SECTION 230900
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Temperature Control & Automation Drawing Sheets

B. The general commissioning process procedures and requirements are given in Section 230800 with responsibilities unique to Division 23. The common process requirements for initial system checkout by this Contractor are found in Section 230800 with some key broad scale requirements detailed further in this section. Detailed specific Cx functional testing requirements are identified in Section 230800.

1.02 SUMMARY

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

1.03 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. BACnet: A communication protocol for building automation and control networks. It is an ASHRAE, ANSI, and ISO standard protocol.

E. PID: Proportional plus integral plus derivative.

F. RTD: Resistance temperature detector.

G. Field Level Controller: Utilize inputs/outputs along with self-contained logics and process loops for controlling HVAC equipment. Field Level controllers communicate on RS485 communication networks that comply with ASHRAE standard 135.

H. Network (Plant) Level Controller: Utilize inputs/outputs along with self-contained logics, scheduling capabilities, and process loops for controlling HVAC equipment. Network Level controllers communicate on Ethernet based communication networks and/or supervisory RS485 networks that comply with ASHRAE standard 135 and ISO 8802-3.

I. Global Level Controller: Utilizes multiple communication protocols, complying with ASHRAE standard 135 and ISO 8802-3, used for sharing and passing information along with self-contained scheduling functions, trend logging, global logics, master time clock, and alarming capabilities.

1.04 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
   2. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
   3. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
      a. Water Temperature: Plus or minus 1 deg F.
      b. Water Flow: Plus or minus 5 percent of full scale.
      c. Water Pressure: Plus or minus 2 percent of full scale.
      d. Space Temperature: Plus or minus 1 deg F.
      e. Ducted Air Temperature: Plus or minus 1 deg F.
      f. Outside Air Temperature: Plus or minus 2 deg F.
      g. Dew Point Temperature: Plus or minus 3 deg F.
      h. Temperature Differential: Plus or minus 0.25 deg F.

i. Relative Humidity: Plus or minus 5 percent.
j. Airflow (Measuring Stations): Plus or minus 3 percent of full scale.
k. Airflow (Terminal): Plus or minus 10 percent of full scale.
l. Air Pressure (Space): Plus or minus 0.01-inch wg.
m. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
n. Carbon Monoxide: Plus or minus 5 percent of reading.
o. Carbon Dioxide: Plus or minus 50 ppm.
p. Electrical: Plus or minus 5 percent of reading.

1.05 SEQUENCES OF OPERATION – SHOWN ON THE TEMPERATURE CONTROLS AND AUTOMATION DRAWING SHEETS

1.06 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
   1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
   2. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
   2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   3. Wiring Diagrams: Power, signal, and control wiring.
   4. Details of control panel faces, including controls, instruments, and labeling.
   5. Written description of sequence of operation.
   6. Schedule of dampers including size, leakage, and flow characteristics.
   7. Schedule of valves including flow characteristics.
   8. DDC System Hardware:
      a. Wiring diagrams for control units with termination numbers.
      b. Schematic diagrams and floor plans for field sensors and control hardware.
      c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
   9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
   10. Controlled Systems:
      a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
      b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
      c. Written description of sequence of operation including schematic diagram.
      d. Points list.
      e. Location of duct air flow measuring stations shall be diagramed on floor plan duct shop drawings and are subject to approval by engineer.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

D. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals: PDF Format

2. Programing & Software Backup: Graphics, Network Level Controllers, & Terminal Level Controllers.
   a. Format: Saved to an SSD and Cloud Based Backups
   b. Updated with each change, not less than weekly throughout the commissioning period
3. Device address list.
4. Printout of software application and graphic screens.

E. Field quality-control test reports including check out sheets and updated controller points list.

F. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Maintenance instructions and lists of spare parts for each type of control device.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

G. Electronic Copies: Provide 2 copies on CD or flash memory stick of all temperature control submittals including but not limited to the information listed above – Items B - G.

1.07 QUALITY ASSURANCE

A. Quality assurance for automatic controls systems shall be accomplished in part through the commissioning process. However, this Contractor shall initiate that process by efforts consisting of in-house submittal review of system engineering work, submittal of pre-functional lists, initial commissioning of control functions, documented functional performance testing, operator training and O&M documentation.

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

C. Comply with ASHRAE 135 for DDC system components.

D. Comply with ISO 8802-3 for Ethernet based system components.

1.08 DELIVERY, STORAGE, AND HANDLING

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

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

1.09 COORDINATION

A. The automatic controls will be installed under the direct and continuous supervision of a lead technician (LIT) authorized by the manufacturer. The LIT must submit written certification of a minimum of 5 years of installation experience subject to acceptance to the Engineer of Record as well as the following information within 14 days after notice to proceed: name; address; cell phone number and email address. A replacement to the LIT must be approved in writing by the Owner and Engineer of Record.

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

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

D. Coordinate network drops for network level and global level controllers with owner’s information technology group.

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 CONTROL SYSTEM

A. Manufacturers: Subject to compliance with all requirements, one of the following systems shall be provided from a single local vendor/installer on a single system manufacturer/platform.
   1. Honeywell

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking networked environment programmed to control mechanical systems. A new operator workstation shall permit interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

C. Software License Holder: Facility Owner for all incremental work on the project.

D. Provide true peer-to-peer networked, stand-alone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, LonWorks, MODBUS and other open and proprietary communication protocols into the one open, interoperable system. Programming shall be accomplished at the lowest possible controller level to allow a degree of autonomy for each piece of HVAC equipment. Field level controllers shall share global point passing directly such that all global points continue to be available at each field level controller upon failure of a global level controller (UNC).

E. Network Architecture shall be designed such that Network Traffic does not exceed 70% of available bandwidth.

F. Completely remove old controls including wiring, tubing and devices. TCC is responsible for field verification of equipment and devices to be controlled.

G. Coordinate graphics standards with Owner and Engineer during submittal process. Sequences of operations and terminal level controls for existing to remain HVAC equipment shall remain, unless equipment is being modified as called out on the drawings.

H. The server shall provide central management of log data for all Network controllers supported by the server. Log data shall include all analog inputs, binary inputs, process logs, runtime and event counter logs, audit logs, and error logs. Archive logs every ~~5 days~~ day. Provide trend logs at intervals as follows:
   1. Every 10 minutes
   2. Every Change of State

2.03 GRAPHICAL REPRESENTATION

A. Summary:
   1. The points in the controls drawings shall be accessible from the GUI and/or the Web browser interface.
   2. The graphics shall provide detailed 2-dimensional building site, 2-dimensional floor plans; and 3-dimensional equipment illustrations with fan, pump, damper, and valve animation for system operation. Each graphic shall be provided with a tabular “hot button” navigational structure enabling a “one-mouse click” access to other building systems and the return, without the use of the browser “back button”.
   3. The graphic shall provide a real-time continuous display of critical points; Outside Air Temperature, Outside Air Relative Humidity, Enthalpy, KWH, and KW visible within the HTML frame on all graphic screens.

B. Home Page:
   1. The graphic shall provide a geographical overview of the multiple-site enterprise or campus buildings. Each building image shall be a “hot button” to access the building floor plans. The image “hot button” is indicated by a “mouse over” function highlighting the building and changing curser icon, enabling a “one-mouse click” access the building floor plans.
      a. Include District Wide One Look Pages:
         1) Food Service Freezers and Coolers
         2) Central Chilled and Hot Water Plants

C. One Look Overview Pages: Summarized list tables with setpoints monitoring points for similar equipment to include: Coordinate pertinent points with Cx Agent and Engineer
   1. VAV Boxes
   2. AHUs & RTUs
   3. Re-Heat Coils
   4. Exhaust Fans
   5. Unit Heaters

D. Floor Plans:
   1. The graphic shall provide an accurate dimensional layout of the building floor(s); including all rooms, room numbers, walls, elevators, doors, entrances, hallways, and stairwells. Room numbering and naming conventions shall be provided by the architect/engineer.
   2. All space sensors shall be placed on the Floor Plan graphic accurately depicting their location. Each sensor image shall be a “hot button” to access the associated equipment. The image “hot button” is indicated by a “mouse over” function changing curser icon, enabling a “one-mouse click” access to the equipment. The sensors shall be tagged with a real-time continuous display of their value.
   3. Building floor layout with large area or high density of sensors. The graphic shall provide an accurate dimensional layout of the building floor(s) divided into logical sections or areas. Each section or area shall be a “hot button” to access an expanded view. The section or area “hot button” is indicated by a “mouse over” function highlighting the section or area and changing curser icon, enabling a “one-mouse click” access to the expanded view. Expanded view; all space sensors shall be placed on the graphic accurately depicting their location. Each sensor image shall be a “hot button” to access the associated equipment. The image “hot button” is indicated by a “mouse over” function changing curser icon, enabling a “one-mouse click” access to the equipment. The sensors shall be tagged with a real-time continuous display of their value.

E. Mechanical Systems:
   1. The graphic shall provide an accurate 3-dimensional representation of the system being controlled; including all sensors, heat exchangers, heating and cooling coils, dampers, CHW/HW piping and pumps, humidifiers, flow directions, safety devices, actuators, and limit devices with fan, pump, damper, and valve animation for real-time system operation.
   2. All data point components shall be placed on the system graphic accurately depicting their location. Each component image shall be a “hot button” to access their respective schedule, set-points, and trend logs. The image “hot button” is indicated by a “mouse over” function changing curser icon, enabling a “one-mouse click” access to the parameters. All analog and digital components shall be tagged with a real-time continuous display of their value.
   3. The terminal unit graphic shall also include a reduced image of the associated AHU with animated fan status and tagged with a real-time continuous display of discharge air temperature and system static pressure.

2.04 DDC EQUIPMENT

A. Application Software:
   1. I/O capability from operator station.
   2. System security for each operator via software password and access levels.
   3. Automatic system diagnostics; monitor system and report failures.

4. Database creation and support.
5. Automatic and manual database save and restore.
6. Dynamic color graphic displays with up to 10 screen displays at once.
7. Custom graphics generation and graphics library of HVAC equipment and symbols.
8. Alarm processing, messages, and reactions.
9. Trend logs retrievable in spreadsheets and database programs.
10. Alarm and event processing.
11. Object and property status and control.
12. Automatic restart of field equipment on restoration of power.
13. Data collection, reports, and trend logs of the following:
    a. Current values of all ~~objects.~~analog and binary inputs and outputs
    b. Current alarm summary
    c. Disabled objects
    d. Alarm lockout objects
    e. Calclated Values and Parameters
    f. Setpoints
14. Custom report development.
15. Utility and weather reports.
16. Workstation application editors for controllers and schedules.
17. Maintenance management.

B. Custom Application Software:
    1. English language oriented.
    2. Full-screen character editor/programming environment.
    3. Allow development of independently executing program modules with debugging/simulation capability.
    4. Support conditional statements.
    5. Support floating-point arithmetic with mathematic functions.
    6. Contains predefined time variables.

C. Global Level Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
    1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
    2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
        a. Monthly Auto Update of Time Clock: Including DST adjustments for local. syncronized with NIST time server
    3. Stand-alone mode control functions operate regardless of network status. Functions include the following:
        a. Global communications.
        b. Monitoring, controlling, or addressing data points.
        c. Software applications, scheduling, and alarm processing.
        d. Testing and developing control algorithms without disrupting field hardware and controlled environment.
    4. Standard Application Programs:
        a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, anti-short cycling, PID control, DDC with fine tuning, and trend logging.
        b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.

c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
e. Remote communications.
f. Maintenance management.
g. Units of Measure: Inch-pound and SI (metric).

5. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
6. ASHRAE 135 Compliance: Control units shall comply with ASHRAE 135 protocol and ISO 8802-3 (Ethernet) datalink/physical layer protocol.

D. Field/Plant Level Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source. Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
3. Binary Inputs: Allow monitoring of on-off signals without external power.
4. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
5. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
6. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights. Isolate digital TRIAC outputs with appropriate relays.
7. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
8. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
9. Universal I/Os: Provide software selectable binary inputs/outputs or analog inputs/outputs.
10. Configuration: Diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios. ~~and 72-hour battery backup.~~
11. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
12. ASHRAE 135 Compliance: Communicate using multiple read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
13. ISO 8802-3 Compliance (where applicable): Communicate using Ethernet local area network operation for selected speeds of operation from 1Mb/s to 100 Gb/s using a common media access control specification and management information base.
14. Enclosure: Dustproof rated for operation at 32 to 120 deg F.
15. Spare Point Capacity: Minimum four points of each of the following types, AO, AI, DO, DI.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current

and voltage requirements and be full-wave rectifier type with the following:

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

F. Power Line Filtering: Internal or external transient voltage and surge suppression for controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.
5. Verify that fan-speed controller is compatible with fan motor.

2.05 ELECTRONIC SENSORS

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

B. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers:
   a. BEC Controls Corporation.
   b. Ebtron, Inc.
   c. Heat-Timer Corporation.
   d. I.T.M. Instruments Inc.
   e. MAMAC Systems, Inc.
   f. RDF Corporation.
   g. Siemens.
   h. Schneider Electric.
2. Accuracy: Plus or minus 0.5 deg F at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
5. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft..
6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Set-Point Adjustment: Concealed.
   b. Set-Point Indication: Keyed.
   c. Color: Selected by the District
   d. Orientation: Vertical.

C. RTDs and Transmitters:

1. Manufacturers:
   a. BEC Controls Corporation.
   b. MAMAC Systems, Inc.
   c. RDF Corporation.
   d. Schneider Electric.
2. Accuracy: Plus or minus 0.2 percent at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
5. Averaging Elements in Ducts: 24 feet long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.

7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: Concealed.
    b. Set-Point Indication: Keyed.
    c. Color: Selected by the District
    d. Orientation: Vertical.

D. Humidity Sensors: Bulk polymer sensor element.
1. Manufacturers:
    a. BEC Controls Corporation.
    b. General Eastern Instruments.
    c. MAMAC Systems, Inc.
    d. ROTRONIC Instrument Corp.
    e. TCS/Basys Controls.
    f. Vaisala.
    g. Schneider Electric.
2. Accuracy: 2 percent full range with linear output.
3. Room Sensor Range: 20 to 80 percent relative humidity.
4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: Concealed.
    b. Set-Point Indication: Keyed.
5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
6. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Combination Humidity/Temperature Sensors: Install complying with the RTD temperature sensor requirements above and the requirements for humidity sensors listed above.

F. Combination Outside Air Humidity/Temperature Sensor: Provide optional radiation shield. Install on Northern side of building away from direct sunlight and any sort of building exhaust. Sensor to not be accessible by general population.
1. Model:
    a. Airtest EE21 with Radiation Shield.
2. Relative Humidity Sensor: HC1000.
    a. Full Scale Range: 0% RH to 100% RH.
    b. Accuracy: ± 3% RH.
    c. Output: 4 to 20 mA.
3. Temperature Sensor: Pt1000.
    a. Full Scale Range: -40ºF to 140ºF
    b. Accuracy: Plus or minus 0.5 deg F at calibration point.
    c. Output: 4 to 20 mA.

G. Walk-In Freezer / Walk-In Cooler Temperature Sensors: Provide fluid filled thermally buffered temp sensors designed for use in walk-in cooler/freezer. Install in suitable location, away from evaporator fan discharge air and locate as to not allow damage from shelving and/or carts.
1. Manufacturers
    a. MAMAC Systems Inc.
    b. BAPI (Building Automation Products Inc.)
    c. Schneider Electric
    d. Vaisala.
2. Accuracy: Plus or minus 0.5 deg F at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Output: Thermistor 10k type III
5. Enclosure: UV-resistant polycarbonate

H. Pressure Transmitters/Transducers:
1. Manufacturers:
    a. BEC Controls Corporation.

b. General Eastern Instruments.
c. MAMAC Systems, Inc.
d. ROTRONIC Instrument Corp.
e. TCS/Basys Controls.
f. Vaisala.

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

I. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   1. Set-Point Adjustment: Concealed.
   2. Set-Point Indication: Keyed.

J. Room sensor accessories include the following:
   1. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.
   2. Adjusting Key: As required for calibration and cover screws.

2.06 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

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

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

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

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

G. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.
   1. Manufacturers:
      a. BEC Controls Corporation.
      b. I.T.M. Instruments Inc.

2.07 GAS DETECTION EQUIPMENT

A. Manufacturers:
   1. B. W. Technologies.
   2. CEA Instruments, Inc.

3. Ebtron, Inc.
4. Gems Sensors Inc.
5. Greystone Energy Systems Inc.
6. Honeywell International Inc.; Home & Building Control.
7. INTEC Controls, Inc.
8. I.T.M. Instruments Inc.
9. MSA Canada Inc.
10. QEL/Quatrosense Environmental Limited.
11. Sauter Controls Corporation.
12. Sensidyne, Inc.
13. TSI Incorporated.
14. Vaisala.
15. Vulcain Inc.

B. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output;, for wall mounting.

C. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.08 DUCT AIR FLOW MEASURING STATIONS

A. Thermal dispersion Air flow measuring station:
1. Manufacturer: EBTRON Hybrid Series.
2. Description: Airflow station shall consist of multiple sensor probes and a remotely mounted microprocessor-based transmitter.
3. Application Considerations: Provide product suitable for location as illustrated on the drawings.
4. Performance:
   a. Capable of independently processing up to 16 independently wired sensor assemblies.
   b. Airflow rate of each independent sensor assembly shall be equally weighted and averaged by transmitter prior to output.
   c. Temperature of each independent sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
   d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
   e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
   f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
   g. Airflow Accuracy: Within 3 percent of reading over the entire operating airflow range.
      1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.
   h. Temperature Accuracy: Within 0.2 deg F (0.11 deg C) over entire operating range of minus 20 to plus 140 deg F (minus 29 to plus 60 deg C).
   i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F (Minus 29 to plus 71 deg C).
   j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F (Minus 29 to plus 49 deg C).
   k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
   l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
5. Sensor Assemblies:

a. Each sensor probe shall contain at least two individually wired, hermetically sealed bead-in-glass thermistors.
b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
c. Thermistor leads shall be protected and not exposed to the environment.
d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.
g. Probe Assembly Mounting Brackets Material: Type 3xx stainless steel.

6. Transmitter:
   a. Integral digital display capable of simultaneously displaying total airflow and average temperature, or individual airflow, and temperature readings of each independent sensor assembly.
   b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
      1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
         (a) Integral protection from transients and power surges.
         (b) Circuitry to ensure reset after power disruption, transients, and brownouts.
         (c) Integral transformer to convert field power source to operating voltage required by instrument.
   c. Remote Signal Interface:
      1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, field selectable, zero- to 10-V dc.

2.09 FAN INLET AIR FLOW MEASURING STATIONS:

A. Furnished by the fan manufacturer factory mounted piezometer style.

B. In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of air volume flow rate.

C. Multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.

D. Sensor points shall not protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.

E. Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.

F. Sensor shall be non-intrusive and not impact fan performance.

G. Product shall be a standard offering of the fan manufacturer and include published literature with supporting test data to validate sensor performance.

2.10 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
   1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
   3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
   4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.

5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc.
2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque calculated as follows:
   a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
   c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
   e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
   f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 120-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: 40 to 104 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
12. Run Time: 30 seconds.

2.11 CONTROL VALVES

A. Manufacturers:
1. Belimo.
2. Danfoss Inc.; Air Conditioning & Refrigeration Div.
3. Flow Control DeltaPValve.
4. Honeywell.
5. Parker Hannifin Corporation.
6. Pneuline Controls.
7. Sauter Controls Corporation.
8. Siemens.
9. Schneider Electric

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

C. AHU chilled water- and heating water coil 2-way control valves: PIV, 2-way pattern, pressure independent up to a minimum of 50 psig range.

D. AHU chilled water- and heating water coil 3-way control valves: Globe valves with the following characteristics:
1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 3-psig to 5-psig pressure drop range at design flow rate or the following:
   a. Two Position: Line size.
   b. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above unless noted on the drawings.
5. Flow Characteristics: Three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total for three-way valves.

E. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
4. Control: Floating or analog.

2.12 DAMPERS

A. Manufacturers:
1. TAMCO (T. A. Morrison & Co. Inc.).
2. Ruskin.

B. Dampers: AMCA-rated, opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.
1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.
5. Internal pressure foam injected when in communication with outdoor air (Outdoor air intake dampers or relief/exhaust dampers).

2.13 DDC VAV BOX CONTROLLERS

A. Provide controllers for all new VAV boxes. The control contractor to provide VAV box DDC controllers, control transformers, space temperature sensors, supply temperature sensor, differential pressure transducers, electronic damper actuators and any other misc. devices required to have a complete and functioning system.

2.14 WATER FLOW METERS

A. Insertion type, single or double turbine as manufactured by Onicon.

B. Provide bi-directional or uni-directional flow meter as called out on drawings.

C. Accuracy of +/- 2% of reading from 0.4 to 20 fps

2.15 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Display all control points including monitoring points on the system graphic.

D. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 60 inches above the floor.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Install guards on thermostats in the following locations:
   1. Everywhere except classrooms and offices.

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

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

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

I. Furnish hydronic instrument wells, valves, and other accessories to piping contractor for installation according to Division 23 Section "Hydronic Piping."

J. Furnish duct volume-control dampers to sheet metal contractor for installation according to Division 23 Sections specifying air ducts.

3.02 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Division 27 Section "Communication Horizontal Cabling."
   1. Conceal cable in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor 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. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions.

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

3.03 PHYSICAL NETWORK ARCHITECTURE

A. Ethernet Cabling: Category 6a

B. Architecture: Physically Isolated and fully stand alone from other district network(s)

C. Cross connects to District Network: Clearly Labeled, Coordinated with the District and approved in writing for Internet/Remote Access to the Stand-Alone Building Automation System.

3.04 TREND LOGGING CAPABILITIES

A. The control system installed shall be capable of, and set up to readily trend data with the following minimum features.
   1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC controller's point group.
   2. Collection may be by either pre-defined time interval or upon a pre-defined change of value (COV).
   3. Each DDC controller panel shall have a dedicated RAM-based buffer for trend data and shall be capable of storing at least 20,000 samples.
   4. At least six columns of data can be viewed on the screen at once and can be graphed using a graphing program integral to the control system, with at least four parameters graphed against time on the same graph. The columnar format shall have time down the left column with columns of data to the right (one column for each parameter).
   5. The system shall have the ability to graph real-time data of up to four points on the EMS at once, giving each point its own scale.
   6. Without any special or difficult conversions, this data shall be able to be designated to be stored as an ASCII delimited file in the same columnar format for use in graphing with normal commercial spreadsheet software.
   7. The trend log data is automatically downloaded at appropriate intervals onto the hard drive when space in the field cabinets becomes full, so that no data is lost. This is done without the user having to calculate the size of the trends and download frequency.
   8. Any limitations in the trending as to speed of sampling vs number of sampled points in a given trend, and the effect on actual sampling rate and simultaneousness of the sampling across parameters shall be clearly explained in writing. Programming and trending setup examples of all representative situations shall be provided.
   9. The trends shall be capable of being set up to start sampling all trended points in a given trend or group of trends at the same exact time.
   10. Specifications for standard trends shall be able to be set up by the user and be saved by a name and initiated by only recalling the name. The control contractor shall assist the operators in setting up at least six standard trends during training.
   11. A key for the names and definitions of all point abbreviations (both physical and virtual) shall be provided.
   12. The system shall have the ability to automatically accumulate and store run-time hours of digital input and output points and to count events (totalization and counting functions).
   13. Ideal, but not required, shall be the capability to graph with the control system software, one or more points against another, rather than just against time.

3.05 FIELD QUALITY CONTROL

A. The Controls Contractor shall comply with and return a signed CONTROLS READINESS STATEMENT (as provided by the Commissioning Agent) to the Commissioning Agent prior to start of Commissioning functional testing. Refer to section 230800.

B. 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.

C. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
   4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID tuning constants.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

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

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

3.06 ADJUSTING

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

B. Adjust initial temperature and humidity set points.

3.07 VARIABLE SPEED DRIVES

A. Furnish all variable speed drives to the Electrical contractor for installation and wiring.

B. Start-up and check out by factory certified technician and documented on a certified start-up form. Provide one copy to the Owner and retain one copy in the manufacturer's project file.

C. Provide 3 hours of training by factory certified technician on site during normal working hours. Include operation, maintenance and trouble-shooting

D. Provide 24 hour phone support.

3.08 AIR FLOW MEASURING STATIONS

A. Provide the stations specified in Part 2 in air ducts at locations shown on the drawings. Deviation from locations illustrated on the drawings must be approved by the Engineer.

B. Controls contractor is responsible for connecting to, and self-commissioning fan air flow measuring stations factory mounted and provided by others. Using factory recommended standard density method, Controls Contractor is responsible for acquiring factory air flow conversion equation as required to calculate CFM. Equations shall not include a cross sectional area variable. Full setup of differential pressure measurement devices, programming of standard density equation in BAS, and testing & adjustment is the responsibility of the Controls Contractor.

C. Coordinate calibration of all air flow measurement devices with balancing contractor by testing various air flows and adjusting factors. Thermal dispersion air flow measuring stations shall not be adjusted or K-factored except as recommended by the manufacturer. Adjustment and setup shall be performed at the device controller. Verify setup of thermal dispersion air flow measuring stations including duct area input.

D. Controls Contractor is responsible for EARLY duct size / location coordination with sheet metal contractor so that all air flow measuring stations are fully operational by date of substantial completion.

3.09 WATER FLOW METERS

A. Provide to piping contractor for installation and coordinate location as indicated on M6x, M7x, and M9x series drawings.

B. Coordinate calibration of all water flow measurement devices with balancing contractor by testing various water flows and adjusting factors.

3.10 OUTDOOR AIR QUALITY EMERGENCY CONTROL

A. Provide a single command function via the building automation system (accessible by offsite personnel) to initiate the following until returned to the normal operation by the operator.
   1. Shut down all exhaust fans controlled by the BAS.
   2. Close all outside air dampers and run in full recirculation mode, all air handling systems controlled by this contractor's BAS.

3.11 TEMPORARY PROGRAMMING AND TESTING TERMINAL

A. If the permanent terminal and display is graphical for viewing values and setpoints, and the update time for the graphical display is considered by the CA to be too slow, the controls contractor shall provide and set up, during the entire functional testing process, a second input and output terminal with a text based format (in addition to the graphics-capable permanent terminal), which will significantly speed up the point readout update time. Both terminals will be simultaneously active.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 230900