ADDENDUM NO. 01

TO: PLANS AND SPECIFICATIONS FOR STATE OF MISSOURI

Replace Building Automation System
Penney State Office Building
Springfield, Missouri
PROJECT NO.: O2012-01

Bid Opening Date: 1:30 PM, Tuesday, December 5, 2023

Bidders are hereby informed that the construction Plans and/or Specifications are modified as follows:

SPECIFICATION CHANGES:

1. Section 230900 – Instrumentation and Control for HVAC

    a. REMOVE and REPLACE entire specification section with attached section 230900.

2. Section 260500 – Common Requirements for Electrical Systems and Equipment

    a. REVISE sub-section 3.2, B., 5. as follows:

    Exposed in occupied/finished areas *below ceiling elevation:* Metal surface-mounted raceway.

DRAWINGS CHANGES:

1. None

GENERAL COMMENTS:

1. The Pre-Bid Meeting was held November 14, 2023. The attendance sheet is included in the attachment.
2. For site access prior to bid date, contact Roger Barnett at 417-522-9196.
3. **For questions regarding bidding requirements or MBE/WBE/SDVE goals contact Paul Girouard, Contract Specialist at 573-751-4797 or** Paul.Girouard@oa.mo.gov
4. **As of July 1, 2020,** all MBE, WBE, and MBE/WBE contractors, subcontractors, and suppliers must be certified by the State of Missouri, Office of Equal Opportunity. No other certifications from other Missouri certifying agencies will be accepted.
5. **MBE/WBE/SDVE participation requirements can be found in DIVISION 00. The MBE/WBE/SDVE participation goals are 10%/10%/3%, respectively. Only certified firms as of the bid opening date can be used to satisfy the MBE/WBE/SDVE participation goals for this project. If a bidder is unable to meet a participation goal, a Good Faith Effort Determination Form must be completed. Failure to complete this process will result in rejection of the bid. Any questions please contact Paul Girouard.**
6. **The Contractor shall pay not less than the prevailing hourly rate of wages for work of a similar character in the locality in which the work is performed, as determined by**

the Missouri Department of Labor and Industrial Relations. Bidders are to adhere to Prevailing Wage Hourly Rate of Wages, and the Department of Labor and Industrial Relations can be contacted to determine the applicable wage rate for the work on this project.

7. **The following questions were received:**
   a. In General Conditions Article 1.7C does the 10% cost refer to an individual product or overall cost of the project?
      i. This refers to the cost of the individual product.
   b. Is a BAS Tech considered a communication tech or are they exempt from prevailing wage?
      i. Please refer to general Note #5 of this addendum.
   c. Can conduit be reused?
      i. In the pre-bid meeting, it was stated that conduit could be reused. After the meeting it was determined that for bidding consistency, all BAS wiring shall be installed in NEW conduit. Existing BAS conduit shall be removed and NOT reused.
   d. Does this project require Davis-Bacon?
      i. There is no federal funding for this project, so this project does not require Davis-Bacon.
   e. Will testing and balancing be required?
      i. Yes. Testing, Adjusting, and Balancing (TAB) is required for all HVAC systems upon completion of the BAS installation. Air and water flow rates are available on the existing building construction documents and will be provided to the TAB contractor for balancing purposes.

8. Existing wooden thermostat chases shall be removed, and the wall shall be repaired and painted to match existing adjacent wall. Extent of new paint shall be 12" on either side of removed chase or to corners of column where thermostat is installed on column. New thermostats shall be installed with surface-mounted metal raceway and coordinating surface-mounted boxes.

<u>ATTACHMENTS</u>:

A. X2226-01 Pre-Bid Meeting Sign-In Sheet (4 Pages)
B. Revised Specification Section 230900 (14 pages)

END ADDENDUM 01

Pre-Bid Meeting Attendance Sheet
Replace Building Automation System
Penney State Office Building
Springfield, MO

Project No. O2012-01
11/14/23 & 10:30 A.M.

Name & Title	Company Name & Type of Contracting	MBE/WBE/ SDVE Status	E-Mail Address of Attendee & E-Mail Address of Individual filling out Bid Documents
Ryan Abbott RA	OA-FMDC		Ryan.Abbott@oa.mo.gov
Ryan Jones RSJ	CJD Engineering		rjones@cjd-eng.com
Michael Askin Estimator	MSE	SDVE	estimating@ msi constructors.com
Daniel Laning PM	4 states Mechanical	WBE	DanLU178@ gmail.com
ROBERT LUTGEN	C+C GROUP		rlutgen@c-cgroup.com
Greg Kline	C+C - GM Elec		Gregandmiss@ Gmail.Com

Pre-Bid Meeting Attendance Sheet
Replace Building Automation System
Penney State Office Building
Springfield, MO

Project No. O2012-01
11/14/23 & 10:30 A.M.

Name & Title	Company Name Type of Contracting	MBE/WBE/ SDVE Status	E-Mail Address of Attendee and E-Mail Address of Individual filling out Bid Documents
Chad Porter	Trane		Chad.porter@trane.com
Joe Koepke	Trane		Joe.koepke@Tranetechnologies.com
Monty Nance	Carrier		monty.nance@carrier.com
Kyle Shannon	Carrier		Kyle.k.shannon@carrier.com
Jeremy Katz	Carrier		jeremy.katz@carrier.com
Tony Payne	Gold Mechanical		apayne@goldmechanical.com

Pre-Bid Meeting Attendance Sheet
Replace Building Automation System
Penney State Office Building
Springfield, MO

Project No. O2012-01
11/14/23 & 10:30 A.M.

Name & Title	Company Name Type of Contracting	MBE/WBE/ SDVE Status	E-Mail Address of Attendee and E-Mail Address of Individual filling out Bid Documents
Don WAGNER	OA - FMDC		DON.WAGNER @ OA.MO.GOV (417) 522-9196
Roger Barnett	OA-FMDC		Roger.Barnett @ OA.MO.GOV
John Gentges	OA - FMDC		John.Gentges @ oa.mo.gov 573-291-9596
John Oke-Thomas	Oke-Thomas + Assoc.	MBE/ G.C.	John@OKE-THOMAS.COM 417.863.6262
Paris SH Denis	Oke-Thomas + Assoc.	G.C. MBE	Paris@ Oke-Thomas.Com 417.863.6262
Dustin Brown	Johnson Controls, Inc		dustin.w.brown @ jci.com

Pre-Bid Meeting Attendance Sheet
Replace Building Automation System
Penney State Office Building
Springfield, MO

Project No. O2012-01
11/14/23 & 10:30 A.M.

Name & Title	Company Name Type of Contracting	MBE/WBE/ SDVE Status	Phone	E-Mail Address of Attendee and E-Mail Address of Individual filling out Bid Documents
Jon Muller Controls Supervisor	Gold Mechanical		417-942-9256	jmuller@ Goldmechanical.com
Gary Davis Controls Tech	Gold Mechanical		417-353-1360	gdavis@ goldmechanical.com

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A.   This Section includes control equipment for HVAC systems and components.

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

C.   See Sequences of Operation on Construction Drawings for requirements that relate to this Section.

1.2 DESCRIPTION

A.   General: The control system shall consist of a high-speed, peer-to-peer network of IP addressable Building Automation System (BAS) controllers/devices and a web-based operator interface.

B.   System software shall be based on thin client architecture, designed around the open standards of web technology. The BAS central controller shall be accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.

C.   System shall use the BACnet protocol for communication to the operator workstation and for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in Sequences of Operation shall be BACnet objects.

1.3 APPROVED MANUFACTURERS

A.   Basis of Design: Automated Logic

B.   Johnson Controls

C.   Schneider Electric

D.   Siemens

1.4 ACTION SUBMITTALS

A.   Product Data and Shop Drawings: Meet requirements of Section 01 30 00 on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide electronic copies and 11" x 17" prints of each drawing. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work.

1. BAS Hardware
   a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
   b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
      1) Direct digital controllers (controller panels)
      2) Transducers and transmitters
      3) Sensors (including accuracy data)
      4) Actuators
      5) Valves
      6) Relays and switches
      7) Control panels
      8) Power supplies
      9) Batteries
      10) Operator interface equipment
      11) Wiring
   c. Wiring diagrams and layouts for each control panel. Show termination numbers.
   d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.
   e. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
   f. Network riser diagrams of wiring between central control unit and control panels.

B. Schedules

   1. Communicate on a weekly basis the schedule and progression of project.

C. Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

   1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD compatible files on magnetic or optical media (file format: .DWG, .DXF, .VSD, or comparable) and as 11" x 17" prints.
   2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs.
   3. Operation and Maintenance (O&M) Manual.
   4. As-built versions of submittal product data.
   5. Licenses, guarantees, and warranty documents for equipment and systems.

D. Training Materials: Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs.

1.5   INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.6   CLOSEOUT SUBMITTALS

A.   Operation and maintenance data.

B.   Software and firmware operational documentation.

1.7   QUALITY ASSURANCE

A.   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.

B.   Installer and Manufacturer Qualifications
   1.   Controls Contractor shall have an established working relationship with Control System Manufacturer.
   2.   Controls Contractor shall have successfully completed Control System Manufacturer's control system training.
   3.   Controls Contractor must provide enterprise level software package with no additional required software upgrades or licensing for a minimum of 3 years. Unlimited concurrent users, unlimited devices, and unlimited BACnet points.
   4.   Controls Contractor must provide thermal floorplans for easily referencing zone temp vs setpoints.
   5.   No wireless devices or sensors. All hard-wired components and devices to ensure consistent and maintenance free operation.
   6.   Training – At least one 4 hours on site training with an additional two - 4 hour trainings in a classroom environment during the 1st year with unlimited phone support during normal business hours 8am-4:30pm for the 1st year.
   7.   Trending - Minimum of 90 days trending data and pre-built trend graphics with a minimum of temp vs occupied & unoccupied heating and cooling setpoints on each zone. RTU trend graphs to compare fan enable, fan status, supply temp, return temp, compressor enable & staging, CO_2 levels - as a minimum.

PART 2 - PRODUCTS

2.1   MATERIALS

A.   Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2   COMMUNICATION

A.   Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. All control products shall be State of Missouri ITSD approved prior to installation. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B.   Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.3 OPERATOR INTERFACE

A. Operator Interface. **Operator Workstation shall be provided by State of Missouri ITSD.** Workstation and central controller shall reside on high-speed network with building controllers. Each standard browser connected to BAS shall be able to access all system information. The system is required to have HTML5 or equivalent graphics. The Operator Workstation shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L. BAS Contractor shall coordinate with State of Missouri ITSD for minimum Operator Workstation requirements.

B. Communication. Workstation and controllers shall communicate using BACnet protocol. Workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J.

C. System Software.

1. Operating System. Workstation shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the BAS manufacturer's minimum requirements for their software. Acceptable systems include Microsoft Windows 10 or 11, Windows Server 2016 or 2022, Linux, or Ubuntu Desktop 22.04.
2. System Graphics. The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. The floorplan graphics must indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
   a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
   b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
   c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
   d. Sequence of Operation. Shall be displayed or linked within the graphic page for each controlled piece of equipment.

e. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in or shall only require widely available no-cost plug-ins (such as Adobe Flash).

3. Custom Graphics. Custom SVG shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.

4. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

D. System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs.

1. Automatic System Database Configuration. Each workstation or central controller shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

2. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.

3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.

4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

5. Security. Each operator shall be required to log on to the system with user name and password in order to view, edit, add, or delete data.
   a. Operator Access. The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users.
   b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
   c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics. The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall trigger an alarm.

7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Sequences of Operation. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

8. Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or central controller hard disk.

9. Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs for a minimum of 90 days of historical data. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Sequences of Operation. Trends shall be BACnet trend objects.

10. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

11. Environmental Index. System shall monitor all occupied zones and compile an index that provides a numerical indication of the environmental comfort within the zone. The system shall also compute an average comfort index for every building included in this contract and maintain trendlogs of these building environmental indices. Similarly, the system shall compute the percentage of occupied time that comfortable conditions were maintained within the zones. Through the UI the user shall be able to add a weighting factor to adjust the contribution of each zone to the average index based upon the floor area of the zone, importance of the zone, or other static criteria.

E. Workstation Application Editors. Each PC or browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.

2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.

3. Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
   a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
   b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
   c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

2.4 CONTROLLER SOFTWARE

A. Enterprise level central controller with unlimited users, BACnet points.

B. Furnish the following applications for building and energy management. All software application shall reside and operate in the system controllers. Applications shall be editable through operator workstation or web browser interface.

C. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:

  1. Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
  2. 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 has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
  3. Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.

D. Remote Communication. System shall automatically contact operator workstation or central controller on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

E. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.

F. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

2.5 CONTROLLERS

A. BACnet.

  1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
  2. BACnet Communication.
      a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
      b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
      c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing.

      d. Each ASC shall reside on a BACnet network using the ARCNET.

      e. Each SA shall reside on a BACnet network using the ARCNET.

      f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing.

B. Communication

1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

C. Memory

1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

D. Local Control Panels

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
2. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

PART 3 - EXECUTION

3.1   EXAMINATION

A. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the owner or engineer for resolution before rough-in work is started.

B. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

3.2   PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3   COORDINATION

A.   Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1.   Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation.
2.   The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
3.   The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.

3.4   GENERAL WORKMANSHIP

A.   Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B.   Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C.   Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).

D.   Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E.   All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5   FIELD QUALITY CONTROL

A.   All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B.   Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C.   Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.6   EXISTING EQUIPMENT

A.   Wiring. Interconnecting control wiring shall be removed and shall become the property of the contractor unless specifically noted or shown to be reused.

B.   Local Control Panels. Remove and deliver existing control panels to Owner.

C.   Repair. The contractor shall be responsible for repair or replacement of existing energy equipment valves, dampers, actuators, etc. as indicated on the Construction Drawings. Should the contractor find existing equipment that requires additional maintenance or repair, the engineer is to be notified immediately.

3.7   WIRING

A.   No wireless devices of any kind allowed.

B.   All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

C.   All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.

D.   All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.

E.   Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

F.   All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

G.   All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

H.   Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

I.   All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

3.8   COMMUNICATION WIRING

A.   No wireless devices of any kind allowed.

B.   The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

C.   All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

D.   Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

E.   Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F.   When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer's instructions.

G. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

   1. The network shall use shielded, twisted-pair cable (CAT-5e minimum).
   2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
   3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
   4. An MS/TP EIA-485 network shall have no T connections.

3.9 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See Sequences of Operation on Construction Drawings. If character limitations or space restrictions make it advisable to shorten the name, abbreviations may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

C. Software Programming.

   1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation.

3.10 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration.

   1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
   2. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
   3. Demonstrate compliance with sequences of operation through all modes of operation.
   4. Demonstrate complete operation of operator interface.
   5. Additionally, the following items shall be demonstrated:
       a. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
       b. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer.

These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

6. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.
1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

3.11   CLEANING

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

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

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

3.12   TRAINING

A. Minimum of 4 hours onsite training, and two training classes within the 1st year.

B. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

C. Training shall enable students to accomplish the following objectives.
1. Day-to-day Operators:
   a. Proficiently operate the system
   b. Understand control system architecture and configuration
   c. Understand BAS components
   d. Understand system operation, including BAS control and optimizing routines (algorithms)
   e. Operate the workstation and peripherals
   f. Log on and off the system
   g. Access graphics, point reports, and logs
   h. Adjust and change system set points, time schedules, and holiday schedules
   i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
   j. Understand system drawings and Operation and Maintenance manual
   k. Understand the job layout and location of control components
   l. Access data from BAS controllers and ASCs

     m.   Perform BAS controller unit operation and maintenance procedures
     n.   Perform workstation and peripheral operation and maintenance procedures
     o.   Perform BAS diagnostic procedures
     p.   Configure hardware including PC boards, switches, communication, and I/O points
     q.   Maintain, calibrate, troubleshoot, diagnose, and repair hardware
     r.   Adjust, calibrate, and replace system components

3.13 SEQUENCES OF OPERATION

A. Refer to Construction Drawings for Sequences of Operation

3.14 START-UP AND CHECKOUT PROCEDURES

A. Start up, check out, and test all hardware and software and verify communication between all components.
1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
2. Verify that all analog and binary input/output points read properly.
3. Verify alarms and interlocks.
4. Verify operation of the integrated system.

3.15 FIELD QUALITY CONTROL

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

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

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

C. BAS Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.

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

E.   Provide deficiency list of mechanical issues to Engineer.

3.16   SYSTEM WARRANTY

A.   Contractor shall provide one-year parts and labor warranty on all BAS components, hardware, wiring, etc.

END OF SECTION 230900