

## SECTION 23 09 54

## DIRECT DIGITAL CONTROL SYSTEMS

01/07

## PART 1 GENERAL

## 1.1 DEFINITIONS

## 1.1.1 Digital Controller

A control module which is microprocessor based, programmable by the user, has integral input/output within the module or on network connected modules, and performs stand-alone operations.

## 1.1.2 Direct Digital Control (DDC)

Digital controls, as defined in this specification, performing control logic. The controller directly senses building environment and makes control decisions based on user defined, controller resident programs. The controller outputs control signals that directly operate valves, dampers, and motor controllers. No conventional control devices, pneumatic or electronic, such as receiver-controllers, thermostats, and logic units are present within or interface with a direct digital control loop. Actuators are electric or pneumatic, and the controller output is converted to the appropriate type of signal.

## 1.1.3 Stand-Alone Control

Refers to the digital controller performing required climate control, and energy management functions without connection to another digital controller or computer. Requirements for stand-alone control are a time clock, a microprocessor, resident control programs, PID control, and I/O. All stand-alone controllers have a communication port and firmware for direct connection and interrogation with a laptop computer or similar hand-held device. This interrogation includes parameter changes and program downloads.

## 1.1.4 Site Building Controller (SBC)

Reuse existing.

## 1.2 DDC SYSTEM DESCRIPTION

- a. Provide new and modify existing DDC systems including associated equipment and accessories. Manufacturer's products, including design, materials, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.1 and NFPA 70, except as modified herein or indicated otherwise.

## 1.3 SUBMITTALS

Submit manufacturers' specification sheets for each type of equipment to show compliance with the project specification. For each type of equipment highlight each compliance item and reference each item to the relevant specification paragraph number. Submit sufficient manufacturers' information to allow verification of compliance by the reviewing authority.

Provide two copies of a Control and HVAC Systems Operators Manual. Provide in a 3 ring binder with a minimum of the following 7 sections. Use tabs to divide each section.

## PART 2 PRODUCTS

## 2.1 DDC SYSTEM

- a. Modify existing or provide new digital controllers to perform required climate control, energy management, and alarm functions.

## 2.1.1 Direct Digital Controllers

DDC hardware shall be UL 916 rated.

## 2.1.2 Distributed Control

Apply digital controllers in a distributed control manner.

## 2.1.3 I/O Point Limitation

Total number of I/O hardware points, including those communicated over a LAN, used by a single stand-alone digital controller, including I/O expansion units shall not exceed 48.

## 2.1.4 Stand-Alone Control

Provide stand-alone digital controllers.

## 2.1.5 Internal Clock

Provide a clock with each stand-alone controller. Each controller shall have its clock backed up by a battery or capacitor with sufficient capacity to maintain clock operation for a minimum of 72 hours during power outage.

## 2.1.6 Memory

- a. Provide sufficient memory for each controller to support required control, communication, trends, alarms, and messages
- b. Memory Protection: Programs residing in memory shall be protected either by using EEPROM, flash memory, or by an uninterruptible power source (battery or uninterruptible power supply (UPS)). The backup power source shall have sufficient capacity to maintain volatile memory during an AC power failure. Where the uninterruptible power source is rechargeable (a rechargeable battery), provide sufficient back-up capacity for a minimum of seventy-two hours. The rechargeable power source shall be constantly charged while the controller is operating under normal line power. Where a non-rechargeable power source is used,

provide sufficient capacity for a minimum of two years accumulated power failure. Batteries shall be replaceable without soldering.

#### 2.1.7 Inputs

Provide input function integral to the direct digital controller. Provide input type(s) as required by the DDC design. For each type of input used on high-level controllers, provide at least one similar spare input point per controller.

- a. Analog Inputs: Allowable input types are 100 ohm (or higher) platinum RTDs, thermistors, 4 to 20 mA, and 0-10 VDC. Thermistor and direct RTD inputs must have appropriate conversion curves stored in controller software or firmware. Analog to digital (A/D) conversion shall have 10-bit minimum resolution.
- b. Digital Inputs: Digital inputs shall sense open/close, on/off, or other two state indications.

#### 2.1.8 Outputs

Provide output function integral to the direct digital controller. Provide output type(s) as required by the DDC design. For each type of output used on high-level controllers, provide at least one similar spare output point per controller.

- a. Analog Outputs: Provide controllers with a minimum output resolution of 10 bits. Output shall be 4 to 20 mA, 0 to 10 VDC, or 0 to 20 psig. Each pneumatic output shall have feedback for monitoring of the actual pneumatic signal.
- b. Digital Outputs: Provide contact closure with contacts rated at a minimum of 1 ampere at 24 volts.

#### 2.1.9 PID Control

Provide controllers with proportional, integral, and derivative control capability. Terminal controllers are not required to have the derivative component.

#### 2.1.10 Digital Controller Networking Capabilities

The upper level digital controllers shall be capable of networking with other similar upper level controllers. Upper level controllers shall also be capable of communicating to the Site Building Controller.

#### 2.1.11 Communications Ports

- a. Controller-to-Controller LAN Communications Ports: Controllers in the building DDC system shall be connected in a communications network. Controllers shall have controller to controller communication ports to both peer controller (upper level controllers) and terminal controllers (lower level controllers). Network may consist of more than one level of local area network and each level may have multiple drops. Communications network shall permit sharing information between controllers, allowing execution of dynamic control strategies, and coordinated response to alarm conditions. Minimum baud rate for the lowest level LAN shall be 9600 Baud. Minimum baud rate for the highest level LAN

shall be 9600 Baud. Minimum baud rate for a DDC system consisting of a single LAN shall be 9600 Baud.

b. On-Site Interface Ports:

(1) All Controllers: Provide a RS-232, RS-485, USB, or RJ-11(Lon/Bacnet) communications port for each digital controller that allows direct connection of a computer or hand held terminal and through which the controller may be fully accessed. Controller access shall not be limited to access through another controller. On-site interface communication ports shall be in addition to the communications port(s) supporting controller to controller communications. Communication rate shall be 9600-Baud minimum.

(2) highest Level LAN: Every controller on the highest level LAN shall have a communications port supporting direct connection of the workstation computer; a hand held terminal port is not sufficient. By connecting the workstation computer to this port, every controller in the direct digital control system shall be able to be fully accessed and programmed. The following operations shall be available: downloading and uploading control programs, modifying programs and program data base, modifying set points, and retrieving or accepting trend reports, status reports, messages, and alarms.

c. SiteNet Interface Port: Provide one additional communications port in each DDC system permitting remote communications via the Site Building controller.

2.1.12 Digital Controller Cabinet

Each indoor digital controller cabinet shall protect the controller from dust and shall be rated NEMA 1, unless specified otherwise. Each outdoor digital controller cabinet shall protect the controller from all outside conditions and shall be rated NEMA 4. Cabinets for high level controllers shall be hinged door, lockable, and have offset removable metal back plate.

2.1.13 Main Power Switch

Each controller on the highest level LAN or each control cabinet shall have a main external power switch for isolation of the controller from AC power. The switch shall be located in the DDC cabinet.

2.2 SENSORS AND INPUT HARDWARE

2.2.1 Field Installed Temperature Sensors and Transmitters

2.2.1.1 Thermistors

Precision thermistors may be used in temperature sensing applications below 200 degrees F. Sensor accuracy over the application range shall be 0.36 degree F or less between the range of 32 to 150 degrees F. Stability error of the thermistor over five years shall not exceed 0.25 degree F cumulative. Sensor element and leads shall be encapsulated. Bead thermistors are not allowed. A/D conversion resolution error shall be kept to 0.1 degree F. Total error for a thermistor circuit shall not exceed 0.5

degree F, which includes sensor error and digital controller A/D conversion resolution error. Provide 18 gage twisted and shielded cable for thermistors.

#### 2.2.1.2 Resistance Temperature Detectors (RTDs)

Provide RTD sensors with 1000 ohm, or higher, platinum elements that are compatible with the digital controllers. Sensors shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 32 degrees F. Temperature sensor stability error over five years shall not exceed 0.25 degree F cumulative. Direct connection of RTDs to digital controllers, without transmitters, is preferred provided controller supports direct connection of RTDs. When RTDs are connected directly to the controller, keep lead resistance error to 0.25 degree F or less. Total error for a RTD circuit shall not exceed 0.5 degree F, which includes sensor error, lead resistance error or 4 to 20 mA or 0 to 10 VDC transmitter error, and A/D conversion resolution error.

#### 2.2.1.3 Temperature Sensor Details

- a. Immersion Type: Three inches total immersion for use with sensor wells, unless otherwise indicated.
- b. Sensor Wells: Stainless steel [brass] material. Provide heat-sensitive transfer agent between exterior sensor surface and interior well surface.

#### 2.2.1.4 Temperature Transmitters

Transmitters shall have 4 to 20 mA or 0 to 10 VDC output linearly scaled to the temperature sensed. Transmitter shall be matched to the sensor, factory calibrated, and sealed. Total error shall not exceed 0.1 percent at any point across the measured span. Supply voltage shall be 24 volts ac or dc. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter stability shall not exceed 0.05 degrees C a year.

#### 2.6.1.1 Temperature Transmitter Spans and Ranges

Transmitter spans or ranges shall meet the following:

- a. Temperature:
  - (1) 50 degrees F span: Room, chilled water, cooling coil discharge air, return air sensors
  - (2) 100 degrees F span: Outside air, hot water, heating coil discharge air, mixed air sensors
  - (3) 200 degrees F span: High temperature hot water, heating hot water, chilled/hot water system sensors.

#### 2.2.2 Pressure Transmitters

Provide integral pressure transducer and transmitter. Output of pressure instrument shall be a 4 to 20 mA signal proportional to the pressure span. Accuracy shall be 1.0 percent. Linearity shall be 0.1 percent. Span shall be as follows:

(1) 0 to 60 psig differential: Water differential pressure

## 2.3 OUTPUT HARDWARE

### 2.3.1 Valves

#### 2.3.1.1 Valve Assembly

Valves shall have stainless steel stems. Valve bodies shall be designed for not less than 125 psig working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Cv. Class 125 copper alloy valve bodies and Class 150 steel or stainless steel valves shall conform to ASME/ANSI B16.5 as a minimum. Cast iron valve components shall conform to ASTM A 126 Class B or C as a minimum.

#### 2.3.1.2 Butterfly Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service and for modulation to the fully closed position, with noncorrosive discs, stainless steel shafts supported by bearing, and EPDM seats suitable for temperatures from minus 20 degrees F to plus 250 degrees F. Valves shall have a manual means of operation independent of the actuator.

#### 2.3.1.3 Two-Way Valves

Two-way modulating valves shall have equal percentage characteristics.

#### 2.3.1.4 Three-Way Valves

Three-way valves shall have equal percentage characteristics.

#### 2.3.1.5 Valves for Hot Water Service

Valves for hot water service below 250 Degrees F:

- a. Bodies for valves 1 1/2 inches and smaller shall be brass or bronze with threaded or union ends. Bodies for valves larger than 2 inches shall have flanged-end connections. Water valves shall be sized for a 3 psi differential through the valve at rated flow, except as indicated otherwise. Select valve flow coefficient (Cv) for an actual pressure drop not less than 50 percent or greater than 125 percent of the design pressure drop at design flow.
- b. Internal trim, including seats, seat rings, modulation plugs, and springs, of valves controlling water hotter than 210 degrees F shall be Type 316 stainless steel.
- c. Internal trim for valves controlling water 210 degrees F or less shall be brass or bronze.
- d. Non-metallic parts of hot water control valves shall be suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.
- e. Valves 4 inches and larger shall be butterfly valves.

### 2.3.1.6 Valves for Steam Service

Entire bodies for valves 1 1/2 inches and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 2 to 3 inches inclusive shall be of brass, bronze, or iron. Bodies for valves 4 inches and larger shall be iron. Bodies for 2 inch valves shall have threaded ends. Provide bodies for valves 2 1/2 inches and larger shall with flanged-end connections.

### 2.3.2 Actuator

#### 2.3.2.1 Electric Actuators

Provide direct drive electric actuators for all control applications. When operated at rated voltage, each actuator shall be capable of delivering torque required for continuous uniform motion and shall have end switch to limit travel, or shall withstand continuous stalling without damage. Actuators shall function properly with range of 85 to 110 percent of line voltage. Provide gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torque less than 16 inch pounds. Provide hardened steel running shafts in sleeve bearing of copper alloy, hardened steel, nylon, or ball bearing. Provide two-position actuators of the single direction, spring return, or reversing type. Provide proportioning actuators capable of stopping at all points in the cycle and starting in either direction, from any point. Provide reversing and proportioning actuators with limit switches to limit travel in either direction unless operator is stall type. Actuators shall have a simple switch for reversing direction, and a button to disengage clutch for manual adjustments. Provide reversible shaded pole, split capacitor, synchronous, or stepper type electric motors.

### 2.3.3 Output Switches

#### 2.3.3.1 Control Relays

Shall be double pole, double throw (DPDT), UL listed, with contacts rated to the application, indicator light, and dust proof enclosure. Light indicator is lit when coil is energized and is off when coil is not energized. Relays shall be socket type, plug into a fixed base, and replaceable without need of tools or removing wiring. Encapsulated "PAM" type relays are permissible for terminal control applications.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Perform installation under supervision of competent technicians regularly employed in the installation of DDC systems.

-- End of Section --