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USACE / NAVFAC / AFCEA / NASA UFGS-23 09 33.00 40 (August 2008)  
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Preparing Activity: NASA Superseding  
UFGS-23 09 33.00 40 (April 2008)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2008

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#### DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

#### SECTION 23 09 33.00 40

#### ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC

08/08

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### SECTION 23 09 33.00 40

#### ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC 08/08

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NOTE: This specification covers the requirements for controls and instrumentation for air handling equipment.

Coordinate with drawings to include flow schematic and control sequence. Drawings should indicate solar compensation requirements in accordance with exposure.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

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## PART 1 GENERAL

### 1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature

when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING  
ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP (2004; Addendas  
a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,r,s,t,u,v,x,ak  
2006; Supp to Addendas 2006; Errata 2007;  
Interpretations 8 - 15:2007; Errata 2008;  
INT 16 2008) Energy Standard for Buildings  
Except Low-Rise Residential Buildings, I-P  
Edition

ASHRAE 90.1 - SI (2004; Addendas  
a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,r,s,t,u,v,x,ak  
2006; Supp to Addendas 2006; Errata 2007;  
Interpretations 8 - 15:2007; Errata 2008;  
INT 16 2008) Energy Standard for Buildings  
Except Low-Rise Residential Buildings, SI  
Edition

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.9 (2004) Welding Handbook; Volume Two -  
Welding Processes

ASME INTERNATIONAL (ASME)

ASME B16.22 (2001; R 2005) Standard for Wrought Copper  
and Copper Alloy Solder Joint Pressure  
Fittings

ASME B40.100 (2006) Pressure Gauges and Gauge  
Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A 666 (2003) Standard Specification for Annealed  
or Cold-Worked Austenitic Stainless Steel  
Sheet, Strip, Plate and Flat Bar

ASTM B 280 (2003) Standard Specification for Seamless  
Copper Tube for Air Conditioning and  
Refrigeration Field Service

ASTM B 62 (2002) Standard Specification for  
Composition Bronze or Ounce Metal Castings

ASTM D 1693 (2008) Standard Test Method for  
Environmental Stress-Cracking of Ethylene  
Plastics

ISA - THE INSTRUMENTATION, SYSTEMS AND AUTOMATION SOCIETY (ISA)

ISA 7.0.01 (1996) Quality Standard for Instrument Air

ISA RP60.9 (1981) Piping Guide for Control Centers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA DC 3 (2003) Standard for Residential Controls -  
Electrical Wall-Mounted Room Thermostats

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A (2002; Errata 2003; Errata 2005) Standard  
for the Installation of Air Conditioning  
and Ventilating Systems

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6 (2000; E 2004) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD-G-24508 (1998d) Grease, High Performance,  
Multipurpose (Metric)

MIL-F-18280 (Rev F; Supp 1; CANC Notice 1) Fittings,  
Flareless Tube, Fluid Connection

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595 (Rev B; Am 1) Colors Used in Government  
Procurement

FS A-A-2962 (Rev J) Enamel, Alkyd, Gloss, Low VOC  
Content

## 1.2 GENERAL REQUIREMENTS

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NOTE: If Section 23 00 00 AIR SUPPLY, DISTRIBUTION,  
VENTILATION, AND EXHAUST SYSTEMS is not included in  
the project specification, applicable requirements  
therefrom should be inserted and the first paragraph  
deleted. If Section 23 31 13.20 40 WELDING METAL  
DUCTWORK is not included in the project  
specification, applicable requirements therefrom  
should be inserted and the second paragraph  
deleted. If Section 26 60 13.00 40 LOW-VOLTAGE  
MOTORS is not included in the project specification,  
applicable requirements therefrom should be inserted  
and the third paragraph deleted.

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[Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS applies to work specified in this section.]

[Section 23 31 13.20 40 WELDING METAL DUCTWORK applies to work specified in this section.]

[Section 26 60 13.00 40 LOW-VOLTAGE MOTORS applies to this section.]

Material, Equipment, and Fixture Lists shall be submitted for control and instrumentation systems including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

### 1.3 SYSTEM DESCRIPTION

Automatic temperature control systems shall be complete in all details and shall include all necessary accessories to maintain conditions indicated or specified.

Automatic temperature control systems may be [equivalent pneumatic] [electronic] [electric/electronic] [low-voltage electric] [pneumatic/electronic]. As far as practical, control equipment shall be the product of a single automatic control systems manufacturer. Automatic control systems components not the product of the control system manufacturer shall be approved for use with the control system as indicated.

Automatically controlled valves to control environment shall be furnished by the automatic control systems manufacturer.

Automatically controlled dampers, independent of dampers integral with manufactured air-handling units, shall be furnished by the automatic control systems manufacturer. Damper manufacturer shall be licensed to display the AMCA seal.

Dual-duct system mixing boxes and air-mixing valve operators shall be furnished by the automatic control systems manufacturer.

Fabrication Drawings shall be submitted for control and instrumentation systems consisting of fabrication and assembly details to be performed in the factory.

Operating Instructions shall be submitted for control and instrumentation consisting of standard operating procedures including startup, shutdown, and emergency operation.

### 1.4 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept

to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

#### SD-01 Preconstruction Submittals

**Material, Equipment, and Fixture Lists** shall be submitted for control and instrumentation systems in accordance with paragraph entitled, "General Requirements," of this section.

**Records of Existing Conditions** shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

#### SD-02 Shop Drawings

**Fabrication Drawings** shall be submitted for control and instrumentation systems in accordance with paragraph entitled, "System Description," of this section.

**Installation Drawings** shall be submitted for the following items in accordance with the paragraph entitled, "Installations," of this section. Drawings shall include details of equipment room layout and design.

#### SD-03 Product Data

Equipment and performance data shall be submitted for the



following items consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.

- Control Components
- Thermometers
- Pressure Gages
- Valves
- Dampers
- Operators

#### SD-04 Samples

Manufacturer's standard color charts shall be submitted for the following items showing the manufacturer's recommended color and finish selections.

- Thermostat Covers
- Thermostat Guards
- Room Humidistats

#### SD-06 Test Reports

Test reports shall be submitted for controls and instrumentation systems in accordance with the paragraph entitled, "Testing, Calibration, and Acceptance," of this section.

#### SD-07 Certificates

Listing of Product Installations for controls and instrumentation systems shall be submitted in accordance with paragraph entitled, "Installation," of this section.

#### SD-08 Manufacturer's Instructions

Operating Instructions shall be submitted for control and instrumentation in accordance with paragraph entitled, "System Description," of this section.

#### SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals shall be provided for the following items:

- Air Supply Source
- Mechanical Refrigeration-Type Air Dryer
- Pneumatic Operators
- Electric Operators

### 1.5 STORAGE AND HANDLING

Openings shall be sealed after manufacturing and inspection, until ready for installation.

Instruments and equipment shall be carefully handled, shall not be subjected to shock, and shall be protected from weather, dust, construction materials, and damage.

## PART 2 PRODUCTS

### 2.1 CONTROL COMPONENTS

#### 2.1.1 Temperature Sensors

Temperature sensors, sensor transmitters, and controller output signals shall be directly proportional to the variations in the measured variable. Linearity shall be within plus or minus  $[1/2]$  [\_\_\_\_\_] percent for a 93 degrees C 200-degree-F span, and plus or minus  $[1]$  [\_\_\_\_\_] percent for a 10 degrees C 50-degree-F span, throughout the scale range.

Where extremely accurate temperature sensing is required or the transmitter is a considerable distance from the receiver controller, a two-pipe relay-type transmitter shall be used. Instrument shall have feedback incorporated into the design and shall have  $[10]$   $[38]$   $[93]$  degrees C  $[50]$   $[100]$   $[200]$ -degree-F temperature range. Capillary shall be compensated and shall be available in [short style]  $[2500 \text{ and } 5000 \text{ millimeter}]$   $[8 \text{ and } 16\text{-foot}]$  averaging lengths. Unit shall operate on  $[140]$   $[20]$  [\_\_\_\_\_] kilopascal pounds per square inch (psi) input pressure, and shall have a  $[20 \text{ to } 100 \text{ kilopascal}]$   $[3 \text{ to } 15\text{-psi}]$  [\_\_\_\_\_] output over the specified range.

#### 2.1.2 Humidity Sensors

Humidity sensors, sensor transmitters, and controller output signals shall be directly proportional to the variations in the measured variable. Linearity shall be within plus or minus  $[1]$  [\_\_\_\_\_] percent for a  $[70]$  [\_\_\_\_\_] -percent relative humidity span. When humidity sensor is duct-mounted downstream from a cooling coil, element shall be capable of withstanding  $[98]$  [\_\_\_\_\_] percent relative humidity without loss of calibration.

#### 2.1.3 Receiver Controllers

Receiver controllers shall have a calibrated set point adjustment, minimum calibrated scale with no greater than  $[\text{minus } 16.7]$   $[2]$  [\_\_\_\_\_] degrees C F divisions for duct and immersion application and  $[\text{minus } 17.2]$   $[1]$  [\_\_\_\_\_] degree C F divisions for room control application. Set point indication and an adjustable proportional band covering the complete range necessary for the specific application shall be provided. Controller range shall match that of the temperature sensor. Each device shall incorporate authority and remote set point calibrated adjustments, as required.

#### 2.1.4 Receiver Indicators

Receiver indicators shall provide visual readout for temperature and humidity, using the transmitted signal from the sensor device to the receiver-controller device. Readout and accuracy of the receiver indicator shall provide the indicated value within plus or minus  $[1/2]$  [\_\_\_\_\_] percent of the span of the measured variable, as transmitted by the sensor. Factory calibration shall be marked on back of instrument. Range shall match that of the temperature or humidity sensor.

Combined accuracy of the sensor and the receiver indicator shall be within  $[\text{minus } 16.7]$   $[2]$  [\_\_\_\_\_] degrees C F and  $[5]$  [\_\_\_\_\_] percent relative humidity of the span.

Ambient conditions to  $[65.6]$   $[150]$  [\_\_\_\_\_] degrees C F shall not cause a shift in control point in pneumatic sensor, receiver controller, or

indicator systems.

#### 2.1.5 Space Thermostats

##### 2.1.5.1 Electrical Control

Space thermostat shall be low-voltage type with [non-setback/setup] [setback/setup] temperature control for [cooling only] [heating only] [cooling and heating]. Thermostat shall conform to **NEMA DC 3**, and shall be as indicated.

##### 2.1.5.2 Pneumatic Control

Space thermostat shall be of the adjustable proportioning type containing [a single bimetallic element for [heating only] [cooling only]] [dual bimetallic elements, one for heating and one for cooling].

Thermostats shall have locking covers and built-in concealed thermostats.

Thermostats with field-adjustable or removable set point limits are not permitted.

Thermostats shall conform to **ASHRAE 90.1 - IP**, **ASHRAE 90.1 - SI** and shall have temperature restrictions as indicated.

##### 2.1.5.3 Space Thermostat Accessories

**Thermostat covers** shall be brushed aluminum.

Insulating bases shall be provided for thermostats located on exterior walls.

**Thermostat guards** in unfinished spaces shall be cast-metal type.

Guards and thermostats shall be mounted on separate bases.

##### 2.1.6 Outdoor Reset Thermostat

Outdoor reset thermostat shall be a [remote-bulb type] [functionally equivalent bimetallic rod and tube type] for proportioning action with an adjustable throttling range. Scale range shall be [minus 23.3 to plus 21.2] [1.7 to 35.0] [minus 10 to plus 70] [35 to 95] degrees C F with adjustable set point over the full range. Unit shall be mounted indoors, with sensing bulb mounted outdoors with solar compensation when indicated. Unit shall proportionally reset the control point of a remote sensing submaster temperature controller.

##### 2.1.7 Immersion Thermostats

Immersion thermostats shall be [remote-bulb type] [functionally equivalent bimetallic rod and tube type], for proportional action with adjustable set point over the full operating range, and adjustable throttling range. A nonferrous separable socket shall be provided for each thermal element.

When used as a secondary controller, a remotely set adjustable set point shall be provided.

#### 2.1.1.8 Airstream Thermostats

Airstream two-position thermostats shall be remote-bulb type or functionally equivalent bimetallic rod and tube type, with adjustable set point. Set point shall be in middle third of range of device.

Airstream thermostats for control of modulating devices shall be remote-bulb type for proportional action with adjustable set point over the full operating range, and adjustable throttling range.

Airstream thermostats for averaging service shall have a remote-bulb element not less than one-half as long as the longest side of the airstream cross section, of a type suitable for averaging service with liquid-filled bulb or equivalent. Gas- or vapor-filled bulbs are not acceptable for averaging service. Bulb shall be located to sense average temperature.

Airstream temperature primary controllers for remote reset or compensating operation, shall be remote-bulb type for proportional operation with adjustable set point over the full operating range, adjustable throttling range, and an adjustable authority of the secondary controller. Low- or high-limit thermostats, or other instruments having one-sided control, are not acceptable where reset or compensating controllers are indicated.

#### 2.1.1.9 Line-Voltage Thermostats

Line-voltage thermostats shall have integral "MANUAL ON/OFF/AUTO" selector switch, a maximum differential of [1] [2] [\_\_\_\_\_] degrees C F, concealed temperature adjustment, and a locking cover. Line-voltage thermostats shall be rated for the load, [single] [two]-pole as required.

Insulating bases for thermostats located on exterior walls shall be provided.

Thermostat guards in unfinished spaces shall be cast-metal type.

Guards and thermostats shall be mounted on separate bases, unless otherwise approved.

Line-voltage thermostats shall be furnished and mounted under this section, and wired in accordance with applicable sections of Division 16, "Electrical," unless otherwise specified.

#### 2.1.1.10 Electrical Low-Limit Duct Thermostat

Air-handling unit freeze protection shall be provided. Lowest temperature across any 300 millimeter 12 inches of bulb length, [single] [multiple] tube, shall be sufficient to trip a snap-acting, single-pole, single-throw switch when the temperature sensed is equal to, or below, set point. Minimum length of bulb shall be [6100] [20] [\_\_\_\_\_] millimeter [\_\_\_\_\_] feet. One limit thermostat shall be provided for every [1.8] [20] [\_\_\_\_\_] square meter [\_\_\_\_\_] square feet of coil surface. Thermostats shall have manual reset.

#### 2.1.1.11 Fire Thermostats

Fire thermostats shall be UL-approved and listed, shall be factory set in accordance with NFPA 90A, and shall have normally closed contacts. Reset shall be performed manually.

#### 2.1.12 Heating/Cooling Valve-Top Thermostat

Induction air-conditioning units shall be furnished with valve-top thermostats. Units shall be proportional acting for proportional flow, remote-bulb liquid-filled element, direct and reverse acting at variable pressures to maximum [170] [25] [\_\_\_\_\_] kilopascal, gage [\_\_\_\_\_] pounds per square inch, gage (psig) air supply. Operator diaphragm shall be molded rubber, housing shall be die-cast, and unit shall be furnished with position indicator and adjusting knob.

#### 2.1.13 Room Humidistats

Room humidistats shall be wall-mounted, reverse acting, proportioning type, with adjustable minimum throttling range no greater than [2] [\_\_\_\_\_] -percent relative humidity. Humidistats shall be capable of maintaining the relative humidity within the limits of the throttling range for relative humidity of [30 to 80] [\_\_\_\_\_] percent and temperatures to [43.3] [110] [\_\_\_\_\_] degrees C F.

#### 2.1.14 Duct Humidistats

Duct humidistats shall be insertion type, mounted on outside of duct, with sensing element within duct. Duct humidistats shall be reverse acting, proportioning type, with adjustable minimum-throttling range no greater than [2] [\_\_\_\_\_] percent relative humidity. Humidistats shall be capable of maintaining relative humidity within the limits of the throttling range for relative humidity of [20 to 80] percent and temperatures to [65.6] [150] [\_\_\_\_\_] degrees C F. Sensing element provided shall be suitable for the indicated installation location.

#### 2.1.15 High-Limit Duct Humidistats

High-limit duct humidistats shall be insertion type, mounted on outside of duct, with sensing element within duct. Humidistats shall be reverse acting, two-position type, with minimum differential no greater than [2] [\_\_\_\_\_] percent relative humidity. Sensing element provided shall be suitable for the indicated installation location.

#### 2.1.16 Water Temperature Controllers

Water temperature controller shall be inserted in a nonferrous separable socket installed in the waterline. Controller shall operate [remotely] [integrally] on an adjustable differential over an adjustable temperature range, and shall be suitable for operating in conjunction with the control valve provided.

#### 2.1.17 Building Static-Pressure Transmitter

Building static-pressure transmitter shall be a double-bell, differential type with temperature compensation. Scale range shall be [minus 125 to plus 125] [minus 0.5 to plus 0.5] [\_\_\_\_\_] kilopascal, gage inch water gage (wg), and sensitivity shall be within plus or minus [0.124] [0.0005] [\_\_\_\_\_] kilopascal, gage inch wg. Transmitter shall transmit an [electronic] [pneumatic] signal to an indicating receiver with a matched scale range.

Total system accuracy shall be not less than [12] [0.05] [\_\_\_\_\_] kilopascal, gage inch wg.

#### 2.1.18 Building Static-Pressure Controller

[Building static-pressure controller shall be a slack diaphragm type, with an adjustable set point, and adjustable throttling range. Controller range shall be [2.5 to 1500] [0.01 inch to 6.0] [\_\_\_\_\_] kilopascal, gage inches wg. Throttling range shall be adjustable from [5 to 12] [0.02 to 0.05] [\_\_\_\_\_] kilopascal, gage inch wg. Output shall be [electronic] [pneumatic].]

[Building static-pressure controller shall be a double bell, differential type with temperature compensation. Scale range shall be [minus 125 to plus 125] [minus 0.5 to plus 0.5] [\_\_\_\_\_] kilopascal, gage inch wg, and sensitivity shall be within plus or minus [12] [0.05] [\_\_\_\_\_] kilopascal, gage inch wg. Controller shall be provided with an adjustable set point over the full-scale range and adjustable throttling range, proportional band. Output shall be [electronic] [pneumatic].]

#### 2.1.19 Pressure Transmitter

Pressure transmitters shall be the indicating type for gas, liquid, or steam service. Transmitter range shall be suitable for system operating characteristics. Output shall be proportional to system pressure and shall be electronic or pneumatic. Indicating receiver shall have a matched scale range.

Total system accuracy shall be not less than [1/2] [\_\_\_\_\_] percent of system range.

#### 2.1.20 Remote Pressure Transmitter

Pressure sensors for gas, liquid, or steam service remote indication shall be [pneumatic] [pressure-to-current] type. Direct current output and power supply shall be compatible with the remote readout indicator.

#### 2.1.21 Remote Element Instruments

All remote element instruments shall have sufficient length of capillary to mount the instrument on the control panel in an accessible location. Excess capillary shall be coiled and concealed. Armored capillary shall be provided where indicated.

#### 2.1.22 Airflow Switches

Airflow switches shall be UL-approved, pressure range shall be [30 to 2500] [0.12 to 10] [\_\_\_\_\_] kilopascal, gage inches wg, and electrical rating shall be [220 volts ac, 5 ampere] [110 volts ac, 10 ampere] and [560] [3/4] [\_\_\_\_\_] wattage rating horsepower ac pilot duty.

#### 2.1.23 Pneumatic Relays

Relays shall be [positive-acting] [gradual-acting] [direct] [reverse].

#### 2.1.24 Switches

Switches shall be provided as indicated.

Adjustable switches shall have indicating plates and accessible adjustment. Minimum-positioning switches that control dampers shall be calibrated and marked in percent of maximum airflow determined by airflow test.

## 2.2 THERMOMETERS

Thermometers adjacent to thermostats shall be provided with nonferrous separable sockets when in immersion service. Thermometer scale range shall be selected according to service. Thermometers shall be readable from operating level.

Dial type temperature indicators shall have a [65] [80] [90] [115] [125] millimeter [2-1/2] [3] [3-1/2] [4-1/2] [5] inch diameter antiparallax dial face with white background and black markings.

Pointer shall be [friction] [micrometer] maximum-registering type with external calibrator adjustment. Accuracy shall be within [1] [\_\_\_\_\_] percent of dial range.

Case shall be [corrosion-resistant steel] [cast aluminum] [brass], [bottom-connection] [back-connection] [adjustable-head] type, with [corrosion-resistant steel] [chrome-plated] close-type ring.

Activating medium shall be [vapor] [solid liquid] [bimetal].

Stem length shall be [ 15 millimeter 1/2 inch taper pipe thread, fixed thread] [ 20 millimeter 3/4 inch taper pipe thread, separable socket].

Thermometers with a minimum 230 millimeter 9 inch vertical scale may be provided, in lieu of dial type.

Temperature sensor, sensor transmitter, and output signals shall be directly proportional to the variations in the measured variable. Linearity shall be within plus or minus [1/2] [\_\_\_\_\_] percent throughout the scale range for a [93.3] [200] [\_\_\_\_\_] degree C F span, and plus or minus [1] [\_\_\_\_\_] percent for [10] [50] [\_\_\_\_\_] degree C F span.

When the transmitter is over [15] [30] meter [50] [100] feet from the receiver indicator, a signal booster shall be used to improve signal response. Transmitter shall have feedback incorporated in the design and shall have a [10] [38] [93] degrees C [50] [100] [200]-degree-F temperature range. Capillary shall be compensated and shall be available in short style, [2.5] [8] [\_\_\_\_\_] to [5.5] [18] [\_\_\_\_\_] meter foot averaging lengths. Unit shall operate on a [140] [20] [\_\_\_\_\_] kilopascal psi input pressure and shall have a [20] [3] [\_\_\_\_\_] to [100] [15] [\_\_\_\_\_] kilopascal psi output over the specified range.

For multizone units, each zone discharge duct shall be provided with a remote-reading panel-mounted dial thermometer. Sensor shall be located not less than [3] [10] [\_\_\_\_\_] meter feet downstream of the mixing dampers or other device causing air turbulence.

## 2.3 PRESSURE GAGES

Pressure gages used to indicate supply and outlet air pressures of automatic control instruments shall be the manufacturer's standard, minimum [90] [3-1/2] [\_\_\_\_\_] millimeter inch diameter.

## 2.4 CONTROL SYSTEM VALVES

Valve bodies, DN50 2 inch iron pipe size (ips) and smaller, shall be bronze with [screwed] [flanged] end connections. Valve bodies, DN65 2-1/2 inch ips and larger, shall be cast iron and shall have flanged end connections.

Valves shall be single seated for dead-end service except where otherwise indicated.

Modulating service valves shall have plugs matched to the characteristics of the coil for effective control. Valve-stem packing shall be tetrafluoroethylene, spring-loaded, and self-adjusting.

Valve stem shall be top and bottom guided and shall be [AISI 303 corrosion-resistant steel] [Monel]. Cage construction is acceptable.

Valves shall be provided with position indicators and, where indicated or required for proper operation, shall be provided with positioners.

Valve linkage shall have an adjustment for valve lift.

#### 2.4.1 Hydronic

Hydronic system valve bodies and trim shall be rated for service pressures through [860] [\_\_\_\_\_] kilopascal at [121] [\_\_\_\_\_] degrees C [125] [\_\_\_\_\_] psi at [250] [\_\_\_\_\_] degrees F.

Hydronic system valves shall have replaceable plugs and seats of [SAE 72 brass] [AISI 303 corrosion-resistant steel], selected for maximum life depending on application conditions.

[Maximum pressure drop across any hydronic system valve at maximum flow shall be [15] [\_\_\_\_\_] kilopascal [5] [\_\_\_\_\_] feet of water.]

#### 2.4.2 Steam

Steam valve bodies and trim shall be rated for service pressures through [860] [\_\_\_\_\_] kilopascal [125] [\_\_\_\_\_] psi saturated steam.

Steam valve replaceable plugs and seats shall be AISI 440C corrosion-resistant steel hardened to not less than [500] [\_\_\_\_\_] Brinell.

Maximum pressure drop across any steam valve at maximum flow shall be as indicated.

### 2.5 PNEUMATIC SYSTEMS ACCESSORIES

\*\*\*\*\*  
**NOTE: Delete the following when only electric or  
electric/electronic systems are used.**  
\*\*\*\*\*

Pipe connections shall be provided in air lines at each pneumatic room controller to connect gages for testing.

#### 2.5.1 Control and Instrumentation Tubing

Copper tubing with [6] [1/4] [\_\_\_\_\_] millimeter inch outside diameter shall be [hard drawn] [annealed] seamless copper, conforming to ASTM B 280.

Fittings shall be solder joint, wrought copper, conforming to ASME B16.22.

Ball-sleeve shall be compression type, [rod] [forged] brass conforming to SAE [72] [88] UL-approved, conforming to MIL-F-18280, with minimum pressure



rating of [1380] [\_\_\_\_\_] kilopascal at [38] [\_\_\_\_\_] degrees C [200] [\_\_\_\_\_] psi at [100] [\_\_\_\_\_] degrees F.

Solder shall be 95-5 tin-antimony, alloy Sb5, conforming to AWS WHB-2.9.

Polyethylene tubing shall be black virgin polyethylene, meeting stress crack test performed in accordance with ASTM D 1693. Multi-tube harness material shall be as specified above, with polyester film barrier and vinyl jacket not less than [1.57] [\_\_\_\_\_] millimeter [0.062] [\_\_\_\_\_] inch thick.

Fittings shall be ball-sleeve compression type, [brass] [aluminum], with internal sleeves.

## 2.5.2 Valves

### 2.5.2.1 Diaphragm Control and Instrument Valves (DCIV)

Diaphragm valves in sizes [8] [\_\_\_\_\_] [10] [\_\_\_\_\_] millimeter [1/4] [\_\_\_\_\_] and [3/8] [\_\_\_\_\_] inch shall have a forged brass body with reinforced tetrafluoroethylene diaphragm, AISI 300 series corrosion-resistant steel spring, and round phenolic handle. Handle shall be fitted with disks color coded in accordance with ISA RP60.9.

### 2.5.2.2 Gage Cocks

Gage cocks shall be [T-head] [lever-handle ground-key type], with washer and screw, constructed of polished ASTM B 62 bronze and rated for 860 kilopascal 125-psi saturated-steam service. End connections shall suit the service.

## 2.5.3 Air-Pressure Reducing Stations

### 2.5.3.1 Pressure-Reducing Stations

Pressure-reducing station shall be installed complete with pressure-reducing valve, particle filter, valved bypass, pressure indicator upstream of station, pressure indicator downstream of station, and regulated air-pressure relief valve.

### 2.5.3.2 Pressure Regulators

Pressure regulator body shall be constructed of [zinc] [aluminum] die castings rated for the service. Diaphragm shall be a reinforced air-, oil-, and water-resistant elastomer. All components exposed to the fluid stream being controlled shall be [nonferrous metallic] [nonmetallic materials]. Valve shall be a balanced-construction relieving type to automatically prevent excessive pressure buildup. Valve shall produce an essentially flat, reduced pressure curve for the capacity demand of the system.

### 2.5.3.3 Particle Filters

Filters shall be constructed of [zinc] [aluminum] die castings, rated for the service, and furnished with ips connections. Bowl material shall be aluminum. Filter shall be serviceable by quick-disconnect devices. Bowl shall be equipped with manual draincock. Liquid particles shall be separated by centrifugal and quiet zone action. Solid particles, to [15] [\_\_\_\_\_] micrometer, shall be removed by filter elements of [sintered bronze] [corrosion-resistant steel] mesh.

#### 2.5.3.4 Combination Filter/Regulators

Combination manual drain filter/regulator units conforming to the above requirements will be acceptable in lieu of separate units.

#### 2.5.3.5 Airborne-Oil Filter

\*\*\*\*\*  
**NOTE: Select when necessary to provide oil-free  
compressed air. Use particle filter for prefilter  
to extend airborne oil filter life.**  
\*\*\*\*\*

Filter shall provide filtration efficiencies of [99.9] [\_\_\_\_\_] percent for particles of [0.5] [\_\_\_\_\_] micrometer or larger in addition to removing [99.4] [\_\_\_\_\_] percent of [2.0] [\_\_\_\_\_] -micrometer and larger particles of airborne lubricating oil. Filter pressure/temperature ratings shall be [1035] [\_\_\_\_\_] kilopascal and [66] degrees C [150] [\_\_\_\_\_] psi and [150] [\_\_\_\_\_] degrees F, respectively.

#### 2.5.3.6 Pressure Relief Valves

Pressure relief valves shall be rated for the pressure of the high-pressure side and sized for the full installed capacity of the pressure regulating station at the pressure of the low-pressure side. Valve shall be set at not more than [20] [\_\_\_\_\_] percent above the correct low-side pressure. Seat material shall be suitable for the service.

#### 2.5.4 Pressure Gages

Pressure gages shall conform to ASME B40.100 and as indicated. Pressure gages shall be Type I, gage for air, steam, oil, and water, Class 1, pressure gage, with range as indicated. Pressure-gage size shall be 90 millimeter 3-1/2 inch nominal diameter. Case shall be AISI 300 series corrosion-resistant steel with No. 4 standard commercial polish, or better, conforming to ASTM A 666. Gages shall be equipped with adjustable marking pointer and damper screw adjustment in inlet connection. Gages shall have safety case, safety glass, and blowout plug.

### 2.6 INSTRUMENT AIR SUPPLY

\*\*\*\*\*  
**NOTE: First paragraph provides for central  
distribution source. Subsequent three paragraphs  
provide for local air compressor source when cost of  
central system tap is prohibitive.**  
\*\*\*\*\*

#### 2.6.1 Air Supply Source

Instrument air shall be supplied from a central, dry, compressed-air header, and shall be complete with filter, pressure-reducing valve, pressure-relief valve, upstream and downstream pressure gages, and shutoff and bypass valves.

A vibration-isolated, simplex, instrument-air, compressor/receiver unit shall be provided, complete with base, motor controller, automatic pressure-regulating controls, off/automatic selector switch, mechanical and

electrical safety devices, filter-silencer intake, and complete intercomponent piping and wiring ready for terminal connections. Unit shall be standard unit of the temperature-controls manufacturer and shall be sized to supply the entire control-air requirements for all connected systems on the basis of not more than [20] [\_\_\_\_\_] minutes of compressor operation in any [1] [\_\_\_\_\_] hour of total connected control-systems operation.

Compressor shall be of oil-free construction.

Vibration isolation shall consist of stable springs, with not less than [50] [\_\_\_\_\_] millimeter [2] [\_\_\_\_\_] inches deflection and not less than [25] [\_\_\_\_\_] millimeter [1] [\_\_\_\_\_] inch freeboard underload to support compressor/receiver assembly.

A wire-braid reinforced rubber hose shall be installed from the compressed air connection to the distribution header.

#### 2.6.2 Mechanical Refrigeration-Type Air Dryer

Air dryer shall be a noncycling, continuously operating, hermetically sealed, refrigeration unit, complete with heat exchangers, insulation, liquid separator, cabinet-type enclosure, dial-type thermometer, valved bypass, and condensate trap suitable for operation with oil-entrained air. Unit shall be rated at [4.7] [\_\_\_\_\_] liter per second at [690] [\_\_\_\_\_] kilopascal at [37.8] [10] [\_\_\_\_\_] scfm at [100] [\_\_\_\_\_] psig at [100] [\_\_\_\_\_] degrees inlet, producing atmospheric dewpoint at minus [23] [\_\_\_\_\_] degrees C [10] [\_\_\_\_\_] degrees F, dehydrating at [690] [\_\_\_\_\_] kilopascal [100] [\_\_\_\_\_] psig. Unit shall have an operating pressure of not less than [1035] [\_\_\_\_\_] kilopascal [150] [\_\_\_\_\_] psig. Refrigeration unit shall be of not less than [125] [\_\_\_\_\_] wattage rating [1/6] [\_\_\_\_\_] horsepower for 115-volt, 60-hertz, single-phase power supply.

#### 2.7 POWER-OPERATED DAMPERS

##### 2.7.1 Frame and Blade Assembly

Frames and blades shall be constructed of [extruded aluminum] [galvanized steel] [rolled carbon steel] [corrosion-resistant steel].

Resilient seals shall be mechanically attached, field replaceable seals. Attachment by adhesive shall not be acceptable. Jamb seals shall be [neoprene] [flexible metal compression-type constructed of [aluminum] [corrosion-resistant steel]].

Frames shall have corner reinforcement and stay rods, where necessary. Frames shall be fabricated by welding or riveting. Damaged galvanized surfaces shall be repaired by coating with an equal weight of zinc.

For static pressures in excess of [750] [\_\_\_\_\_] pascal [3] [\_\_\_\_\_] inches wg, master-blade-driven dampers with blades longer than [610] [\_\_\_\_\_] millimeter [24] [\_\_\_\_\_] inches shall have a maximum blade width of [200] [\_\_\_\_\_] millimeter [8] [\_\_\_\_\_] inches. Maximum blade width for other services shall be [250] [\_\_\_\_\_] millimeter [10] [\_\_\_\_\_] inches. Maximum blade length shall be [1220] [\_\_\_\_\_] millimeter [48] [\_\_\_\_\_] inches. Dampers more than [1220] [\_\_\_\_\_] millimeter [48] [\_\_\_\_\_] inches wide shall be made in two or more sections with intermediate mullions; each section shall be mechanically interlocked with adjoining section or sections.

Minimum shaft size shall be [15] [\_\_\_\_\_] millimeter [1/2] [\_\_\_\_\_] inch, [round] [square].

Where linkage is such that operator torque is applied to a master blade and transmitted therefrom, that blade shall be reinforced and the shaft shall be full length. This type construction shall be limited to [500] [\_\_\_\_\_] pascal [2] [\_\_\_\_\_] inch wg, static pressure.

Blades shall be attached to round shafts by hardened cup-point setscrews, or by being pinned. A minimum three-thread engagement shall be provided. Where setscrews are used, two setscrews, 90 degrees apart, shall be provided to secure master blade. Shaft end retainers may be secured by pins or spring washers in grooved shaft or by similar construction.

Frames shall be calked with elastomer compounds to prevent bypass leakage.

[Blades without resilient seals shall have interlocking edges.]

Maximum leakage of dampers shall be [\_\_\_\_\_] .

#### 2.7.2 Bearings

\*\*\*\*\*  
NOTE: When possible the use of sealed bearings is encouraged. One of the major causes of bearing failures is overlubrication and lubrication contamination. Using sealed bearings helps to eliminate this failure mode.  
\*\*\*\*\*

[Shaft bearings shall be [oil-impregnated sintered bronze] [graphite-impregnated nylon sleeve type], except as otherwise indicated. Thrust washers shall be provided at bearings, when necessary to maintain blade alignment.]

\*\*\*\*\*  
NOTE: Select for dampers with high pressure per square meter foot of area and similar special application.  
\*\*\*\*\*

[Shaft bearings shall be single row, unground, flanged, radial, antifriction type with extended inner race suitable for press mounting in damper frame. Bearing materials shall be AISI type 316 corrosion-resistant steel. Bearings shall be lubricant free. Operation and maintenance manual shall be marked, and instructions shall be attached to the damper frame noting: "DO NOT LUBRICATE CORROSION-RESISTANT STEEL BEARINGS." Factory sealed, shielded carbon-steel ball bearings will be acceptable provided lubricant conforms to DOD-G-24508.]

Linkage pivot bearings shall be [oil-impregnated sintered bronze] [graphite-impregnated nylon].

#### 2.7.3 Installation

Dampers shall be installed in accordance with the manufacturer's instructions.

## 2.8 CONTROL SYSTEM VALVE AND DAMPER OPERATORS

### 2.8.1 Operators

Motor operators shall provide smooth proportional control under operating conditions normal to the system.

Spring-return operators shall be provided for two-position control.

Spring returns shall be provided on reversible operators where required for fail-safe operation.

Operators operating in sequence with other operators shall have adjustable operating ranges and set points.

Operators shall have sufficient power on closeoff to provide tight sealing against maximum system pressures.

Operators shall close valves and dampers to fail-safe position indicated.

### 2.8.2 Dampers

Dampers shall be equipped with operators of sufficient power to control dampers, without flutter or hunting, through the entire operating range at air velocities at least [20] [\_\_\_\_\_] percent greater than maximum design velocity.

### 2.8.3 Pneumatic Operators

Positioners shall be provided where two or more operators are controlled from the same controller, and where indicated. Positioners shall be mounted directly on the driven device. Feedback from the [stem] [rod] shall be through a pilot spring. Starting point shall be adjustable from [15] [\_\_\_\_\_] to [85] [\_\_\_\_\_] kilopascal [2] [\_\_\_\_\_] to [12] [\_\_\_\_\_] psi. Operating span shall be adjustable from [35] [\_\_\_\_\_] to [90] [\_\_\_\_\_] kilopascal [5] [\_\_\_\_\_] to [13] [\_\_\_\_\_] psi.

### 2.8.4 Electric Operators

Electric motor operators for modulating control shall be reversible type.

Electric motor operators shall be split-phase type with oil-immersed gear train. Motor shall have ample capacity to handle applied loads under operating conditions normal to the system. Locations where temperatures fall below minimum operating temperature of operator shall be heated.

## 2.9 CENTRAL CONTROL CABINET

[Control cabinet shall be a free-standing modular type with hinged, locking access door, one per module.]

[Control cabinet shall consist of enclosed wall-mounted modular cabinet sections. Front of each cabinet shall be hinged to provide access to the interior of each cabinet and shall be lockable.]

A 1.5 millimeter 60-mil thick, high-pressure laminate-covered writing surface and recessed storage drawers with locks shall be provided.

### 2.9.1 Cabinet Construction

Cabinets shall be made of [steel] [aluminum], suitably reinforced and braced to provide a flat-faced, rigid-front panel.

Surfaces shall be free of scale, welding slag, and dirt, and shall be flat without waves. Handling during installation shall not distort or buckle the cabinet.

Cutouts shall be square with panels to ensure that instruments will be installed level and square.

Finished cutouts and holes shall be free of burrs and sharp edges. Cutouts shall be made up of [modular sections] [fabricated sections] in sizes suitable for handling. Cabinet section joints shall be neat and straight. Cabinets shall be securely fastened together and aligned, and each cabinet shall be securely wall or floor anchored, as required.

Exterior hardware shall be high-grade steel with [polished-nickel] [chrome-plated] finish.

Interior hardware shall be cadmium-plated steel.

Access doors shall be provided with hinges, latches, and locks. Cabinet frames shall be sufficiently sturdy to prevent doors from sagging when open. Latches shall be provided to hold doors open at 90 degrees and roller latches shall be provided to hold doors closed. Keys shall be furnished and shall be common to all access door locks.

### 2.9.2 Finish

Surfaces shall be cleaned in accordance with SSPC SP 6. Blast pattern shall have a maximum surface profile of [0.05] [\_\_\_\_\_] millimeter [2.0] [\_\_\_\_\_] mils. Not more than [8] [\_\_\_\_\_] hours after cleaning, the manufacturer's standard procedure shall be followed for priming and finish painting. Final coat shall conform to FS A-A-2962 or shall conform to FED-STD-595, semi-gloss green enamel for all external surfaces. Soft gloss white paint shall be used for interior surfaces. When painting is not started within 8 hours after cleaning, surfaces shall be recleaned before painting.

### 2.9.3 Graphic System Portrayal

Cabinet shall be provided with individual modules portraying systems configurations. Portrayals shall be by approved color-coded graphic tapes in laminated plastic securely fastened to the front panel. Edges shall be beveled and finished smooth and shall be free of waves, scratches, or gouges. Instruments and auxiliary equipment shall be identified by engraved [plastic] [formica] labels. Tape shall not be acceptable.

### 2.9.4 Instruments and Components

Instruments shall be approved prior to installation. Instruments shall be clean and free of foreign matter.

Pipe connections shall be provided in air lines at each pneumatic room controller to connect gages for testing.

#### 2.9.4.1 Receiver-Type Indicator

Receiver-type dial size indicators shall be as indicated.

Indicator cases shall be made of drawn steel, flush mounted with three equally spaced [screws] [panel clamps] and panel cutout to match indicator as furnished.

Bourdon tube shall be of material and construction suitable for 20 to 100 kilopascal 3 to 15 psig input.

Indicator movement shall be accomplished by [precision brass] [approved manufacturer's standard practice].

Dial shall be black numerals and graduating marks on a flat white background.

Pointer shall be by fixed needle.

Indicator calibration shall be by means of calibration screw on face of indicator, with dial accuracy to within 0.5 degrees C 1 degree F in the applicable range.

Scale ranges shall operate full scale between 20 and 100 kilopascal 3 and 15 psig, with scale ranges as indicated.

#### 2.9.4.2 Electronic Temperature Indicator

\*\*\*\*\*  
NOTE: This indicator is for use with temperature transmitters that transmit an air signal of 20 to 100 kilopascal 3 to 15 psig proportional to the imposed temperature.  
\*\*\*\*\*

Electronic temperature indicator shall indicate the sensor input throughout the operating range of the system. Accuracy shall be within plus or minus [1/2] [\_\_\_\_\_] percent of the system range. Input shall be proportional to the measured variable. Scale range shall be minus [29] [\_\_\_\_\_] to plus [95] [\_\_\_\_\_] degrees C [20] [\_\_\_\_\_] to plus [200] [\_\_\_\_\_] degrees F.

#### 2.9.4.3 Electronic Pressure Indicator

Electronic pressure indicator, calibrated in pascal inches wg, shall indicate the pressure drop through range of transmitter. Accuracy shall be not less than plus or minus [10] [\_\_\_\_\_] pascal [0.05] [\_\_\_\_\_] inch wg.

#### 2.9.4.4 Remote Control Point Adjuster

Remote adjustment for resetting the set point of the control device shall be in [2] [\_\_\_\_\_] -degree increments for the full range of the control span.

#### 2.9.4.5 Manual Minimum Position Switch

Manual minimum position switch shall have an adjustable minimum output between [20] [\_\_\_\_\_] and [90] [\_\_\_\_\_] kilopascal, [3] [\_\_\_\_\_] and [13] [\_\_\_\_\_] psi, shall be furnished with a calibrated [0] [\_\_\_\_\_] to [100] [\_\_\_\_\_] percent set point scale with scale divisions of [5] [\_\_\_\_\_] or less, and shall have a set point-locking adjustment knob. Switch shall be

suitable for a maximum pressure of not less than [175] [\_\_\_\_\_] kilopascal [25] [\_\_\_\_\_] psig.

#### 2.9.4.6 Remote Temperature Transmitter

Remote temperature transmission of discharge air and space temperature shall transmit a signal in proportion to the measured temperature to an electronic thermometer in the central control panel. Total system accuracy shall be plus or minus [0.25] [0.5] [\_\_\_\_\_] degree C F.

#### 2.9.4.7 Remote Filter Pressure Transmitter

Filter pressure-drop transmitter shall transmit an electronic signal to a common pressure indicator, calibrated in pascal inches wg, at the control center. Accuracy shall be of not less than plus or minus [10] [\_\_\_\_\_] pascal [0.05] [\_\_\_\_\_] inch wg. Range of the pressure transmitter shall be from [0] [\_\_\_\_\_] to [1500] [\_\_\_\_\_] pascal [6] [\_\_\_\_\_] inches wg.

#### 2.9.5 Panel Instrument Tubing

Instrument tubing within panels shall be copper or black polyethylene tubing. Tubing connections at panels shall be made with through-bulkhead-type fittings.

Tubing shall be neatly installed and properly supported. Instruments and accessories mounted on hinged access panels shall have sufficient flexible tubing to allow the door to open at least 135 degrees. Flexible tubing shall be tied into a single cable.

Fittings and joints shall be pressure-tight, and as indicated.

#### 2.10 INDIVIDUAL SYSTEM CONTROL PANELS

\*\*\*\*\*

**NOTE: Ability to open and/or remove access covers is required for maintenance activities. In addition, access may be required to inspect this device while circuits are energized (for example, using infrared imaging). Minimum distances to energized circuits is specified in OSHA Standards Part 1910.333 (Electrical - Safety-Related work practices). OSHA Standards are available on the internet.**

\*\*\*\*\*

Each air handling system shall be provided with an individual control panel mounted adjacent to and vibration isolated from the air handling unit.

Control panel shall be of manufacturer's standard steel construction of adequate gage and sufficient reinforcement to be completely rigid. Finish shall be manufacturer's color approved by the Contracting Officer. Identification plates shall be mechanically attached, engraved, [3] [\_\_\_\_\_] millimeter [1/8] [\_\_\_\_\_] inch thick, laminated, black and white plastic. Panel location shall be as indicated.

Panel shall contain a thermometer for each duct or immersion thermostat, as indicated, and for electropneumatic and pneumoelectric switches not connected to starters, pilot lights for fan air filters, pump motors, filter runout pilot lights, air switches, or other accessories, as



indicated. Panel shall also contain all controllers, recorders, and other instruments, including a 40 millimeter 1-1/2 inch gage showing pressure of primary air to pneumatic controllers; and 40 millimeter 1-1/2 inch gages showing pressures of controlled air from each controller, other than room controllers.

## PART 3 EXECUTION

### 3.1 INSTALLATION

[Installation of control components shall be done by qualified control and instrumentation specialists working under the direction of the manufacturer's representative.]

[Installation of control components shall be done by Contractor-certified control and instrumentation specialists.]

Installation shall be in accordance with the manufacturer's instructions and as indicated.

Installation Drawings shall be submitted and drawings shall include details of equipment room layout and design.

Listing of Product Installations for controls and instrumentation systems shall include identification of at least [5] [\_\_\_\_\_] units, similar to those proposed for use, that have been in successful service for a minimum period of [5] [\_\_\_\_\_] years. List shall include purchaser, address of installation, service organization, and date of installation.

### 3.2 CONTROL- AND INSTRUMENT-AIR TUBING INSTALLATION

Tubing shall be concealed, except in mechanical rooms or areas where other piping is exposed.

Multiple tube runs shall be neatly nested.

Tubing shall be mechanically attached to supporting surfaces. Supporting adhesives are not acceptable. See additional requirements under Section 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

Tubing penetrations in concrete surfaces shall be made through minimum, [25] [\_\_\_\_\_] millimeter [1] [\_\_\_\_\_] inch ips, Schedule 40, rigid, unplasticized, polyvinylchloride (PVC) sleeves. Sleeves shall extend [150] [\_\_\_\_\_] millimeter [6] [\_\_\_\_\_] inches above floors and [25] [\_\_\_\_\_] millimeter [1] [\_\_\_\_\_] inch below bottom surface of slabs. Where water- or vapor-barrier sealing is required, [15] [\_\_\_\_\_] millimeter [1/2] [\_\_\_\_\_] inch deep elastomer calk shall be applied to surfaces cleaned free of oil and other deleterious substances.

Tubing shall be purged with dry, oil-free compressed air to rid system of impurities generated during joint making and installation and to remove atmospheric moisture before connecting control instruments.

#### 3.2.1 Copper Tubing

Tubing with mechanical joints shall be cut square and burrs shall be removed. Care shall be exercised not to work-harden copper surfaces. Tube ends shall be cut off or annealed by heating and air cooling in accordance with the manufacturer's instructions.

Copper tubing for solder joints shall be cut square and burrs shall be removed. Inside surfaces of fittings and outside surfaces of tubes in joint area shall be cleaned before assembly of joint. Joint flux, filler material, and heat source shall be applied in accordance with the manufacturer's instructions. Valves in copper piping shall have screwed ends with end adaptors to suit mechanical connections, unless solder jointing is otherwise indicated. Copper joints that fail pressure tests shall be remade with new materials, including pipe or tubing fittings and filler metal.

Hard-drawn copper tubing shall be used in all exposed areas. [Hard drawn] [annealed tubing] shall be used where tubing is concealed.

Fittings for supply system copper tubing shall be wrought-copper solder-joint type except at connection to apparatus where specified brass mechanical and ips thread-adaptor fittings shall be used. Tool-made bends in copper tubing will be acceptable in lieu of fittings.

Copper-tubing runs embedded in concrete shall be annealed and shall be protected by [metallic] [plastic electric] conduit.

Copper tubing horizontal supports for less than three tubes shall be rigid [25 by 10] [\_\_\_\_\_] millimeter [1- by 3/8] [\_\_\_\_\_] inch metal channel and shall be proprietary metal tube race for three or more tubes.

[Copper tubing runs in soil shall be jointless and shall be protected by [ 0.305 millimeter 12-mil thick bituminous coating] [PVC tape wrapping].]

### 3.2.2 Plastic Tubing

Plastic tubing, [sheathed] [unsheathed], except as otherwise indicated, may be used in lieu of, or in conjunction with, copper tubing upon prior approval, provided:

Tubing is not exposed to ultraviolet light or continuous ambient temperatures in excess of [50] [120] [\_\_\_\_\_] degrees C F at any point along run.

Tubing is free from danger of mechanical damage and readily accessible for replacement with a minimum of tools and without need to remove plaster, furring, equipment, or similar permanent construction.

Tubing is enclosed within conduit or control panel cabinets, or is concealed behind control panels.

Plastic tubing, installed inside or behind control panels, shall be color coded or number coded. Tubing shall be neatly tied and supported. Flexible connections bridging the cabinet and cabinet door shall be neatly fastened along the hinge side and protected against abrasion.

Plastic tubing, in mechanical rooms or in spaces where copper tubing is exposed, shall be run within adequately supported metal raceways or in metallic or plastic electric conduit.

Multiple-tube plastic harness or sheathing shall be used in place of single plastic tubes where a number of plastic tubes run to the same point, unless such use is otherwise prohibited.

Fittings for plastic tubing shall be used in accordance with the manufacturer's instructions.

Multiple-tube plastic [harness] [sheathing] may be embedded in concrete or run in soil below concrete without additional protection provided it is jointless, contains [30] [\_\_\_\_\_] percent spares, and prior approval has been obtained.

Terminal single lines shall be hard-drawn copper tubing, except that where the run is less than [300] [\_\_\_\_\_] millimeter [12] [\_\_\_\_\_] inches, plastic tubing may be used.

### 3.3 MECHANICAL REFRIGERATION AIR DRYER INSTALLATION

Wall mounting shall be through rubber-in-shear mounts. Dryer shall be connected to air compressor outlet with pressure regulator installed downstream of dryer.

### 3.4 VIBRATION ISOLATION

To prevent vibration, controllers shall be isolated by location or by mounting devices supplied by the equipment manufacturer.

Tubing and conduit shall be installed to prevent the transmission of equipment vibration. Single tube runs shall be mounted in aircraft-type clamps containing an elastomer insert, and mounting shall prevent contact with ducting or air handling unit housing, casing, or enclosure. Multiple runs shall conform to the same isolation requirements, but mounting details shall be submitted for approval. Refer to Section 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations.

### 3.5 TESTING, CALIBRATION, AND ACCEPTANCE

\*\*\*\*\*  
NOTE: The Systems Engineer/Condition Monitoring Office/Predictive Testing Group should inspect the installation during acceptance testing using advanced monitoring technologies such as Infrared Imaging or Ultrasonic Listening. These technologies can identify loose electrical connections (hot spots), insulation voids/settling, and system/pressure/vacuum leaks.  
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Test reports shall be performed in accordance with referenced standards in this section.

[Multizone unit dampers shall be tested for temperature pickup due to leakage when hot deck is closed and cold deck is open. Maximum temperature rise shall be [1] [2] [\_\_\_\_\_] degrees C F when the temperature difference between the hot and cold decks is [10] [\_\_\_\_\_] degrees C [20] [\_\_\_\_\_] degrees F, unless otherwise approved.]

After the inspection has been completed, systems shall be checked for continuity.

After completion of control and instrument piping, control equipment shall be tested and adjusted in terms of design, function, systems balance, and

performance, and shall otherwise be made ready for air handling systems acceptance tests. Data showing set points and final adjustments of controls shall be provided.

After air handling system acceptance and after the systems have operated in normal service for [2] [\_\_\_\_\_] weeks, the adjustment on instruments and devices shall be checked. Items found to be out of order shall be corrected. When air handling systems are in specified operating condition and when all other pertinent specifications requirements have been met, automatic temperature-control systems will be accepted.

Pneumatic systems shall be tested in accordance with ISA 7.0.01. System pressure shall not exceed [200] [\_\_\_\_\_] kilopascal [30] [\_\_\_\_\_] psig.

Equipment to check the calibration of instruments shall be provided by the Contractor. Instruments not in calibration shall be recalibrated or replaced.

### 3.6 OPERATOR TRAINING

Written operating instructions and not less than [8] [\_\_\_\_\_] hours of operator training shall be provided.

Contractor shall provide classroom and field instructions in operation and maintenance of systems equipment where required by the technical provisions. These services shall be directed by the Contractor, using the manufacturer's factory trained personnel or qualified representative. Contracting Officer shall be given [seven] [\_\_\_\_\_] calendar days written notice of scheduled instructional services. Instructional materials belonging to the manufacturer or vendor shall be made available to the Contracting Officer.

### 3.7 SPECIAL TOOLS

Special tools shall be provided as required for the operation and adjustment of controllers, instruments, or other control system devices.

### 3.8 OPERATION AND MAINTENANCE

Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions.

-- End of Section --