

**SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC**

SPEC WRITER NOTES:

1. Use this section only for NCA projects. If a complex networked DDC system is required in this project the section shall be obtained from VA Masters.
2. Delete between // // if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs.
3. Provide an Input/Output (I/O) point schedule for all applicable equipment including electrical and plumbing as well as mechanical on drawings.
4. Make sure 120 volts power is provided for automatic temperature control systems, including DDC panels and damper and valve motors, and the locations are shown on electrical drawings.

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The control system(s) shall be as indicated on the project documents, point list, drawings, and described in these specifications. Include in this scope of work a complete and working system including all controls and installation materials, installation labor, commissioning and start-up.

SPEC WRITER NOTE: Include in paragraph B any special project description or conditions that may pertain to this project such as existing equipment or items to be reused and connection provisions to remote facilities.

- B. //Base bid includes the replacement of the DDC controls and the installation of new DDC controls as well as electronic operators as indicated on the temperature control diagrams and the I/O Points List.//
- C. Supply as required, all necessary hardware equipment and software packages to interface between any existing and new system Unitary Control Units (UCU) as part of this contract. Number of controllers required is dependent on the type and quantity of devices, hardware and software points provided.

- D. The control systems is designed such that each mechanical system operates under stand-alone mode. Provide controllers for each mechanical system.
- E. Do not run power wiring in conduit with communications trunk wiring, signal, or control wiring operating at 100 volts or less.
- F. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- G. Definitions:
1. Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.
 2. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
 3. BAC: Building Automation Control.
 4. BAS: Building Automation System.
 5. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).
 6. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.
 7. BMP or bmp: Bitmap, Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.
 8. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller.
 9. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22 to 25 degrees C (72 to 77 degrees F), as opposed to a single point change over or overlap).
 10. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.
 11. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and

- processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.
12. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.
 13. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.
 14. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.
 15. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.
 16. Ethernet: Physical and data link layer technology system for exchanging messages between computers on a LAN using coaxial, fiber optic, or twisted-pair cables.
 17. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.
 18. GIF: Abbreviation of Graphic interchange format.
 19. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input (AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.
 20. Operating system (OS): Software, which controls the execution of computer application programs.
 21. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.
 22. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

23. PICS: Protocol Implementation Conformance Statement.
24. UCU: Unitary Control Unit, digital controller, dedicated to a specific piece of equipment, such as: air handling unit, heat pump, chiller, heat exchanger etc.

1.2 RELATED WORK

SPEC WRITER NOTE: Retain one of two paragraphs below.

- A. //Section 01 00 01, GENERAL REQUIREMENTS (Major NCA Projects).//
- B. //Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects).//
- C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- D. Section 01 42 19, REFERENCE STANDARDS.
- E. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS.
- F. //Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.//
- G. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items which are common to more than one section of Division 23.
- H. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- I. //Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//
- J. Section 23 31 00, HVAC DUCTS AND CASINGS.
- K. Section 23 36 00, AIR TERMINAL UNITS.
- L. Section 23 81 00, UNITARY HVAC EQUIPMENT.
- M. Section 23 81 43, AIR-SOURCE UNITARY HEAT PUMPS.
- N. Section 23 81 46, WATER-SOURCE UNITARY HEAT PUMPS.
- O. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
- P. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).
- Q. Section 27 10 00, NETWORK CABLING.

1.3 APPLICABLE PUBLICATIONS

SPEC WRITER NOTE: Make material requirements agree with requirements specified in the referenced Applicable Publications. Verify and update the publication list to that which applies to the project, unless the reference applies to all mechanical systems. Publications that apply to all mechanical systems may not be specifically referenced in the body of the specification, but, shall form a part of this specification.

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 90.1-2013.....Energy Efficient Design of New Buildings Except Low-Rise Residential Buidings
 - 135-2012.....BACnet - A Data Communication Protocol for Building Automation and Control Networks
- C. Federal Communication Commission (FCC):
 - Rules and Regulations Title 47 Chapter 1-2001 Part 15, Radio Frequency Devices.
- D. National Fire Protection Association (NFPA):
 - 70-2014.....National Electric Code (nec)
- E. Underwriter Laboratories Inc (UL):
 - 508A-2013 (R2014).....Standard for Industrial Control Panels
 - 916-2015.....Standard for Energy Management Equipment

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. A wiring diagram for each type of input device and output device including DDC controllers, etc. Ensure diagram shows how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature sensors and transmitters.
 - 2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.

3. Control dampers schedule, including the size and pressure drop.
 4. Installation instructions for smoke dampers, if furnished.
 5. Catalog cut sheets of all equipment used. This includes, but is not limited to DDC controllers, panels, peripherals, associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer's cut sheets apply to a product series rather than a specific product, highlight the data specifically applicable to the project. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent and provided in both hardcopy and electronic formats.
 6. Provide sequence of operations for each HVAC system and the associated control diagrams. Ensure equipment and control labels correspond to those shown on the drawings. Ensure all control diagrams shown on drawings are represented accurately by graphics on the system. Generic graphics lacking some components or have components not in the project are not acceptable.
 7. Color prints of proposed graphics with a list of points for display.
 8. Furnish PICS (protocol implementation conformance statement) for each device.
- D. Product Certificates: Compliance with paragraph, QUALITY ASSURANCE.
- E. As Built Control Drawings:
1. Furnish three (3) copies of as-built drawings for each control system. Ensure the documents are submitted for approval prior to final completion.
 2. Furnish one (1) CD-ROM in PDF format for the drawings noted in subparagraphs above.
- F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.
 2. Include complete diagrams of the internal wiring for each item of equipment.
 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- G. //Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician

and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

H. //Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

1.5 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of Contractor: Ensure that the controls contractor obtain hardware and software specified under this Section and that the controls contractor also installs the system. Ensure the controls contractor is responsible for the complete design, installation, and commissioning of the system. Ensure the controls contractor is in the business of design, installation and service of such building automation control systems similar in size and complexity.
2. Equipment and Materials: Ensure equipment and materials are cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Ensure products are manufacturer's latest standard design and have been tested and proven in actual use.

B. Codes and Standards:

1. Ensure all work conforms to the applicable Codes and Standards.
2. Ensure electronic equipment conforms to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.
3. Ensure unitary controllers conform to the requirements of UL 916, Category PAZX.
4. UL 508A for auxiliary fabricated control panels.
5. Ensure all controllers provided be UL tested and labeled.
6. System provided to comply with ASHRAE 135 and be UL tested, certified and labeled.
7. Ventilation Sequence of control to comply with ASHRAE 90.1.

1.6 PERFORMANCE

A. Ensure the system conforms to the following:

1. Object Command: Ensure the maximum time between the command of a binary object by the operator and the reaction by the device be 10 seconds. Ensure analog objects start to adjust within 3 seconds.

2. Object Scan: Ensure all changes of state and change of analog values are to be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior 10 seconds.
3. Alarm Response Time: Ensure the maximum time from when an object goes into alarm to when it is annunciated at the workstation not exceed 10 seconds.
4. Program Execution Frequency: Ensure custom and standard applications are capable of running as often as once every 5 seconds. Ensure that the controls contractor select execution times consistent with the mechanical process under control.
5. Performance: Ensure programmable controllers are able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. Ensure the controller scans and updates the process value and output generated by this calculation at this same frequency.

SPEC WRITER NOTE: Edit the following Table to suit Project.

6. Reporting Accuracy: Listed below are minimum acceptable reporting accuracies for all values reported by the specified system:

Measured Variable	Reported Accuracy
Space temperature	±0.5 degrees C (±1 degrees F)
Ducted air temperature	±1.0 degrees C (±2 degrees F)
Outdoor air temperature	±1.0 degrees C (±2 degrees F)

1.7 INSTRUCTIONS

- A. Instructions to VA operations personnel: Perform in accordance with paragraph, INSTRUCTIONS, in //Section 01 00 01, GENERAL REQUIREMENTS (Major NCA Projects)// //Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects)//, and as noted below.

1.8 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

- A. Ensure the CUs and associated equipment used in controlled environment are mounted in NEMA 1 enclosures for operation at 0 to 50 degrees C (32 to 122 degrees F) at a relative humidity of 10 to 90 percent non-condensing.
- B. Ensure the CUs used outdoors are mounted in NEMA 4 waterproof enclosures, and are rated for operation at minus 40 to plus 65 degrees C (minus 40 to plus 150 degrees F).

- C. Ensure all electronic equipment operates properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.
- D. Ensure sensors and controlling devices are designed to operate in the environment, which they are sensing or controlling.

1.9 AS-BUILT DOCUMENTATION

SPEC WRITER NOTE: Coordinate O&M Manual requirements with Section 01 00 01, GENERAL REQUIREMENTS (Major NCA Projects) or Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects). O&M manuals shall be submitted for content review as part of the close-out documents.

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be //in electronic version on CD or DVD// inserted into a three ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version //____// provided on CD or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing

work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 CONTROLS SYSTEM ARCHITECTURE

- A. General: Provide licenses for all software residing on and used by the Controls Systems and transfer these licenses to the Government prior to completion.
- B. The Specifications for the individual elements and component subsystems are the minimum requirements and augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards and to meet all requirements of the Contract Documents.

SPEC. WRITER NOTE: Edit as per project specific requirements.

- C. Third Party Interfaces: Ensure the Controls Systems include necessary hardware, equipment and software to allow data communications between the Controls Systems and building systems supplied by other trades.

SPEC WRITER NOTE: Have the other disciplines to include language in their drawings and specs to coordinate with the controls contractor.

- 1. The contractor shall ensure the other manufacturers and subcontractors supplying other associated systems and equipment will provide the necessary hardware, software, and start-up and will cooperate fully with the controls contractor in a timely manner to ensure complete functional integration.

2.2 DIRECT DIGITAL CONTROLLERS

SPEC WRITER NOTE: Edit the following paragraphs based on the requirement of different control units, which are defined in paragraph, DEFINITIONS.

- A. Ensure Unitary Control Units (UCUs) are microprocessor-based. Ensure they are capable of stand-alone operation, continuing to provide stable control functions if communication is lost with the rest of the system.
 - 1. Ensure the each UCU have sufficient memory to support its own operating system, including data sharing.
 - 2. Ensure all UCUs are provided with LCD type annunciation to continually display its operational mode, power and communications.

3. In the event of loss of normal power, ensure the orderly shut down of the controllers to prevent the loss of database or software programming. When power is restored flash memory, battery backup, or super capacitor will be automatically loaded into non-volatile flash memory and incorporated for all programming data.
- B. Provide I/O module that connects sensors and actuators onto the field bus network for use by the direct digital controllers. Ensure I/O devices support the communication technology specified for each controller.
1. Ensure analog input allow the monitoring of low voltage (0-10 VDC), current (4-20 ma), or resistance signals (thermistor, RTD). Ensure analog input be compatible with, and field configurable to commonly available sensing devices. Ensure that analog output provide a modulating signal for these control devices.
 2. Ensure binary inputs allow the monitoring of on/off signals from remote devices. Ensure that binary inputs provide a wetting current of at least 12 milliamps to be compatible with commonly available control devices. Ensure that binary outputs provide on/off operation, or a pulsed low voltage signal for pulse width modulation control. Ensure outputs be selectable for either normally open or normally closed operation.
 3. Ensure binary outputs on remote and auxiliary controllers have 3-position (on/off/auto) override switches and status lights. Ensure analog outputs on remote and auxiliary controllers have status lights and a 2-position (auto/manual) switch and manually adjustable potentiometer for manual override.
 4. Ensure each output point be provided with a light emitting diode (LED) to indicate status of outputs.

2.3 DIRECT DIGITAL CONTROLLER SOFTWARE

- A. Ensure the software programs specified in this section are commercially available, concurrent, multi-tasking operating system and support the use of software application that operates under DOS or Microsoft Windows.
- B. Ensure all points are to be identified by up to 30-character point name and 16-character point descriptor.
- C. Ensure all control functions execute within the stand-alone control units via DDC algorithms.

- D. Ensure all CU's are capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Ensure default values be invoked upon sensor failure or, if the primary value is normally provided by the central or another CU, or by loss of bus communication. Ensure individual application software packages are structured to assume a fail-safe condition upon loss of input sensors.
- E. Ensure all DDC control loops are able to utilize any of the following control modes:
1. Two position (on-off, slow-fast) control.
 2. Proportional control.
 3. Proportional plus integral (PI) control.
 4. Proportional plus integral plus derivative (PID) control. Ensure all PID programs automatically invoke integral wind up prevention routines whenever the controlled unit is off, under manual control of an automation system or time initiated program.
 5. Automatic tuning of control loops.
- F. System Security: Ensure operator access be secured using individual password and operator's name. Ensure passwords restrict the operator to the level of object, applications, and system functions assigned to him. Provide a minimum of six (6) levels of security for operator access.
- G. Application Software: Ensure the CUs provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. Ensure all application software reside and run in the system digital controllers.

SPEC WRITER NOTE: Edit out the following programs that are not applicable to the project. Add new programs to the list, if required.

1. Power Demand Limiting (PDL): Ensure power demand limiting program monitor the building power consumption and limit the consumption of electricity to prevent peak demand charges. Ensure PDL continuously tracks the electricity consumption from a pulse input generated at the kilowatt-hour/demand electric meter. Ensure PDL samples the meter data to continuously forecast the electric demand likely to be used during successive time intervals. If the forecast demand indicates that electricity usage will likely exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads. Once the demand load has met, restore and return

to normal mode all loads that have been shed. Ensure control system is capable of demand limiting by resetting the HVAC system set points to reduce load while maintaining indoor air quality.

SPEC WRITER NOTE: ASHRAE 90.1 indicates the allowable and prohibited economizer control types. Ensure the contract documents incorporate the appropriate type for the project's climate zone.

2. //Economizer: Ensure an economizer program be provided for VAV systems. Ensure that this program controls the position of air handler relief, return, and outdoors dampers. Ensure economizer sequence of controls comply with ASHRAE 90.1. Ensure that the operator be able to override the economizer cycle and return to minimum outdoor air operation at any time.//
3. Night Setback/Morning Warm up Control: Ensure the system provides the ability to automatically adjust set points for this mode of operation.

SPEC WRITER NOTE: Check local codes if Optimum stop can shutdown the ventilation supply before the end of the occupancy period.

4. Optimum Start/Stop (OSS): Ensure optimum start/stop program automatically coordinates with event scheduling. Ensure the OSS program starts HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by the time of occupancy, and also shut down HVAC equipment at the earliest possible time before the end of the occupancy period and still maintain desired comfort conditions. Ensure the OSS program considers both outside weather conditions and inside zone conditions. Ensure the program automatically assigns longer lead times for weekend and holiday shutdowns. Ensure the program polls all zones served by the associated air handling unit and selects the warmest and coolest zones. Use these in the start time calculation. Ensure the possibility to assign occupancy start times on a per air handler unit basis. Ensure the program meets the local code requirements for minimum outdoor air while the building is occupied.
5. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or a group of points according to a stored time. Ensure this program provides the capability to individually command a point or group of points. When

- points are assigned to one common load group, ensure the possibility to assign variable time advances/delays between each successive start or stop within that group. Ensure scheduling be calendar based and advance schedules may be defined up to one year in advance. Ensure advance schedule overrides the day-to-day schedule. Ensure the operator is able to define the following information:
- a. Time, day.
 - b. Commands such as on, off, auto.
 - c. Time delays between successive commands.
 - d. Manual overriding of each schedule.
 - e. Allow operator intervention.
6. Alarm Reporting: Ensure the system is able to start programs, log the event, and display the messages.
7. Maintenance Management (PM): Ensure the system monitors equipment status and generate maintenance messages based upon the operators defined equipment run time, starts, and/or calendar date limits. Ensure a preventative maintenance alarm is displayed indicating maintenance requirements based on pre-defined run time. Ensure each preventive message include point description, limit criteria, and preventative maintenance instruction assigned to that limit. Ensure a minimum of 480-character PM be provided for each component of units such as air handling units.

2.4 SENSORS (AIR AND WATER)

A. Temperature Sensors:

1. Electronic Sensors: Provide all remote sensors as required for the systems. Ensure all sensors are vibration and corrosion resistant for wall, and/or duct mounting.
 - a. Temperature Sensors: Thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral transmitter type for all other sensors.
 - 1) Ensure duct sensors are rigid or averaging type as shown on drawings. Ensure averaging sensor is a minimum of 1 linear foot of sensing element for each square foot of cooling coil face area.
 - 2) Ensure space sensors are equipped with set-point adjustment, override switch, display, and/or communication port as shown on the drawings. Match room thermostats, locking cover.

- 3) Ensure outdoor air temperature sensors have watertight inlet fittings and be shielded from direct sunlight.
 - 4) Ensure room security sensors have stainless steel cover plate with insulated back and security screws.
 - 5) Wire: Twisted, shielded-pair cable.
 - 6) Output Signal: 4-20 ma.
- B. Current Switches: Ensure current operated switches are self-powered, solid state with adjustable trip current as well as status, power, and relay command status LED indication. Ensure the switches are selected to match the current of the application and output requirements of the DDC systems.

2.5 CONTROL CABLES

- A. As specified in Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).
- B. As specified in Section 27 10 00, NETWORK CABLING.

2.6 THERMOSTATS

- A. Ensure room thermostats controlling heating and cooling devices have three modes of operation (heating - null or dead band - cooling). Ensure wall mounted thermostats have //polished or brushed aluminum// //satin chrome// //manufacturer's recommendation// finish, setpoint range and temperature display and external adjustment:
 - 1. Electronic Thermostats: Solid-state, microprocessor based, programmable to daily, weekend, and holiday schedules.
 - a. Public Space Thermostat: Ensure public space thermostat is a platinum sensor and not have a visible means of set point adjustment. Ensure adjustment be via the digital controller to which it is connected.
- B. Ensure strap-on thermostats are enclosed in a dirt and moisture proof housing with fixed temperature switching point and single pole, double throw switch.
- C. Ensure freezestats have a minimum of 300 mm (1 linear foot) of sensing element for each 0.093 square meter (1 square foot) of coil area. Ensure that the thermostatic element operated with just the onset of freezing condition at any increment of 300 mm (1 foot) anywhere along the sensing element.

SPEC WRITER NOTE: Designer shall identify the normal position of control valves and control dampers; normally open (NO) or normally closed (NC).

2.7 FINAL CONTROL ELEMENTS AND OPERATORS

- A. Fail Safe Operation: Ensure control valves and dampers provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.
- B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.
- C. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. Ensure all modulating dampers are opposed blade type and gasketed. Ensure blades for two-position, duct-mounted dampers are the parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.

SPEC WRITER NOTE: ASHRAE 90.1 indicates the allowable damper leakage rates in a given climate zone.

- 1. Leakage: Ensure maximum leakage in closed position not to exceed //4// //10// cfm/sq.ft. at 1.0 inch WG differential pressure.
- 2. Ensure frame is galvanized steel channel with seals as required to meet leakage criteria.
- 3. Ensure blades are galvanized steel or aluminum, 200 mm (8 inch) maximum width, with edges sealed as required.
- 4. Ensure bearing is nylon, bronze sleeve or ball type.
- 5. Ensure hardware is zinc-plated steel. Ensure connected rods and linkage be non-slip. Ensure working parts of joints are brass, bronze, nylon or stainless steel.
- 6. Ensure metal parts are aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel.
- 7. Maximum air velocity and pressure drop through free area of the dampers:
 - a. Smoke damper in air handling unit: 210 meter per minute (688 fpm).
 - b. Duct mounted damper: 600 meter per minute (1968 fpm).
 - c. Maximum static pressure loss: 50 Pascal (0.20 inches water gage).
- D. Ensure operators are electric type. See drawings for required control operation.
- E. Smoke Dampers: Dampers and operators are specified in Section 23 31 00, HVAC DUCTS AND CASINGS. Control of these dampers is specified under this Section.

F. Damper Operators and Relays:

1. Ensure electric damper operator provides full modulating control of dampers. Ensure a linkage and pushrod be furnished for mounting the actuator on the damper frame internally in the duct or externally in the duct or externally on the duct wall, or be furnished with a direct-coupled design.
2. Electronic Damper Operators: Ensure VAV Box actuator to be mounted on the damper axle or be of the air valve design, and provide complete modulating control of the damper. Ensure the motor has a closure torque of 35-inch pounds minimum with full torque applied at close off to attain minimum leakage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

B. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to COR for resolution before proceeding for installation.
2. Install equipment wiring /conduit parallel to or at right angles to building lines.
3. Install all equipment in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
4. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
5. Provide sufficient slack and flexible connections to allow for vibration of equipment.
6. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
7. Install equipment level and plum.

C. Electrical Wiring Installation:

1. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

2. Install signal and communication cables in accordance with Specification Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section. Ensure all wiring is installed in conduits.

SPEC WRITER NOTE: Include language in electrical contract documents to provide power to all HVAC control devices requiring 120 volt power.

4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage power is required, provide suitable transformers.
5. Install all system components in accordance with local Building Code and National Electric Code.
 - a. Splices: Ensure splices in shielded and coaxial cables consist of terminations and the use of shielded cable couplers. Ensure terminations are in accessible locations. Ensure cables are harnessed with cable ties.
 - b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Ensure equipment for fiber optics system is rack mounted, as applicable, in ventilated, self-supporting, code gage steel enclosure. Ensure cables are supported for minimum sag.
 - c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
 - d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.
6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
7. Permanently label or code each point of all field terminal strips to show the instrument or item served along with the name and address

- of the point. Color-coded cable with cable diagrams may be used to accomplish cable identification.
8. Grounding: ground electrical systems per manufacturer's written requirements for proper and safe operation.
 9. Ensure fabricated control panels built to support auxiliary devices such as power supplies, relays, controllers, and control devices are certified to UL 508A.
- D. Install Sensors and Controls:
1. Temperature Sensors:
 - a. Install all sensors and instrumentation according to manufacturer's written instructions. Ensure temperature sensor locations are readily accessible, permitting quick replacement and servicing of them without special skills and tools.
 - b. Calibrate sensors to accuracy specified, if not factory calibrated.
 - c. Ensure use of sensors are limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.
 - d. Install room sensors permanently supported on wall frame. Ensure sensors are mounted at 1.5 meter (5.0 feet) above the finished floor.
 - e. Mount sensors rigidly and adequately for the environment within which the sensor operates.
 - f. Ensure sensors used in mixing plenum, and hot and cold decks are of the averaging type. Ensure averaging sensors are installed in a serpentine manner horizontally across duct. Ensure each bend is supported with a capillary clip.
 - g. Ensure all pipe mounted temperature sensors are installed in wells.
 - h. Ensure all wires attached to sensors are air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.
 - i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Actuators:

- a. Mount and link damper and valve actuators according to manufacturer's written instructions.
- b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
- c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

3.2 STARTUP AND TESTING

- A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. //The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.//

3.3 //COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.//

3.4 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for //16//
// // hours to instruct each VA personnel responsible in the operation and maintenance of units.
- B. //Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//
- C. Demonstration:
 1. System operation and calibration to be demonstrated by the Installer in the presence of the Government's representative
 2. Demonstrate to authorities that systems are fully functional and complete.

3. Make accessible, personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.

SPEC WRITER NOTE: The following demonstrations are for a DDC system. Edit as necessary to conform to project requirements.

4. Include the following witnessed demonstrations of field control equipment:
 - a. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.
 - b. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.

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