFICATION

1. Identify system components, wiring, and cabling according to TIAIEIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems".

2. Refer to paragraph “G” hereinbefore.

3.2 INSTALLATION

A. Install equipment level and plumb.

B. Verify location of thermostats, sensors, humidistats and other exposed control sensors with plans and room details before installation. Locate all 60" above the floor or as otherwise required by ADA.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

C. Install guards on thermostats in the following locations:

1. Mechanical/Electrical Rooms

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

E. Install automatic dampers according to Division 23 Section "Sheet Metal Work”.

F. Install labels and nameplates to identify control components according to Division 23 Section "Basic Mechanical Materials and Methods" and "Mechanical Identification".

G. Install hydronic instrument wells, turbine flow meters, valves, and other accessories according to Division 23 Section "Piping." for the project.

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

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings and related wiring accessories.

B. All exposed wiring and wiring in mechanical equipment rooms, tunnels, central utility plants, penthouses (concealed and exposed) shall be installed in conduit.

C. Plenum rated cable shall be used and installed above all hung ceilings and within all walls and chases.

D. All wiring located outside shall be installed in rigid aluminum conduit, seal tite.

E. Conceal all cable, except in mechanical rooms, penthouses and areas where other conduit and piping are exposed.

F. Install cable in raceway.

G. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

H. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

I. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

J. Wires and cables shall be as follows:

1. Single Conductor (120VAC): Type THWN 12AWG stranded copper with 600V insulation

K. Primary and Secondary Communications Network Cabling

1. Cable shall be of type recommend by the DDC System Manufacturer and 20AWG at a minimum.

2. Cable shall be shielded.

L. Room Sensor Cabling

1. Cable shall consist of copper conductors not less than No. 24 AWG.

M. Cables for 120VAC wiring and low level signal wiring (Le., 4 -20mA analog) shall always be run in separate raceways.

3.4 CONNECTIONS

A. Install piping adjacent to equipment served to allow service and maintenance.

B. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

C. Connect HOA selector switches to override automatic interlock controls when switch is in hand position.

D. Ground equipment.

3.5 FIELD QUALITY CONTROL

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

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.

3. Calibration test controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Engage a factory-authorized service representative to perform startup service. Refer to Section 230800-"Commissioning" for additional startup and testing services required under this contract.

C. Replace damaged or malfunctioning controls and equipment.

1. Start, test, and adjust control systems.

2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.

3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.6 COMMISSIONING

A. Prior to full operation, the Contractor in the presence of the owner's representative, including the owner's Commissioning Agent shall perform a complete demonstration and testing of the system operating functions and alarms. This testing shall take place after having satisfactorily met the requirements of shop drawing acceptance. Upon successful completion of system operation, the contractor shall submit a statement in writing stating that the full operation of all systems, functions, and alarms has been demonstrated and are operational as well as a listing of all systems, alarms, and functions that have been commissioned. All items shall be submitted for review and acceptance to the owner, owner's representative, and engineer before final acceptance can take place.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 1 Section "Closeout Procedures" and "Demonstration and Training."

3.8 TRAINING

A. The BMS contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation, and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30PM weekdays..

B. Provide 16hrs of training for Owner's operating and maintenance personnel. All training shall be on-site training. Videotape all sessions and edit each session to 1-hour tapes. Turn over two copies each unedited and edited tape to the Owner. Training shall include:

1. Explanation of drawings, operator’s and maintenance manuals.

2. Walk-through of the job to locate all control components.

3. Operator workstation and peripherals.
4. DDC Controller and ASC operation/function.
5. Operator control functions including graphic generation, if design includes color graphics, and field panel programming.
6. Explanation of adjustment, calibration and replacement procedures.

C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer’s standard pricing such as transportation, meals, etc

3.9 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project-site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

B. The Commissioning Agent will provide a Post-Occupancy review prior to the lapse of the one year warranty/guarantee period. This Contractor shall provide all recalibration replacement and/or controls adjustments necessary to provide project close-out in accordance with the Commissioning Agents final project review.

3.10 PROJECT CLOSEOUT

A. his contractor, in cooperation with the Construction Manager, shall download onto the web server in separate and distinct folders all mechanical, electrical, plumbing, fire protection and DDC/Control Shop Drawings. Each specific shop drawings file shall be cross-referenced and identified by specification number and product titles (pumps, switchgear, air handling units, chiller, boiler, etc.)

B. Turnover to the owner all third party software and licenses to allow rebuilding the systems.

End Of Section