1.1 SUMMARY

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

B. See "Sequences of Operation" for requirements that relate to this Section.

C. The BAS control system shall be extension of the existing Siemens Apogee BAS and all controllers and software shall match existing or be latest version of existing.

1.2 RELATED DOCUMENTS

A. Drawings and Specification Sections of the Contract, including General and Supplementary Conditions, apply to this Section.
   1. General Requirements Section 01 00 00
   2. Section 01 00 00 – General and Special Requirements
   3. Section 01 33 00 – Submittal Requirements
   4. Section 27 05 26 – Commissioning of HVAC
   5. Section 05 45 19 – Commissioning of Integrated Automation
   6. Section 23 31 03 – Detection and Alarm (Fire and Smoke Alarm Systems)
   7. Section 01 60 00 – Materials and Equipment
   8. Section 23 05 00 – Common Work Results for HVAC
   9. Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC
   10. Section 26 01 00 – General Electrical Provisions for Electrical Work
   11. Section 26 05 00 – Common Work Results for Electrical
   12. Section 26 05 19 – Low Voltage Electrical Power Conductors and Cables
   13. Section 26 05 29 – Hangers and Supports for Electrical Systems
   14. Section 26 05 33 – Raceway and Boxes for Electrical Systems
   15. Section 26 05 53 – Identification for Electrical Systems
   16. Section 26 27 26 – Wiring Devices

1.3 DEFINITIONS

A. DDC: Direct digital controls

B. IP: Internet Protocol

C. I/O: Input/Output

D. LAN: Local area network.

E. TCP: Transfer Control Protocol
F. Scope Terminology
   1. Provide = Furnish equipment, engineer, program and install
   2. Furnish = Furnish equipment, engineer and program
   3. Mount = securely fasten or pipe
   4. Install = mount and wire
   5. Wire = wire only

1.4 SYSTEM DESCRIPTION

A. The Building Automation System (BAS) contractor shall furnish and install a networked system of HVAC controls. The contractor shall incorporating direct digital control (DDC) for central plant equipment, building ventilation equipment, supplemental heating and cooling equipment, and terminal units.

B. Provide networking to new DDC equipment using communication standards. The system shall not be limited to only standard protocols, but shall also be able to integrate to a wide variety of third-party devices and applications via drivers and gateways.

C. Provide standalone controls where called for on the drawings or sequences.

1.5 WORK INCLUDED

A. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.

B. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all system 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 general contractor.
   3. Provide installation of all panels and devices unless otherwise stated.
   4. Provide power for panels and control devices.
   5. Provide all low voltage control wiring for the DDC system.
   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. Participate in commissioning for all equipment that is integrated into the BAS (Refer to Commissioning sections of the equipment or systems in other parts of this specification.)
   9. Provide testing, demonstration and training as specified below.

1.6 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 5 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 5 seconds.
3. Object Command: Reaction time of less than 5 seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within 5 seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 2 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Programmable controllers shall execute DDC PI control loops, and scan and update process values and outputs at least once per second.
7. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
   a. Water Temperature: Plus or minus 1 deg F.
   b. Water Flow: Plus or minus 5 percent of full scale.
   c. Water Pressure: Plus or minus 2 percent of full scale.
   d. Space Temperature: Plus or minus 1 deg F.
   e. Ducted Air Temperature: Plus or minus 1 deg F.
   f. Outside Air Temperature: Plus or minus 2 deg F.
   g. Dew Point Temperature: Plus or minus 3 deg F.
   h. Temperature Differential: Plus or minus 0.25 deg F.
   i. Relative Humidity: Plus or minus 2 percent.
   j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
   k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   l. Airflow (Terminal): Plus or minus 10 percent of full scale.
   m. Air Pressure (Space): Plus or minus 0.01-inch wg.
   n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
   o. Carbon Monoxide: Plus or minus 5 percent of reading.
   p. Carbon Dioxide: Plus or minus 50 ppm.
   q. Electrical: Plus or minus 5 percent of reading.

1.7 SUBMITTALS

A. Provide submittals for fast track items that need to be approved and released to meet the schedule of the project. Provide submissions for the following items separately:
   1. Valve schedule and cut sheets
   2. Factory mounting and wiring diagrams and cut sheets
   3. Thermostat locations

B. Provide BIM symbols (Revit) for control devices that are to be shown on the coordinated BIM model.

C. Provide a complete submittal with all controls system information for approval before construction starts. Include the following:
   1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   2. Wiring Diagrams: Power, signal, and control wiring.
   3. Details of control panel faces, including sizes, controls, instruments, and labeling.
   4. Schedule of dampers and actuators including size, leakage, and flow characteristics.
5. If dampers are furnished by other, submit a damper actuator schedule coordinating actuator sizes with the damper schedule.
6. Schedule of valves including leakage and flow characteristics.
7. Written description of the Sequence of Operations.
8. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses. Show all routers, switches, hubs and repeaters.
9. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.
10. Starter and variable frequency drive wiring details of all automatically controlled motors.
11. Reduced size floor plan drawings showing locations of control panels, thermostats and any devices mounted in occupied space.

D. Wireless Communication: If wireless sensors and/or network are used, submit a radio signal layout showing the signal reach of every wireless mesh device. Show where repeaters are needed so that a wireless signals overlap.

E. Product Data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

F. Submit PICS statements for all direct digital controllers and interfaces.

G. Submit a description of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

H. Wiring Diagrams: Detail the wiring of the control devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels, including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.

I. Submit blank field check-out and commissioning test reports, customized for each panel or system, which will be filled out by the technician during start-up.

J. Submit sample graphics for approval before starting system commissioning.

K. Variance letter: Submit a letter detailing each item in the submission that varies from the contract specification or sequence of operation in any way.

L. After the BAS system is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.

1.8 QUALITY ASSURANCE
A. Codes
1. Perform all wiring in accordance with Division 26, NEC, local codes and Owner’s requirements.
2. Uniform Building Code (UBC)
3. 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.
5. All equipment shall be UL listed and approved and shall meet with all applicable NFPA standards, including UL 916 - PAZX Energy Management Systems,
6. Provide UL 864 – UUKL Smoke Control, where controllers and networks are used for that purpose.
   a. Provide written approvals and certifications after installation has been completed.
7. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
8. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

1.9 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.

1.10 COORDINATION
A. Coordinate location of thermostats, humidistats, panels, and other exposed control components with plans and room details before installation.
B. Coordinate equipment with Section 26 00 00 "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.
C. Coordinate power for control units and operator workstation with electrical contractor.
D. Coordinate equipment with provider of starters and drives to achieve compatibility with motor starter control coils and VFD control wiring.
E. Coordinate scheduling with the mechanical contractor and general contractor. Submit a schedule for approval based upon the installation schedule of the mechanical equipment.
F. Products Furnished but Not Installed Under This Section
   1. Hydronic Piping:
      a. Control Valves
      b. Temperature Sensor Wells and Sockets
c. Flow Switches
d. Flow Meters
2. Refrigerant Piping
   a. Pressure and Temperature Sensor Wells and Sockets
3. Sheetmetal accessories
   a. Dampers
   b. Airflow Stations
   c. Terminal Unit Controls

G. Products Installed but Not Furnished Under This Section
1. Refrigeration Equipment:
   a. Refrigerant Leak Detection System
   b. Proof of flow pressure switches
2. Rooftop Air Handling Equipment:
   a. Thermostats
   b. Duct Static Pressure Sensors

H. Integrate to equipment as called for in the sequence of operations

1.11 WARRANTY

A. Conform to the warranty requirement of the Contract Documents, General Requirements and this section or a minimum of 12 months. Provide the strictest.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system demonstration.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

D. During normal building occupied hours, failure of items that are critical for system operation shall be provided within 4 hours of notification from the Owner’s Representative.

E. This warranty shall apply equally to both hardware and software.

PART 2 - PRODUCTS

2.1 ACCEPTABLE SYSTEMS

A. Provide an extension to an existing Siemens APOGEE System as installed by the Siemens Industry branch office.

B. The vendors and products listed shall comply with these specifications. It shall not be assumed that standard products and methods will be acceptable without prior approval. Exceptions shall be noted during the bid process and documented in the submittal process.

2.2 SOFTWARE UPDATES
A. Provide an update to the operator interface software to the latest version of the type of software it is. For instance, if the existing software is Base, upgrade to the latest Base version.

B. Provide an update for each concurrent user license.

C. Provide an update for each of the existing user features, such as RENO, GO, etc.

2.3 ELECTRONIC DOCUMENTATION

A. Provide software applications and files to view documentation through the GUI.

B. Provide a CAD viewer to view all project AutoCAD documents that are made available by the Architect and Owner.

C. Provide all controls cut sheets in PDF format. Make them available to any user accessing the system over the Internet.

D. Provide a text version of the sequence of operation. Make the written sequence available from the graphic that represents each system. The sequence shall pop up in a printable format such as HTML or PDF.

2.4 CONTROLLER SOFTWARE (i.e. Building Controller software, DDC software, Field Panel software)

A. Reuse existing software. If new controllers need updated versions of the controller software, then provide updated versions, such that at the completion of this project, the Owner has controller software licenses for all of the existing and new generations of controllers.

2.5 BUILDING CONTROLLERS (B-BC)

A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Siemens PX Modular and Compact Controllers (PXC).

C. This level of controller shall be used for the following types of systems:
   1. Chiller plant systems
   2. Heating plant systems
   3. Cooling Towers
   4. Pumping systems
   5. VAV air handlers
   6. Air handlers over 15,000 cfm
   7. Systems with over 24 input/output points

D. Computing power and memory minimum:
   1. A 32-bit, stand-alone, multi-tasking, multi-user, real-time 100MHz digital control microprocessor module.
   2. Inputs shall be 16-bit minimum analog-to-digital resolution
3. Outputs shall be 10-bit minimum digital-to-analog resolution
4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), 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.
5. Real time clock and battery
6. Data collection/ Data Trend module sized for 10,000 data samples.
7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

E. Onboard or Modular hardware and connections:
1. Primary Network communication module, if needed for primary network communications.
2. Secondary Network communication module, if needed for secondary network communications.
3. RJ45 port 10/100Mbaud
4. RS485 ports for subnetworks and point expansion
5. Man to Machine Interface port (MMI)
6. USB Port

F. Input and Output Points Hardware
1. Input/output point modules as required including spare capacity.
3. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
4. 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.
5. Graduated intensity LEDs or analog indication of value for each analog output.

G. Code compliance
1. Approvals and standards: UL916; CE; FCC
2. Provide UL864-UUKL where called for in the sequences of operations.

H. Accessories:
1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

I. Keypad.
1. Where called for in the sequence of operation, or on the plans, a local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display.

J. The 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. Provide hand/off/auto switch for each digital output, including spares.

K. Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level 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.

L. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

M. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

N. Building Level control panels shall provide at least two 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 communications, operation of permanently connected modems, printers or terminals.

O. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and the BAS. Provide software, drives and programming.

P. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

Q. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point 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.

R. Environment.
   1. Controller hardware shall be suitable for the anticipated ambient conditions.
   2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
   3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

S. Immunity to power and noise.
   1. Controller shall be able to operate at 90% to 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 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
   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 (RFCl) 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 8 kV air discharge, 4 kV contact.
c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

4. Isolation shall be provided at all Building Controller’s AC input terminals to suppress induced voltage transients consistent with:
   b. UL 864 Supply Line Transients
   c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.6 ADVANCED APPLICATION CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Unitary Equipment Controller (PXCxx-UCM).

C. This level of controller shall be used for the following types of systems:
   1. Secondary Pumping systems
   2. VAV air handlers
   3. Air handlers up to 15,000 cfm
   4. Systems with over 12 controlled points
   5. Systems with custom sequences

D. Each System Level Control Panel shall, at a minimum, be provided with:
   1. Appropriate NEMA rated metal enclosure.
   3. Inputs shall be 16-bit minimum digital resolution
   4. Outputs shall be 10-bit minimum digital resolution
   5. Primary Network communication module, if needed for primary network communications.
   7. Memory module (4 Megabyte, 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.
   8. Real time clock and battery
   9. Data collection/ Data Trend module sized for 10,000 data samples.
   10. Power supplies as required for all associated modules, sensors, actuators, etc.
   11. Input/output point modules as required including spare capacity.
   12. Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
   13. Monitoring of the status of all hand-off-auto switches. The status of the hand-off-auto switch shall be available as a BAS data point.
14. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
15. 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.
16. Graduated intensity LEDs or analog indication of value for each analog output.
17. Approvals and standards: UL916; CE; FCC
18. Provide UL864-UUKL where called for in the sequences of operations.

E. Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level 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. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

G. Each Advanced Application Control Panel shall provide battery backup to support the real-time clock and RAM memory, such as trend logs, for a minimum of 100 hours.

H. Each System Level Control Panel shall support firmware upgrades without the need to replace hardware.

I. System Level control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications.

J. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

K. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point 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.

2.7 APPLICATION SPECIFIC CONTROLLERS

A. Each Application Level 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 application specific controller shall be a microprocessor-based, multi-tasking, real-time digital control processor.

B. Basis of design is Siemens TEC controller or PTEC for unique applications.

C. Provide a Application Specific Control Panel for each of the following types of equipment (if applicable):
   1. Constant Air Volume (CAV) boxes
2. Chilled beams  
3. Duct mounted reheat coils  
4. Fan coil Units  
5. Fan Powered Variable Air Volume (VAV) Boxes  
6. Reheat Coils  
7. Supplemental AC units  
8. Variable Air Volume (VAV) Boxes  
9. Other terminal equipment

D. Each Application Specific Controller shall, at a minimum, be provided with:
1. Appropriate NEMA rated enclosure  
2. Floor Level network communications ability  
3. Power supplies as required for all associated modules, sensors, actuators, etc.  
4. Software as required for all sequences of operation, logic sequences and energy management routines.  
5. A portable operator terminal connection port  
6. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure  
7. 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  
8. Each controller measuring air volume shall include a differential pressure transducer  
9. Approvals and standards: UL916; CE; FCC

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

F. Provide each Application Specific Controller 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. 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 (UPSs) 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.

G. The Application Specific Controller shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. Install plenum data line and sensor cable in accordance with local code and NEC. The controllers shall also function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

2.8 ROUTERS
A. Provide a router for each subnetwork to connect the floor level network to the base building backbone level network. The router shall connect FLN subnetworks to TCP/IP over Ethernet.

2.9 CONTROL PANELS

A. Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.

B. Mount on walls at an approved location or provide a free standing rack.

C. Panels shall be constructed of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed. Provide common keying for all panels.

D. Provide power supplies for control voltage power.

E. Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.

F. Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

G. All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.

H. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator’s workstations.

I. All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

J. Provide a pocket to hold documentation.

2.10 GENERAL SPECIFICATIONS FOR DEVICES

A. Provide mounting hardware for all devices, including actuator linkages, wells, installation kits for insertion devices, wall boxes and fudge plates, brackets, etc.

B. If a special tool is required to mount a device, provide that tool.

2.11 SENSORS

A. Terminal Unit Space Thermostats
   1. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
      a. Plain Space Temperature Sensors – Wired: Where called for in the sequences or on the drawings, provide sensors with plain covers.
b. The sensing element for the space temperature sensor shall be thermistor type providing the following.
   1) Element Accuracy: +/− 1.0°F
   2) Operating Range: 55 to 95°F
   3) Set Point Adjustment Range: 55 to 95°F
   4) Calibration Adjustments: None required
   5) Installation: Up to 100 ft. from controller
   6) Auxiliary Communications Port: as required
   7) Local LCD Temperature Display: as required
   8) Setpoint Adjustment Dial as required
   9) Occupancy Override Switch as required
   
c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

2. Digital Display temperature sensor specifications – Wired:
   a. As called for in the sequences of operations or on the drawings, provide temperature sensors with digital displays.
   b. The sensing element for the space temperature sensor must be IC-based and provide the following.
      1) Digitally communicating with the Application Specific Controller.
      2) Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
      3) IC Element Accuracy: +/- 0.9°F
      4) Operating Range: 55 to 95°F
      5) Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
      6) Display of temperature setpoint with numerical temperature values
      7) Display of temperature setpoint graphically, with a visual Hotter/Colder setpoint indication
      8) Calibration: Single point, field adjustable at the space sensor to +/- 5°F
      9) Installation: Up to 100 ft. from controller
      10) Auxiliary Communications Port: included
      11) Local OLED Temperature Display: included
      12) Display of Temperature to one decimal place
      13) Temperature Setpoint Adjustment included
      14) Occupancy Override Function included
   c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

3. Provide the following options as they are called for in the sequences or on the drawings:
   a. Setpoint Adjustment. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an
authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator’s terminal.

b. Override Switch. An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator’s terminal.

c. Space Combination Temperature and Humidity Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

B. Temperature Sensors

1. All temperature sensors shall meet the following specifications:
   a. Accuracy: Plus or minus 0.2 percent at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Vibration and corrosion resistant

2. Space temperature sensors shall meet the following specifications:
   a. 10k ohm type 2 thermisters

3. Insertion Elements in Ducts shall meet the following specifications:
   a. Single point 10k ohm thermister
   b. Use where not affected by temperature stratification
   c. The sensor shall reach more that 1/3 the distance from the duct wall
   d. Junction box for wire splices

4. Averaging Elements in Ducts shall meet the following specifications:
   a. 72 inches (183 cm) long
   b. Flexible
   c. Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
   d. Junction box for wire splices

5. Insertion Elements for Liquids shall meet the following specifications:
   a. Platinum RTD with 4-20mA transmitter
   b. Threaded mounting with matching well
   c. Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4” diameter
   d. Brass well with insertion length of 6 inches for pipes up to 10” diameter
   e. Junction box for wire splices

6. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
   a. Watertight enclosure, shielded from direct sunlight
   b. Circulation fan
   c. Watertight conduit fitting

C. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:

1. Security Sensors: Stainless-steel cover plate with insulated back and security screws
2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC
3. Space Sensors with LCD display:
   a. Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to on/off
   b. Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint

D. Humidity Sensors shall meet the following specifications:
   1. Bulk polymer sensor element
   2. Accuracy: 2 percent full range with linear output
   3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
   4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity

E. Air Static Pressure Transmitter shall meet the following specifications:
   1. Non-directional sensor with suitable range for expected input, and temperature compensated.
   2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   3. Output: 4 to 20 mA.
   4. Building Static-Pressure Range: 0 to 0.25 inches wg.
   5. Duct Static-Pressure Range: 0 to 5 inches wg.

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

G. Equipment operation sensors as follows:
   1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
   2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
   3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
   4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20mA output

H. Electronic Valve/Damper Position indication: Visual scale indicating percent of travel and 0 to 10 V dc, feedback signal.

I. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury 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.

J. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die cast aluminum housing, adjustable setpoint, minimum 5 amp switch rating at 120VAC, SPDT switches, and the switch pressure range shall be suited for the application. Provide Dwyer or equal. These switches shall be utilized for filter status.
K. Leak detectors: Provide spot leak detectors that can be secured to the floor or secured to a drain pan. The detection shall used a microchip controlled energized probes. The detector shall operate on 24V or less. Provide a way to adjust the height of the leak probes. The SPDT contacts shall be inside a watertight enclosure.

2.12 ELECTRO-MECHANICAL THERMOSTATS

A. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, with the following:
   1. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.

B. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Setpoint shall be adjustable.
   2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

C. Electric space thermostats: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

D. Aquastat: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

2.13 SMOKE DETECTORS

A. Provide a smoke detector for each unit above 2000 cfm. Turn it over to the mechanical contractor for installation. Wire it to stop the fan upon sensing smoke.

2.14 AUTOMATIC CONTROL VALVES

A. General:
   1. All automatic control valves shall be fully proportioning, unless specified otherwise. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of control air failure. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements. The valves shall be capable of operating in sequence with other valves and/or dampers when required by the sequence of operation. All control valves shall be sized by the control vendor and shall be guaranteed to accommodate the flow rates as scheduled. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved. Body pressure rating and connection type construction shall conform to fitting and valve schedules. Control valve operators shall be sized to close against a differential pressure equal to the design pump heads plus 10 percent.
   2. Cold water, hot water and steam valves, throttling type, and bypass valves shall have equal percentage flow characteristics.
3. Unless otherwise specified, control valves 2 inches and smaller shall have cast iron or bronze bodies with screwed NPT connections.
4. Valves between 2-1/2 inch and 4 inch shall have cast iron bodies with flanged connections.
5. All automatic control valves installed exposed to the elements shall be provided with electric actuators with operating characteristics and accessories as described in herein. Coordinate with electrical contractor for power availability and point of connection.
6. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless noted otherwise in these documents.
7. All automatic control valves shall be installed by the mechanical trade.
8. The controls contractor shall provide wiring as follows:
   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
   b. All wiring between the control system and the valve actuator shall be wired by the controls contractor.
   c. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.
   d. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

B. Hot Water / Condenser Water / Control Valves
   2. Fully proportioning with modulating plug or V-port inner valves.
   3. Body pressure rating and connection type construction shall conform to fitting and valve schedules. The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.
   4. Stainless steel stems and trim.
   5. Spring loaded Teflon packing
   6. Quiet in operation.
   7. Fail-safe in either normally open or normally closed position in the event of power failure.
   8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.
   9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

C. Differential Pressure Control Valves:
   1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each closed loop water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

D. Butterfly Valves
   1. Furnish automatic butterfly valves for isolation requirements as shown on the drawings or required herein.
   2. Butterfly valves shall have body ratings in accordance with the piping specifications.
   3. Valves that are in high static locations or where flanges are ANSI300 per the piping design shall be high performance, fully lugged with carbon steel body ANSI 300 as required by pipe specifications.
4. Valves that are in locations where ANSI150 flanges are allowed shall be ANSI 150 valves.
5. Valves shall be bubble tight with 316 stainless steel disc, stainless steel shaft and reinforced Teflon seat.
6. Actuators shall be fail in place with factory mounted open and closed position limit switches mounted.
7. Provide fail in place, electric actuators with waterproof enclosure and crankcase heater for actuator and accessories mounted outside.
8. Provide manual override hand wheels for each valve.
9. Butterfly valves will only be approved for cooling tower bypass and all two-position (open or close) applications.
10. Valves must have full lug type body connections.

E. Steam Valves:
1. Steam control valves shall be of linear flow characteristics for modulating service.

2. Sizing Criteria:
   a. 15 psig or less; pressure drop 80% of inlet psig.
   b. 16 to 50 psig; pressure drop 50% of inlet psig.
   c. Over 50 psig; pressure drop as scheduled on plans.
   d. Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:
      1) Heating coils in air handlers: normally open.
      2) Steam to hot water heat exchanger: normally closed.
      3) Other applications: as required by sequences of operation.

2.15 ELECTRONIC ACTUATOR SPECIFICATION

A. ELECTRONIC VALVE ACTUATORS
1. Actuator shall be fully modulating, floating (tri-state), two position, and/or spring return as indicated in the control sequences. Specified fail safe actuators shall require mechanical spring return.
2. Modulating valves shall be positive positioning, responding to a 2-10VDC or 4-20mA signal. There shall be a visual valve position indicator.
3. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
4. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
5. Actuators shall be UL listed.

B. ELECTRONIC DAMPER ACTUATORS
1. Actuator shall be direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator-to-shaft clamp shall use a "V" bolt and "V" shaped, toothed cradle to attach to the damper shaft for maximum holding strength. Single bolt or set screw type fasteners are not acceptable.
2. Actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.
3. For power-failure/safety applications, a mechanical, spring return mechanism shall be used.
4. Actuators with spring return mechanisms shall be capable of either clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
5. Proportional actuators shall accept a 2-10VDC, 4-20mA signal, or be of the 2 point floating type and provide a 2-10VDC actuator position feedback signal.
6. All actuators shall have an external manual gear release (clutch) or manual crank to aid in installation and for allowing manual positioning when the actuator is not powered.
7. All actuators shall have an external direction of rotation switch to aid in installation and to allow proper control response.
8. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box.
9. Actuators shall be listed under Underwriters Laboratories Standard 873 and Canadian Standards Association. They must be manufactured under ISO 9001.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. 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 engineer for resolution before rough-in work is started.

C. 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.

3.2 INSTALLATION

A. Provide all relays, switches, sources of emergency and UPS battery back-up electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. All field wiring shall be by this contractor.

B. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

C. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.
D. Install equipment level and plumb.

E. Install control valves horizontally with the power unit up.

F. Unless otherwise noted, install wall mounted thermostats and humidistat 60” above the floor measured to the center line of the instrument, or as otherwise directed by the Architect.

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

H. Install outdoor sensors in perforated tube and sunshield.

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

J. Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.

K. Furnish hydronic instrument wells, valves, and other accessories to the mechanical contractor for installation.

L. Furnish automatic dampers to mechanical contractor for installation.

3.3 ELECTRICAL WIRING SCOPE

A. This contractor shall be responsible for power that is not shown on the electrical drawings, to controls furnished by this contractor. If power circuits are shown on the electrical drawings, this contractor shall continue the power run to the control device. If power circuits are not shown, this contractor shall coordinate with the electrical contractor to provide breakers at distribution panels for power to controls. This contractor is then responsible for power from the distribution panel.
   1. Coordinate panel locations. If enclosures for panels are shown on the electrical drawings, furnish the enclosures according to the electrician’s installation schedule.

B. This contractor shall not be responsible for power to control panels and control devices that are furnished by others, unless it is part of the control interlock wiring.

C. Refer to Coordination section for what devices this contractor is responsible to mount and which are turned over to others to mount.

D. This contractor shall be responsible for wiring of any control device that is furnished as part of this section of specification.

E. Wiring for controls furnished by others:
   1. Provide control wiring for HVAC controls furnished by others. Wiring may include, but not limited to, interlocks, standalone thermostats, safeties and remote control devices such as valves, sensors, etc.

F. Interlock wiring shall be run in separate conduits from BAS associated wiring.

G. Provide network wiring for equipment that is called to be integrated to the BAS.
3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All low voltage control wiring shall be class 2. Control wiring that is not class 2 shall be run in separate conduits from class 2 wiring.

B. Floor level network wiring between terminal units can be combined with thermostat and other low voltage wiring in the same conduit. All other network wiring shall be in dedicated conduits.

C. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

D. Install building wire and cable according to Division 26 Section "Conductors and Cables."

E. Installation shall meet the following requirements:
   1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway or conduit.
   3. Install concealed cable using plenum rated cable.
   4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. All wiring in lab areas shall be in conduit.
   8. All unsupported risers shall be rigid steel conduit. Supported risers shall be EMT.

F. Rigid conduit shall be steel, hot dip galvanized, threaded with couplings, ¾ inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.

G. Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

H. Install conduit adjacent to machine to allow service and maintenance.

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

J. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

K. Ground equipment.

3.5 COMMUNICATION WIRING
A. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication cabling.

B. Do not install communication wiring in raceway and enclosures containing Class 1 wiring.

C. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

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

E. Cable bundling:
   1. RS485 cabling run open air in accessible areas can be bundled with other class 2 low voltage cabling.
   2. RS485 cabling run between terminal units in conduits above ceilings or under floors or in inaccessible areas can be bundled with other class 2 low voltage cabling.
   3. RS485 cabling run between floors shall be in a communication only conduit.
   4. RS485 conduit run long distances between utility rooms or between buildings shall be in a communication only conduit.
   5. Ethernet cabling shall be in a communication only conduit.
   6. Ethernet and RS485 can be run together.
   7. Fiber optics can be run with Ethernet and RS485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.

F. FLN Cabling
   1. FLN cabling shall be low capacitance, 20-24 gauge, twisted shielded pair.
   2. The shields shall be tied together at each device.
   3. The shield shall be grounded at one end only and capped at the other end.

G. Ethernet Cabling
   1. Ethernet shall not be run with any Class 1 or low voltage Class 2 wiring.
   2. CAT6, unshielded twisted pair (UTP) cable shall be used for BAS Ethernet.
   3. Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.
   4. When the BAS Ethernet connects to an Owner’s network switch, document the port number on the BAS As-builts.

H. When a cable enters or exits a building, a lightning arrester must be installed between the lines and ground. The lightning arrester shall be installed according to the manufacturer’s instructions.

I. All runs of communication wiring shall be unspliced length when that length is commercially available.

J. All communication wiring shall be labeled to indicate origination and destination data.

K. Grounding of coaxial cable shall be in accordance with NEC regulations article on “Communications Circuits, Cable, and Protector Grounding.”

3.6 IDENTIFICATION

Project Name 230900 - 23 BAS AND CONTROL FOR HVAC
A. Match the existing wiring and conduit identification methods.

3.7 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.

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.

3.8 SYSTEM CHECKOUT AND STARTUP

A. Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.

B. After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:

1. Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.
2. Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.
3. Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range accuracy matches the DDC setup.
4. Inspect the reading of each status switch to verify the DDC reads the open and close correctly.
5. Command each relay to open and close to verify its operation.
6. Command each 2-position damper actuator to open and close to verify operation.
7. Command each 2-position valve to open and close to verify operation.
8. Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.
9. Ramp each modulating output signal, such as a VFD speed, to verify its operation.
10. Test each safety device with a real life simulation, for instance check freezestats with ice water, water detectors with water, etc.
C. Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.

D. Verify that each DDC controller communicates on its respective network correctly.

E. After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:
   1. Start systems from DDC.
   2. Verify that each setpoint can be met by the system.
   3. Change setpoints and verify system response.
   4. Change sensor readings to verify system response.
   5. Test safety shutdowns.
   6. Verify time delays.
   7. Verify mode changes.
   8. Adjust filter switches and current switches for proper reactions.
   9. Adjust proportional bands and integration times to stabilize control loops.

F. Perform all program changes and debugging of the system for a fully operational system.

G. Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.

H. After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

3.9 SYSTEM COMMISSIONING, DEMONSTRATION AND TURNOVER

A. The BAS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to acceptance of the BAS by the Owner and Engineer, the BAS contractor shall completely test the BAS using the approved test procedure.

B. After the BAS contractor has completed the tests and certified the BAS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BAS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).

C. The BAS contractor shall fix punch list items within 30 days of acceptance.

D. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

3.10 PROJECT RECORD DOCUMENTS
A. Project Record Documents: Submit three (3) copies of record (as-built) documents upon completion of installation. Submittal shall consist of:
   1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD compatible files in electronic format and as 11 x 17 inch prints.
   2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements in the Control System Demonstration and Acceptance section of this specification.
      a. Operator’s Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
      b. Documentation of all programs created using custom programming language, including setpoints, tuning parameters, and object database.
      c. Graphic files, programs, and database on electronic media.
      d. List of recommended spare parts with part numbers and suppliers.
      e. Licenses, guarantees, and warranty documents for equipment and systems.

B. Provide updated versions of Operating manuals.

3.11 TRAINING

A. At a time mutually agreed upon, during System commissioning as stated above, the BAS contractor shall give 16-hours of onsite training on the operation of all BAS equipment. Describe its intended use with respect to the programmed functions specified. Operator orientation of the automation system shall include, but not be limited to:
   1. Explanation of drawings and operator’s maintenance manuals.
   2. Walk-through of the job to locate all control components.
   3. Operator workstation and peripherals.
   4. DDC Controller and ASC operation/sequence.
   5. Operator control functions including scheduling, alarming, and trending.
   6. Explanation of adjustment, calibration and replacement procedures.

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