

SECTION 23 09 00
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): INCITS 4, Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
 - a. Handbook Fundamentals.
 - b. Guideline 3, Reducing Emission of Fully Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems.
 - c. 135, Data Communication Protocol for Building Automation and Control Networks.
3. American Society of Mechanical Engineers (ASME): B19.3, Safety Standard for Compressors for Process Industries.
4. American Water Works Association (AWWA): C704, Propeller-Type Meters for Waterworks Applications.
5. Electronic Industries Alliance (EIA):
 - a. TIA-232-F, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
 - b. 485, Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
6. Federal Communications Commission (FCC).
7. International Organization for Standardization (ISO): 8802-3, Information Technology - Telecommunication and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Carrier Sense Multiple Access with Detection (CSMA/CD) Access Method and Physical Layer Specifications.
8. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
9. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code.
 - b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
10. UL: 916, Standard for Safety Energy Management Equipment.

1.02 DEFINITIONS

- A. The terms “HVAC Control System,” “Automatic Temperature Control System,” “Building Automation System,” and “Environmental Management and Control System” shall be considered equivalent and used interchangeably for the purposes of this Contract.
- B. Algorithm: A software procedure for solving a recurrent mathematical or logical problem.
- C. Analog: A continuously varying signal or value (temperature, current, velocity, etc.).
- D. Binary: A two-state system where an “ON” condition is represented by a high signal level and an “OFF” condition is represented by a low signal level.
- E. Control Wiring:
 - 1. Wiring, high or low voltage other than power wiring required for proper operation of mechanical systems.
 - 2. Includes conduit, wire and wiring devices to install complete control system including motor control circuits, interlocks, thermostats, PE and EP switches and like devices.
 - 3. Includes wiring from DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute sequence of operation.
 - 4. Includes necessary power wiring to HVAC control devices, digital controllers including terminal units and actuators.
- F. Control Process: Software required to complete control loop from input signal to interlock logic and process calculation to final output signal control.
- G. Deadband: Temperature range over which no heating or cooling energy is supplied, such as 72 degrees F to 78 degrees F; as opposed to single point changeover or overlap, or a range from set point over which no control action is taken.
- H. Direct Digital Control (DDC): Consists of microprocessor-based controllers with control logic performed by software. Analog-to-digital (A/D) converters transform analog values into digital signals that microprocessor can use.
- I. Power Wiring: Line voltage wiring to mechanical equipment. Line voltage wiring that also serves as control circuit, such as line voltage thermostat or involves interlocking with damper shall be considered control wiring.

J. Abbreviations that may be used in this section:

1. AC: Air Conditioning.
2. ATC: Automatic Temperature Control.
3. BAS: Building Automation System.
4. CHWS/R: Chilled/Hot Water Supply/Return.
5. CMOS: Complementary Metal Oxide Semiconductor.
6. DDC: Direct Digital Control.
7. DX: Direct Expansion.
8. EP: Electro-Pneumatic.
9. EEPROM: Electronic Erasable Programmable Read Only Memory.
10. EMCS: Environmental Management and Control System.
11. HCP: HVAC Control Panel.
12. HGS/R: Hot Glycol Supply/Return.
13. HMI: Human-Machine Interface.
14. HOA: Hand-Off-Auto (Switch).
15. HVAC: Heating, Ventilation, and Air Conditioning.
16. IP: Current (I) - Pressure (P), as in IP transducer.
17. LCD: Liquid Crystal Display.
18. LED: Light Emitting Diode.
19. PE: Pneumatic-Electric.
20. PLC: Programmable Logic Controller.
21. RAM: Random Access Memory.
22. RTD: Resistance Temperature Detectors.
23. VAV: Variable Air Volume.
24. W3: Nonpotable Water.

1.03 SYSTEM DESCRIPTION

A. General Requirements:

1. Provide control wiring, power wiring, conduit, hardware, and electrical work associated with the HVAC control system.
2. Provide control wiring between HVAC control panel contacts and field control devices, such as duct smoke detectors and motor starter control coil contacts.
3. Provide controls necessary for entire system to have fail-safe operation.
4. Control sequences and functions including alarms, monitoring and resetting functions, and operational sequences shall not be limited to point schedules and sequences of operation.
5. Provide sequences and functions as required to deliver a fully functioning HVAC system.

B. Control System Types:

1. The following control system types may be used in this Project:
 - a. Electric/Electronic Control System (ELECTRIC):
 - 1) System using simple electric or electronic control devices.
 - 2) User interface at control device.
 - b. Standalone DDC Control System (STANDALONE DDC):
 - 1) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
 - 2) No information sharing between controllers.
 - 3) User interface at DDC controller.
 - 4) Refer to Section 23 09 23, Direct-Digital Control System for HVAC, for additional requirements.
 - c. Networked DDC Control System (NETWORKED DDC):
 - 1) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
 - 2) Information within control system can be utilized by any control component over high-speed network.
 - 3) User interface via computer workstation and/or portable terminal.
 - 4) Refer to Section 23 09 23, Direct-Digital Control System for HVAC, for additional requirements.
2. Provide control system(s) of architecture defined in Control Type Schedule, below:

Control Type Schedule		
Location	System	Control Type
All	Where operating sequences call for simple thermostatic or interlock control	ELECTRIC
Process Areas	All	STANDALONE DDC
Office Building	All	NETWORKED DDC
Maintenance	All	STANDALONE DDC

C. Performance Requirements:

1. Design control system and equipment to perform under the following conditions:
 - a. Temperature, Ambient:
 - 1) Summer maximum 89.6 DB/56.5 WB degrees F.
 - 2) Winter minimum minus 1.1 DB degrees F.
 - 3) Based on ASHRAE Handbook fundamentals weather data for the City of Grand Canyon National Park.
 - b. Temperature, Indoor:
 - 1) Heated and Ventilated Process Areas: Summer maximum 100 degrees F. winter minimum 50 degrees F.
 - 2) Air-conditioned Nonprocess Areas: Summer maximum 75 degrees F; Winter minimum 72 degrees F.
 - 3) Laboratory: Summer maximum 75 degrees F; winter minimum 72 degrees F.
 - 4) Maintenance Facility: Summer maximum 80 degrees F in Mech/Elec Shop, winter minimum 65 degrees F.
 - 5) Electrical Rooms: Summer maximum 80 degrees F, winter minimum 50 degrees F.

D. Refer to Section 01 67 00, Product Requirements, for additional environmental performance requirements.

1.04 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that includes make, model, dimensions, weight of equipment, and electrical schematics, for all control system components.
2. Complete system power, interlock, control, and data transmission wiring diagrams no smaller than 11 inches by 17 inches.
3. Complete drawings and schematics of proposed control system, including panel power requirements.
4. System operating sequences to be programmed, in exact English language.
5. Complete points list.
6. Interfaces with HVAC equipment.
 - a. Schematic diagram of each equipment item.
 - b. Indicate location of each control item in equipment.
 - c. Show equipment manufacturer controls where installed.
7. Panel face layout drawings.
8. Damper actuator sizing calculations, in schedule form.

B. Informational Submittals:

1. Table identifying which member of Contractor's team is responsible for furnishing and setting in-place power wiring and control wiring of each item or component of HVAC equipment.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 67 00, Product Requirements.
4. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
5. Confirmation that control system Supplier has received and coordinated with all approved HVAC equipment submittals.
6. Experience and qualifications of control system Supplier's proposed representative who will supervise installation, adjustment, and calibration of control systems.
7. Performance test plan and schedule.
8. Test Results:
 - a. Functional and performance test documentation.
 - b. Component calibration sheets for each instrument and panel component as described in Section 40 90 00, Instrumentation and Control for Process Systems.
9. Operation and maintenance data: In accordance with Section 01 78 23, Operation and Maintenance Data. In addition, include the following detailed information:
 - a. Operation and maintenance instructions for control system as furnished and installed, including control of associated mechanical and electrical equipment.
 - b. Record of system adjustments and calibration methods.
 - c. Performance test results.

1.05 QUALITY ASSURANCE

- A. Materials, devices, appliances, and equipment used shall be indicated as acceptable by established standards of UL.
- B. Codes and Standards: Meet requirements of applicable standards and codes, except when more detailed or stringent requirements are indicated by Contract Documents, including requirements of this section.
 1. UL: Products shall be UL 916-PAZX listed.
 2. National Electrical Code NFPA 70.
 3. Federal Communications Commission Part J.
 4. Networked DDC Control Systems shall comply with ASHRAE 135 (BACnet).

C. Qualifications of HVAC Controls System Supplier:

1. Minimum of 15 years' experience in design, installation, and maintenance of fully electronic building automation systems.
2. Minimum of 10 years' experience in design, installation, and maintenance of computer based, direct digital control, facility automation systems.
3. Minimum of 5 years' experience as manufacturer's authorized representative in design, installation, and maintenance of manufacturer's system and products.
4. Capable of furnishing factory-trained technicians, competent to provide instruction, routine maintenance, and emergency service onsite within 4 hours after receipt of request.
5. Factory trained certified engineering and commissioning staff, and complete offsite training facilities.
6. Necessary facilities to provide Contracting Officer with complete maintenance, periodic inspection, and service contract. Refer to Paragraph, Maintenance.

D. FCC Regulation: Electronic equipment shall conform to requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

E. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years. Future compatibility shall be supported for no less than 10 years.
2. Compatibility shall be defined as:
 - a. Ability to upgrade existing field panels to current level of technology, and extend new field panels on previously installed network.
 - b. Ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 67 00, Product Requirements.

B. Corrosion Protection:

1. Control panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, shall be protected from corrosion through use of corrosion-inhibiting vapor capsules.

2. Prior to shipment, capsules shall be provided within shipping containers and equipment as recommended by capsule manufacturer.
3. During construction period, capsules shall be replaced in accordance with capsule manufacturer's recommendations.

1.07 MAINTENANCE

- A. Maintenance Service Agreement shall be provided upon determination of Government needs.
1. Furnish a draft maintenance agreement, prepared, and signed by the Controls Supplier, to provide the necessary preventative maintenance to keep the various control systems in proper working condition.
 2. Fully describe the maintenance work to be performed and estimate cost of the maintenance during the 1-year correction period and the subsequent year.
 3. This service contract shall include 24-hour emergency service, 7 days per week.

1.08 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following special tools:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different unit size

1. Spare parts shall be available for at least 5 years after substantial completion.

- B. Tools:

1. For each building, furnish one complete set of special tools recommended by manufacturer for maintenance, dismantling, or repair of each separate type of equipment item.
2. Furnish toolbox for storage of special tools. Identify purpose by means of stainless steel or solid plastic nametag attached to box.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified shall be products of the following manufacturers:
1. Siemens Building Technologies.
 2. Or equal.

2.02 PHYSICAL CHARACTERISTICS

A. Materials:

1. General:

- a. Products used in this installation shall be new, currently under manufacture, and shall have been applied in similar installations for minimum of 2 years.
- b. System shall not be used as test Site for new products, unless explicitly approved by Contracting Officer, in writing.

B. Labeling

1. All products, namely electrical materials, devices, appliances, and equipment used, shall be indicated as acceptable by established standards of UL and Factory Mutual (FM).
2. Valid label affixed to item shall provide indication of product acceptance by required agencies.
3. HVAC control panels and control components that consist of multiple components shall bear UL listing mark on unit.

C. Service Conditions:

1. Refer to Section 01 67 00, Product Requirements, Section 26 05 02, Basic Electrical Requirements, and Electrical Drawings for classification of areas as hazardous, corrosive, wet, indoor dry, and dust tight.
 - a. Use materials and methods and enclose devices in NEMA enclosure types suitable for classification indicated, and as required by NFPA 70.
 - b. Exhaust ductwork shall be considered same classification as area served.
 - c. Instruments within 3 feet of ducts conveying air from spaces classified as Class I, Division 1, or Division 2 (in accordance with NFPA 70) shall be suitable for same area classification as space exhausted.

2.03 FUNCTIONAL CHARACTERISTICS

A. Control Components:

1. Control range to obtain specified capacities.
2. Sensitivity to maintain control points close enough to set point for acceptable offset, without cycling equipment more frequently than recommended by manufacturer.
3. Field or computer adjustable to actual set point, ranges. Adjustable to other settings that will provide proper operation of entire control system.

B. Controls Interfacing:

1. Interface controls properly with factory supplied components of mechanical systems. Coordinate special control interfacing requirements.
2. For equipment that requires special interfacing with control system, provide equipment with integral controls or provide accessory devices required for operation of total mechanical system.
3. Coordinate interfaces with electrical work as necessary.
4. Provide electric, electronic, and mechanical devices as required to properly interface with prewired control panels furnished with HVAC equipment and with other mechanical and electrical components.

2.04 PERFORMANCE CHARACTERISTICS

A. Electrical Components and Accessories:

1. Electrical components shall be provided in accordance with requirements of Division 26, Electrical.
2. Wiring:
 - a. In accordance with Section 26 05 05, Conductors, and NFPA 70.
 - b. Insulation shall be rated 600 volts, minimum.
3. Electrical Raceways: In accordance with Section 26 05 33, Raceway and Boxes, and NFPA 70.
4. Provide surge suppressors on each power connection, meeting applicable requirements of Section 40 90 0, Instrumentation and Control for Process Systems.

2.05 FIELD COMPONENTS AND INSTRUMENTS

- A. Refer to HVAC controls detailed specification, Section 23 09 13, HVAC Controls, Field Components, and Instruments.

2.06 MICROELECTRONIC CONTROL COMPONENTS

- A. Refer to HVAC controls detailed specification, Section 23 09 23, Direct-Digital Control System for HVAC.

2.07 ACCESSORIES

A. Corrosion-inhibiting vapor capsules:

1. Physical Characteristics:
 - a. 5 cubic foot capsule based on size of control cabinet.
 - b. 10 cubic foot capsule based on size of control cabinet.

2. Functional Characteristics:
 - a. Operating Temperature: 199 degrees F.
 - b. Maximum life expectancy shortening of 25 percent above 104 degrees F.
 3. Performance Characteristics: None.
 4. Manufacturers:
 - a. Hoffman; Model A-HCI.
 - b. One equal.
- B. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.
- C. Equipment Identification Plates:
1. Physical Characteristics:
 - a. Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8 inch high engraved or die-stamped block type black enamel filled equipment identification number and letters as specified and as shown.
 - b. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
 - 1) Night low limit thermostats.
 - 2) Manual override timers.
 - 3) START/STOP switches.
 - 4) Humidistats.
 - 5) Emergency STOP switches.
 - 6) Special purpose devices.
 - 7) HVAC control panels.
 2. Functional Characteristics: None.
 3. Performance Characteristics: None.
- D. Anchor Bolts: Galvanized, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

2.08 EQUIPMENT FINISH

- A. Provide materials and equipment with manufacturer's standard finish system. Provide manufacturer's standard finish color, except where specific color is indicated.
- B. If manufacturer has no standard color, provide gray finish as approved by Contracting Officer.

PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

- A. Reference the Contract Drawings.

3.02 INSTALLATION

A. General:

1. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings, and equipment details.
2. Changes in location or installation of control devices or equipment shall be approved by Contracting Officer before proceeding with the Work.
3. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.

B. Hazardous and Corrosive Areas:

1. In the following areas, provide control equipment and wiring suitable for installation in Class 1, Division 2, Group C or Group D hazardous areas:
 - a. Headworks.
2. In the following areas, control equipment and wiring shall be suitable for continuous exposure to saturated hydrogen sulfide.
 - a. Headworks.
3. In the following areas, control equipment and wiring shall be suitable for corrosive environments, as follows:
 - a. Headworks.
4. Protect control equipment located in areas identified as being corrosive as follows:
 - a. Use corrosion-inhibiting vapor capsules inside control equipment enclosures and HCP.
 - b. Replace capsules prior to Contracting Officer's acceptance of equipment.

C. Wiring:

1. General:
 - a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.
 - b. Install control and interlock wiring separate from power wiring.
 - c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.

- d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.
- e. Restrain wiring in control panels by plastic ties or ducts.
- f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.
- g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.
- h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in single crimp lug and no more than two lugs may be installed on single screw terminal.
- i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.
- j. Adequately support and run wiring in a neat manner.
- k. Run wiring parallel or at right angles to building structure.
- 2. Concealment:
 - a. Conceal wiring from view, except in mechanical rooms and areas where other conduit and piping are exposed; install exposed wiring and conduit to be as unobtrusive as possible.
 - b. Install line voltage control wiring, wiring exposed to view, surface-mounted wiring, and wiring concealed within walls in conduit, in accordance with Division 26, Electrical.
 - c. Plenum rated low voltage control wiring system may be used without conduit in concealed, but accessible areas.
 - d. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
 - e. Conduit shall be sized to suit the number, type, and size of conductors as specified in Section 26 05 05, Conductors.

D. End-User Accessible Control Components:

- 1. Do not mark room thermostats.
- 2. Mount user adjustable control components (room thermostats, humidistats, temperature sensors, humidity sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

E. Control Dampers:

- 1. Verify correctness of installation.
- 2. For pneumatic systems, calibrate and adjust positioners and IP transducers.
- 3. Verify proper control action.
- 4. Adjust limit switch settings.

5. Adjust opening and closing speeds, and travel stops.
6. Stroke control dampers by means of associated control output.

F. Adjustable Frequency Drives:

1. Verify control wiring installed to adjustable frequency drive.
2. Calibrate and adjust remote speed control loop and feedback loop.
3. Verify control actions and interlocks.
4. Adjust minimum and maximum speed settings.
5. Ramp adjustable frequency drive by simulation of associated controller output.

G. DDC Controllers:

1. Verify control wiring for correctness.
2. Verify power wiring.
3. Calibrate and adjust manual and auto control actions of controllers.
4. Tune control loop.
5. Stroke associated final element through controller output.
6. Verify set points and alarm functions.

H. HVAC Control Panel (HCP) Equipment:

1. Mount HCPs level, plumb, and securely to wall or column. Verify that adequate clearance is provided to allow for full front panel swing.
2. Provide field terminations and conduit knockouts for control/instrumentation wiring.
3. Field termination wiring shall have designated instrument tag.
4. Panel cutouts shall be cut, punched, or drilled and smoothly finished with round edges.
5. Provide separate conduit entry for each power feeder circuit.
6. Signals requiring grounding shall be grounded within panel.
7. Field end of conductor shield/drain wires shall be folded back and placed under heat-shrink tubing without being grounded.
8. Panel end of conductor shield/drain wires shall be covered with clear tubing at panel and grounded.
9. Calibrate instrumentation provided on control panels.
10. Provide labels for internal panel material (such as, terminal blocks, power supplies, relays, PLC racks).

3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing:

1. Tests and certification shall be as specified in Section 01 91 14, Equipment Testing and Facility Startup, and Section 01 43 33, Manufacturers' Field Services.

2. HVAC controls interface with process control system shall be coordinated with the Work of Section 40 90 00, Instrumentation and Control for Process Systems.

3.04 MANUFACTURER'S SERVICES

- A. Provide manufacturer's services in conformance with requirements of Section 01 43 33, Manufacturers' Field Services.
- B. Manufacturer's Representative:
 1. Present at Site or classroom as designated by Contracting Officer, for minimum person-days listed below, travel time excluded:
 - a. 3 person-days for installation, assistance, and inspection.
 - b. 5 person-days for functional and performance testing and Manufacturer's Certificate of Proper Installation.
 - c. 1 person-day for prestartup classroom or Site training.
 - d. 2 person-days for facility startup.
 - e. 1 person-day for post-startup training.

3.05 TRAINING

- A. Provide training of Contracting Officer's personnel to enable them to operate HVAC equipment in available modes, to adjust set points, and to interpret alarm signals.
- B. Training sessions shall be prepared in advance, and arranged for clear, effective transfer of information in minimum time.

3.06 ADJUSTING AND CALIBRATING

- A. Control system shall be adjusted and calibrated by qualified manufacturer's representative.
- B. Calibrate control devices at time of installation to ensure measuring and reading accuracy.
- C. Adjustment Record:
 1. Prepare complete record of system adjustments for each control system.
 2. Indicate deviations from specified temperatures.
 3. Include copy of completed record in each copy of Operation and Maintenance Manual.

3.07 CLEANING AND TOUCHUP PAINTING

- A. Touchup scratches, scrapes, or chips in exterior surfaces with finish matching type, color, consistency, and type of surface of original finish.

3.08 SUPPLEMENT

- A. The supplement listed below, following “End of Section,” is a part of this specification:
1. HVAC Controls Sequence of Operation, General Control Types.

END OF SECTION