Preparing Activity: NASA Superseding
UFGS-23 09 33.00 40 (November 2015)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 09 33.00 40

ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC

11/20

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

Coordinate with drawings to include flow schematic and control sequence. Indicate solar compensation requirements in accordance with exposure on drawings.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

][Section 40 17 30.00 40 WELDING GENERAL PIPING applies to work specified in this section.

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

]1.1 REFERENCES

****

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 Reference Identifier (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 are automatically 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	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASTM INTERNATIONAL (ASTM)

ASTM A666	(2023) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280	(2020) Standard Specification for Seamless

	Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air
ISA RP60.9	(1981) Piping Guide for Control Centers

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA DC 3	(2013) Residential Controls - Electrical Wall-Mounted Room Thermostats

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2024) Standard for the Installation of Air Conditioning and Ventilating Systems

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-STD-595A	(2017) Colors used in Government Procurement

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD-G-24508	(1977; Rev A; Am 4 1998) Grease, High Performance, Multipurpose (Metric)
MIL-F-18280	(1995; Rev F; Supp 1; CANC Notice 1) Fittings, Flareless Tube, Fluid Connection

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-2962	(Rev A; Notice 2) Enamel, Alkyd, Gloss, Low VOC Content

1.2 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that

require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification 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[; G[, [____]]]

Records of Existing Conditions[; G[, [____]]]

SD-02 Shop Drawings

Fabrication Drawings[; G[, [____]]]

Installation Drawings[; G[, [____]]]

SD-03 Product Data

Control Components[; G[, [____]]]

Thermometers[; G[, [____]]]

Pressure Gages[; G[, [____]]]

Valves[; G[, [____]]]

Dampers[; G[, [____]]]

Operators[; G[, [____]]]

SD-04 Samples

Manufacturer's Standard Color Charts[; G[, [____]]]

Thermostat Covers[; G[, [____]]]

Thermostat Guards[; G[, [____]]]

Room Humidistats[; G[, [____]]]

SD-06 Test Reports

Set Points and Final Adjustments Of Controls[; G[, [____]]]

Test Reports[; G[, [____]]]

SD-07 Certificates

Listing of Product Installations[; G[, [____]]]

Qualified Permanent Service Organizations[; G[, [____]]]

Manufacturer's Standard Factory Finishing[; G[, [____]]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals[; G[, [____]]]

Scheduled Instructional Services[; G[, [____]]]

Air Supply Source[; G[, [____]]]

Mechanical Refrigeration-Type Air Dryer[; G[, [____]]]

Pneumatic Operators[; G[, [____]]]

Electric Operators[; G[, [____]]]

1.3 QUALITY CONTROL

1.3.1 Predictive Testing and Inspection Technology Requirements

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NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS for additional information regarding cost feasibility of PT&I.

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This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

1.3.2 Product Installations

Provide listing of product installations for controls and instrumentation systems that 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. Include purchaser, address of installation, service organization, and date of installation on list.

1.3.3 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of similar material, design and workmanship. Provide standard products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening that includes applications of equipment and materials under similar circumstances and of similar size. Provide a product that has been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

1.3.4 Alternative Qualifications

Products having less than a two-year field service record are acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, are shown.

1.3.5 Service Support

Support the equipment items by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. Provide service organizations that are reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of contract.

1.3.6 Manufacturer's Nameplate

Provide each item of equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable.

1.3.7 Modifications of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, wherever the words shall, should, will, would, or may appear. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the "Contracting Officer."

1.4 DELIVERY, STORAGE, AND HANDLING

Seal openings after manufacturing and inspection, until ready for installation.

Carefully handle instruments and equipment, do not subject to shock, and protect from weather, dust, construction materials, and damage.

1.5 PROJECT/SITE CONDITIONS

Submit records of existing conditions consisting of the results of survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of existing conditions.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide automatic temperature control systems that are complete in all details and that include all necessary accessories to maintain conditions indicated or specified.

Provide [equivalent pneumatic] [electronic] [electric/electronic] [low-voltage electric] [pneumatic/electronic] automatic temperature control systems. As far as practical, provide control equipment that is the product of a single automatic control systems manufacturer. Provide automatic control systems components not the product of the control system manufacturer that are approved for use with the control system as indicated.

Provide motors, controllers, disconnects and contactors with their respective pieces of equipment. Provide motors, controllers, disconnects and contactors that conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors are not permitted. Provide controllers and contactors that have a maximum of 120 volt control circuits, and have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, include the cost of additional electrical service and related work under the section that specified that motor or equipment. Provide power wiring and conduit for field installed equipment under and conforming to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

Provide system mixing boxes and variable air volume boxes with air-mixing valve operators and controllers that are furnished by the automatic control systems manufacturer.

Provide automatically controlled valves to control environment that are

furnished by the automatic control systems manufacturer.

Provide automatically controlled dampers, independent of dampers integral with manufactured air-handling units, furnished by the automatic control systems manufacturer. Use a damper manufacturer that is licensed to display the AMCA seal.

2.2 FABRICATION

Submit fabrication drawings for control and instrumentation systems consisting of fabrication and assembly details to be performed in the factory.

2.3 EQUIPMENT

Submit material, equipment, and fixture lists for control and instrumentation systems including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Submit Equipment and performance data for the following items consisting of use life, system functional flows, safety features, and mechanical automated details. Submit curves indicating tested and certified equipment response and performance characteristics.

a. Control Components

b. Thermometers

c. Pressure Gages

d. Valves

e. Dampers

f. Operators

2.3.1 Thermometers

Provide thermometers adjacent to thermostats with nonferrous separable sockets when in immersion service. Select thermometer scale range according to service. Provide thermometers that are readable from operating level.

Provide dial type temperature indicators that 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.

Provide [friction] [micrometer] maximum-registering type pointer with external calibrator adjustment. Provide accuracy within [1] [_____] percent of dial range.

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

Provide [vapor] [solid liquid] [bimetal] activating medium.

Provide stem length that is[15 millimeter 1/2 inch taper pipe thread,

fixed thread][20 millimeter 3/4 inch taper pipe thread, separable socket].

Provide dial type thermometers or thermometers with a minimum 230 millimeter9 inch vertical scale.

Provide temperature sensor, sensor transmitter, and output signals that are directly proportional to the variations in the measured variable. Provide linearity that is within plus or minus [1/2] [_____] percent throughout the scale range for a [93.3] [_____] degree C [200] [_____] degrees F span, and plus or minus [1] [_____] percent for [10] [_____] degrees C [50] [_____] degrees F span.

When the transmitter is over [15] [30] meter [50] [100] feet from the receiver indicator, use a signal booster to improve signal response. Provide a transmitter that has feedback incorporated in the design and has a [10] [38] [93] degrees C [50] [100] [200] degrees F temperature range. Provide capillary that is compensated and is available in short style, [2.5] [_____] [8] [_____] to [5.5] [_____] [18] [_____] meter foot averaging lengths. Provide unit that operates on a [140] [_____] kilopascal [20] [_____] psi input pressure and has a [20] [_____] [3] [_____] to [100] [_____] kilopascal [15] [_____] psi output over the specified range.

For multizone units, provide each zone discharge duct with a remote-reading panel-mounted dial thermometer. Locate sensor not less than [3] [_____] meter [10] [_____] feet downstream of the mixing dampers or other device causing air turbulence.

2.3.2 Pressure Gages

Provide pressure gages used to indicate supply and outlet air pressures of automatic control instruments that are the manufacturer's standard, minimum [90] [_____] [3-1/2] [_____] millimeter inch diameter.

2.3.3 Control System Valve Boxes

Provide bronze valve bodies, DN50 2 inch iron pipe size (ips) and smaller, with [screwed] [flanged] end connections. If DN65 2-1/2 inch ips and larger, provide cast iron valve bodies with flanged end connections.

Provide single seated valves for dead-end service except where otherwise indicated.

Provide modulating service valves with plugs matched to the characteristics of the coil for effective control. Provide tetrafluoroethylene, spring-loaded, and self-adjusting valve-stem packing.

Provide top and bottom guided and [AISI, Type 303 corrosion-resistant steel] [Monel] valve stem. Cage construction is acceptable.

Provide valves with position indicators and, where indicated or required for proper operation, provide with positioners.

Provide valve linkage with an adjustment for valve lift.

2.3.3.1 Hydronic

Provide hydronic system valve bodies and trim that are rated for service pressures through [860] [_____] kilopascal at [121] [_____] degrees C

[125] [_____] psi at [250] [_____] degrees F.

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

[Provide maximum pressure drop across any hydronic system valve at maximum flow of [15] [_____] kilopascal [5] [_____] feet of water.

]2.3.3.2 Steam

Provide steam valve bodies and trim that are rated for service pressures through [860] [_____] kilopascal [125] [_____] psi saturated steam.

Provide steam valve replaceable plugs and seats that are AISI, Type 440C corrosion-resistant steel hardened to not less than [500] [_____] Brinell.

Provide maximum pressure drop across any steam valve at maximum flow as indicated.

2.3.4 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.
****

2.3.4.1 Air Supply Source

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

Provide a vibration-isolated, simplex, instrument-air, compressor/receiver unit, 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. Provide a standard unit of the temperature-controls manufacturer 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.

Provide compressor that is of oil-free construction.

Provide vibration isolation that consists 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.

Install a wire-braid reinforced rubber hose from the compressed air connection to the distribution header.

2.3.4.2 Mechanical Refrigeration-Type Air Dryer

Provide a noncycling, continuously operating, hermetically sealed, refrigeration unit air dryer, 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. Provide unit that is 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. Provide unit with an operating pressure of not less than [1035] [_____] kilopascal [150] [_____] psig. Provide refrigeration unit of not less than [125] [_____] wattage rating [1/6] [_____] horsepower for 115-volt, 60-hertz, single-phase power supply.

2.3.5 Power-Operated Dampers

2.3.5.1 Frame and Blade Assembly

Provide frames and blades that are constructed of [extruded aluminum] [galvanized steel] [rolled carbon steel] [corrosion-resistant steel].

Provide mechanically attached, field replaceable resilient seals. Attachment by adhesive is not acceptable. Provide [neoprene] [flexible metal compression-type jamb seals constructed of [aluminum] [corrosion-resistant steel]].

Provide frames that have corner reinforcement and stay rods, where necessary. Provide frames that are fabricated by welding or riveting. Repair damaged galvanized surfaces by coating with an equal weight of zinc.

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

Provide minimum shaft size of [15] [_____] millimeter [1/2] [_____] inch, [round] [square].

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

Provide blades that are attached to round shafts by hardened cup-point setscrews, or by being pinned. Provide a minimum three-thread engagement. Where setscrews are used, provide two setscrews, 90 degrees apart, to secure master blade. Secure shaft end retainers by pins or spring washers in grooved shaft or by similar construction.

Caulk frames with elastomer compounds to prevent bypass leakage.

[Provide blades without resilient seals that have interlocking edges.

] Provide maximum leakage of dampers of [_____].

2.3.5.2 Bearings

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

[Provide [oil-impregnated sintered bronze] [graphite-impregnated nylon sleeve type] shaft bearings, except as otherwise indicated. Provide thrust washers 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.
****

[Provide single row, unground, flanged, radial, antifriction type shaft bearings with extended inner race suitable for press mounting in damper frame. Provide AISI type 316 corrosion-resistant steel bearing materials. Provide lubricant free bearings. Mark operation and maintenance manual, and attach instructions to the damper frame noting: "DO NOT LUBRICATE CORROSION-RESISTANT STEEL BEARINGS." Factory sealed, shielded carbon-steel ball bearings are acceptable provided lubricant conforms to DOD-G-24508.

] Provide [oil-impregnated sintered bronze] [graphite-impregnated nylon] linkage pivot bearings.

2.3.5.3 Dampers

Provide dampers that are 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.

2.3.5.4 Installation

Install dampers in accordance with the manufacturer's instructions.

2.3.6 Control System Valve and Damper Operators

2.3.6.1 Operators

Provide motor operators that provide smooth proportional control under operating conditions normal to the system.

Provide spring-return operators for two-position control.

Provide spring returns on reversible operators where required for fail-safe operation.

For operators operating in sequence with other operators, provide operators that have adjustable operating ranges and set points.

Provide operators that have sufficient power on close-off to provide tight

sealing against maximum system pressures.

Provide operators that close valves and dampers to fail-safe position indicated.

2.3.6.2 Pneumatic Operators

Provide positioners where two or more operators are controlled from the same controller, and where indicated. Mount positioners directly on the driven device. Provide feedback from the [stem] [rod] through a pilot spring. Provide adjustable starting point from [15] [_____] to [85] [_____] kilopascal [2] [_____] to [12] [_____] psi. Provide adjustable operating span from [35] [_____] to [90] [_____] kilopascal [5] [_____] to [13] [_____] psi.

2.3.6.3 Electric Operators

Provide reversible type electric motor operators for modulating control.

Provide split-phase type electric motor operators with oil-immersed gear train. Provide motor that has ample capacity to handle applied loads under operating conditions normal to the system. Heat locations where temperatures fall below minimum operating temperature of operator.

2.3.7 Central Control Cabinet

[Provide a free-standing modular type control cabinet with hinged, locking access door, one per module.

][Provide control cabinet that consists of enclosed wall-mounted modular cabinet sections. Provide lockable cabinets with hinged fronts to provide access to the interior of each cabinet.

] Provide a 1.5 millimeter 60-mil thick, high-pressure laminate-covered writing surface and recessed storage drawers with locks.

2.3.7.1 Cabinet Construction

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

Provide surfaces that are free of scale, welding slag, and dirt, and are flat without waves. Do not distort or buckle the cabinet during installation handling.

Provide square cutouts with panels to ensure that instruments are installed level and square.

Make finished cutouts and holes free of burrs and sharp edges. Provide cutouts made up of [modular sections] [fabricated sections] in sizes suitable for handling. Provide neat and straight section joints. Securely fasten together and align cabinets, and securely wall or floor anchor each cabinet, as required.

Provide high-grade steel exterior hardware with [polished-nickel] [chrome-plated] finish.

Provide cadmium-plated steel interior hardware.

Provide access doors with hinges, latches, and locks. Provide sufficiently sturdy cabinet frames to prevent doors from sagging when open. Provide latches to hold doors open at 90 degrees and provide roller latches to hold doors closed. Furnish keys that are common to all access door locks.

[2.3.7.2 Factory Finishing

Manufacturer's standard factory finishing is acceptable with certification that the factory painting system applied withstands 125 hours in a salt-spray fog test, and equipment located outdoors withstands 500 hours in salt-spray fog test. Perform salt-spray fog test in accordance with ASTM B117, and for that test the acceptance criteria are the following: immediately after completion of the test, the paint shows no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shows no signs of rust creepage beyond 3.0 mm 0.125 inch on either side of the scratch mark.

Provide a film thickness of not less than the film thickness used on the test specimen for the factory finishing system applied on the equipment. If manufacturer's standard factory finishing system is being proposed for use on surfaces subject to temperatures above 50 degrees C 120 degrees F, provide a factory finishing system designed for the temperature service.

][2.3.7.3 Finish

Clean surfaces in accordance with SSPC SP 6/NACE No.3. Provide blast pattern that has a maximum surface profile of [0.05] [_____] millimeter [2.0] [_____] mils. Not more than [8] [_____] hours after cleaning, follow the manufacturer's standard procedure for priming and finish painting. Conform to CID A-A-2962 or SAE AMS-STD-595A for final coat, semi-gloss green enamel for all external surfaces. Use soft gloss white paint for interior surfaces. When painting is not started within 8 hours after cleaning, reclean surfaces before painting.

]2.3.7.4 Graphic System Portrayal

Provide cabinets with individual modules portraying systems configurations. Provide portrayals by approved color-coded graphic tapes in laminated plastic securely fastened to the front panel. Provide beveled edges that are finished smooth and free of waves, scratches, or gouges. Identify instruments and auxiliary equipment by engraved [plastic] [formica] labels. Tape is not acceptable.

2.3.7.5 Instruments and Components

Provide pipe connections in air lines at each pneumatic room controller to connect gages for testing.

a. Receiver-Type Indicator

Provide receiver-type dial size indicators as indicated.

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

Provide bourdon tube of material and construction suitable for 20 to 100 kilopascal 3 to 15 psig input.

Accomplish indicator movement by [precision brass] [approved manufacturer's standard practice].

Provide a dial with black numerals and graduating marks on a flat white background.

Provide fixed needle pointer.

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

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

b. Electronic Temperature Indicator

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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.

****

Provide electronic temperature indicator that indicates the sensor input throughout the operating range of the system. Provide accuracy within plus or minus [1/2] [_____] percent of the system range. Provide input that is proportional to the measured variable. Provide scale range of minus [29] [_____] to plus [95] [_____] degrees C [20] [_____] to plus [200] [_____] degrees F.

c. Electronic Pressure Indicator

Provide electronic pressure indicator, calibrated in pascal inches wg, that indicates the pressure drop through range of transmitter. Provide accuracy of not less than plus or minus [10] [_____] pascal [0.05] [_____] inch wg.

d. Remote Control Point Adjuster

Provide remote adjustment for resetting the set point of the control device in [2] [_____]-degree increments for the full range of the control span.

e. Manual Minimum Position Switch

Provide manual minimum position switch that has an adjustable minimum output between [20] [_____] and [90] [_____] kilopascal, [3] [_____] and [13] [_____] psi, that is furnished with a calibrated [0] [_____] to [100] [_____] percent set point scale with scale divisions of [5] [_____] or less, and that has a set point-locking adjustment knob. Provide a switch suitable for a maximum pressure of not less than [175] [_____] kilopascal [25] [_____] psig.

f. Remote Temperature Transmitter

Provide remote temperature transmission of discharge air and space temperature that transmits a signal in proportion to the measured

temperature to an electronic thermometer in the central control panel. Provide plus or minus [0.25] degree C [0.5] degree F [_____] total system accuracy.

g. Remote Filter Pressure Transmitter

Provide filter pressure-drop transmitter that transmits an electronic signal to a common pressure indicator, calibrated in pascal inches wg, at the control center. Provide accuracy of not less than plus or minus [10] [_____] pascal [0.05] [_____] inch wg. Provide pressure transmitter range from [0] [_____] to [1500] [_____] pascal [6] [_____] inches wg.

2.3.7.6 Panel Instrument Tubing

Provide copper or black polyethylene instrument tubing within panels. Provide tubing connections at panels that are made with through-bulkhead type fittings.

Neatly install and properly support tubing. For instruments and accessories mounted on hinged access panels, provide sufficient flexible tubing to allow the door to open at least 135 degrees. Tie flexible tubing into a single cable.

Provide pressuretight fittings and joints, and as indicated.

2.3.8 Individual System Control Panels

****

NOTE: Ability to open and/or remove access covers is required for maintenance activities. In addition, access is 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.

****

Provide each air handling system with an individual control panel mounted adjacent to and vibration isolated from the air handling unit.

Provide manufacturer's standard steel construction control panel of adequate gage and sufficient reinforcement to be completely rigid. Provide manufacturer's color finish approved by the Contracting Officer. Provide mechanically attached, engraved, [3] [_____] millimeter [1/8] [_____] inch thick, laminated, black and white plastic identification plates. Locate panel as indicated.

Provide panel that contains 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. Provide panel that contains 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.

2.4 COMPONENTS

2.4.1 Temperature Sensors

Provide temperature sensors, sensor transmitters, and controller output signals that are directly proportional to the variations in the measured variable. Provide linearity that is within plus or minus [1/2] [_____] percent for a 93 degrees C 200 degrees F span, and plus or minus [1] [_____] percent for a 10 degrees C 50 degrees F span, throughout the scale range.

Where extremely accurate temperature sensing is required or the transmitter is a considerable distance from the receiver controller, use a two-pipe relay-type transmitter. Provide instrument that has feedback incorporated into the design and [10] [38] [93] degrees C [50] [100] [200] degrees F temperature range. Provide capillary that is compensated and is available in [short style] 2500 and 5000 millimeter 8 and 16-foot averaging lengths. Provide unit that operates on [140] [_____] [20] [_____] kilopascal pounds per square inch (psi)input pressure, and has a [20 to 100 kilopascal] [_____] [3 to 15-psi] [_____] output over the specified range.

2.4.2 Humidity Sensors

Provide humidity sensors, sensor transmitters, and controller output signals that are directly proportional to the variations in the measured variable. Provide linearity that is within plus or minus [1] [_____] percent for a [70] [_____]-percent relative humidity span. Provide element that is capable of withstanding [98] [_____] percent relative humidity without loss of calibration when humidity sensor is duct-mounted downstream from a cooling coil.

2.4.3 Receiver Controllers

Provide receiver controllers that have a calibrated set point adjustment, minimum calibrated scale with no greater than minus [16.7] [_____] degrees C [2] [_____] degrees F degrees divisions for duct and immersion application and minus [17.2] [_____] degrees C [1] [_____] degrees F divisions for room control application. Provide set point indication and an adjustable proportional band covering the complete range necessary for the specific application. Provide controller range that matches that of the temperature sensor. Provide devices that incorporate authority and remote set point calibrated adjustments, as required.

2.4.4 Receiver Indicators

Provide receiver indicators that have visual readout for temperature and humidity, using the transmitted signal from the sensor device to the receiver-controller device. Provide readout and accuracy of the receiver indicator that has the indicated value within plus or minus [1/2] [_____] percent of the span of the measured variable, as transmitted by the sensor. Mark factory calibration on back of instrument. Provide range that matches that of the temperature or humidity sensor.

Provide a combined accuracy of the sensor and the receiver indicator that is within [minus 16.7] [_____] degrees C [2] [_____] degrees F and [5] [_____] percent relative humidity of the span.

Provide ambient conditions to [65.6] [_____] degrees C [150] [_____]

degrees F that do not cause a shift in control point in pneumatic sensor, receiver controller, or indicator systems.

2.4.5 Space Thermostats

2.4.5.1 Electrical Control

Provide low-voltage type space thermostat with [non-setback/setup] [setback/setup] temperature control for [cooling only] [heating only] [cooling and heating]. Provide thermostat that conforms to NEMA DC 3, and is as indicated.

2.4.5.2 Pneumatic Control

Provide the adjustable proportioning type space thermostat containing [a single bimetallic element for [heating only] [cooling only]] [dual bimetallic elements, one for heating and one for cooling].

Provide thermostats that have locking covers and built-in concealed thermostats.

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

Provide thermostats that conform to ASHRAE 90.1 - SI ASHRAE 90.1 - IP, and that have temperature restrictions as indicated.

2.4.5.3 Space Thermostat Accessories

Provide brushed aluminum Thermostat covers.

Provide insulating bases for thermostats located on exterior walls.

Provide cast-metal Thermostat guards in unfinished spaces.

Mount guards and thermostats on separate bases.

Submit samples of thermostat covers, thermostat guards and manufacturer's standard color charts showing the manufacturer's recommended color and finish selections.

2.4.6 Outdoor Reset Thermostat

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

2.4.7 Immersion Thermostats

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

When used as a secondary controller, provide a remotely set adjustable set point.

2.4.8 Airstream Thermostats

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

Provide airstream thermostats for control of modulating devices that are the remote-bulb type for proportional action with adjustable set point over the full operating range, and adjustable throttling range.

Provide airstream thermostats for averaging service that 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. Locate bulb to sense average temperature.

Provide airstream temperature primary controllers for remote reset or compensating operation, that are 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.

2.4.9 Line-Voltage Thermostats

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

Provide insulating bases for thermostats located on exterior walls.

Provide cast metal type thermostat guards in unfinished spaces.

Mount guards and thermostats on separate bases, unless otherwise approved.

Provide line-voltage thermostats that are furnished and mounted under this section, and wired in accordance with applicable sections of DIVISION 26 ELECTRICAL unless otherwise specified.

2.4.10 Electrical Low-Limit Duct Thermostat

Provide air-handling unit freeze protection. Make the lowest temperature across any 300 millimeter 12 inches of bulb length, [single] [multiple] tube, sufficient to trip a snap-acting, single-pole, single-throw switch when the temperature sensed is equal to, or below, set point. Provide 610020 [_____] millimeter [_____] foot minimum length of bulb. Provide one limit thermostat for every 1.8 20 [_____] square meter [_____] square feet of coil surface. Provide thermostats that have manual reset.

2.4.11 Fire Thermostats

Provide fire thermostats that are UL-approved and listed, are factory set

in accordance with NFPA 90A, and have normally closed contacts. Perform reset manually.

2.4.12 Heating/Cooling Valve-Top Thermostat

Furnish induction air-conditioning units with valve-top thermostats. Provide units that are proportional acting for proportional flow, remote-bulb liquid-filled element, direct and reverse acting at variable pressures to maximum 170 [_____] kilopascal, gage 25 [_____] pounds per square inch, gage (psig) air supply. Provide molded rubber operator diaphragm, die-cast housing, and furnish unit with position indicator and adjusting knob.

2.4.13 Room Humidistats

Provide room humidistats that are wall-mounted, reverse acting, proportioning type, with adjustable minimum throttling range no greater than [2] [_____]-percent relative humidity. Provide humidistats that are 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] [_____] degrees C [110] [_____] degrees F.

Submit manufacturer's standard color charts showing the manufacturer's recommended color and finish selections.

2.4.14 Duct Humidistats

Provide insertion type duct humidistats, mounted on outside of duct, with sensing element within duct. Provide reverse acting, proportioning type duct humidistats, with adjustable minimum-throttling range no greater than [2] [_____] percent relative humidity. Provide humidistats 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] [_____] degrees C [150] [_____] degrees F. Provide sensing element suitable for the indicated installation location.

2.4.15 High-Limit Duct Humidistats

Provide insertion type high-limit duct humidistats, mounted on outside of duct, with sensing element within duct. Provide reverse acting, two-position type humidistats, with minimum differential no greater than [2] [_____] percent relative humidity. Provide sensing element suitable for the indicated installation location.

2.4.16 Water Temperature Controllers

Insert water temperature controller in a nonferrous separable socket installed in the waterline. Provide controller that operates [remotely] [integrally] on an adjustable differential over an adjustable temperature range, and is suitable for operating in conjunction with the control valve provided.

2.4.17 Building Static-Pressure Transmitter

Provide a double-bell, differential type building static-pressure transmitter with temperature compensation. Provide scale range of [minus 125 to plus 125] [_____] [minus 0.5 to plus 0.5] [_____] kilopascal, gage inch water gage (wg), and sensitivity within plus or minus [0.124] [_____] 0.0005 [_____] kilopascal, gage inch wg. Provide transmitter that

transmits an [electronic] [pneumatic] signal to an indicating receiver with a matched scale range.

Provide a total system accuracy of not less than [12] [_____] [0.05] [_____] kilopascal, gage inch wg.

2.4.18 Building Static-Pressure Controller

[Provide a slack diaphragm type building static-pressure controller, with an adjustable set point, and adjustable throttling range. Provide controller range of [2.5 to 1500] [_____] [0.01 inch to 6.0] [_____] kilopascal, gage inches wg. Provide throttling range that is adjustable from [5 to 12] [_____] [0.02 to 0.0] [_____] kilopascal, gage inch wg. Provide [electronic] [pneumatic] output.

][Provide a double bell, differential type building static-pressure controller with temperature compensation. Provide scale range of [minus 125 to plus 125] [_____] [minus 0.5 to plus 0.5] [_____] kilopascal, gage inch wg, and sensitivity within plus or minus [12] [_____] [0.05] [_____] kilopascal, gage inch wg. Provide controller with an adjustable set point over the full-scale range and adjustable throttling range, proportional band. Provide [electronic] [pneumatic] output.

]2.4.19 Pressure Transmitter

Provide the indicating type pressure transmitters for gas, liquid, or steam service. Provide transmitter range suitable for system operating characteristics. Provide output that is proportional to system pressure and is electronic or pneumatic. Provide indicating receiver with a matched scale range.

Provide total system accuracy that is not less than [1/2] [_____] percent of system range.

2.4.20 Remote Pressure Transmitter

Provide pressure sensors for gas, liquid, or steam service remote indication that are [pneumatic] [pressure-to-current] type. Provide direct current output and power supply that is compatible with the remote readout indicator.

2.4.21 Remote Element Instruments

Provide remote element instruments that have sufficient length of capillary to mount the instrument on the control panel in an accessible location. Provide excess capillary that is coiled and concealed. Provide armored capillary where indicated.

2.4.22 Airflow Switches

Provide UL approved airflow switches, with pressure range of [30 to 2500] [_____] [0.12 to 10] [_____] kilopascal, gage inches wg, and electrical rating of [220 volts ac, 5 ampere] [110 volts ac, 10 ampere] and [560] [_____] [3/4] [_____] wattage rating horsepower ac pilot duty.

2.4.23 Pneumatic Relays

Provide [positive-acting] [gradual-acting] [direct] [reverse] relays.

2.4.24 Switches

Provide switches as indicated.

Provide adjustable switches with indicating plates and accessible adjustment. Calibrate and mark minimum-positioning switches that control dampers in percent of maximum airflow determined by airflow test.

2.5 ACCESSORIES

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

Provide pipe connections in air lines at each pneumatic room controller to connect gages for testing.

2.5.1 Control and Instrumentation Tubing

Provide copper tubing with [6] [_____] [1/4] [_____] millimeter inch outside diameter that is [hard drawn] [annealed] seamless copper, conforming to ASTM B280.

Provide solder joint, wrought copper fittings, conforming to ASME B16.22.

Provide compression type, [rod] [forged] brass ball-sleeve conforming to SAE, Type [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.

Provide 95-5 tin-antimony solder, alloy Sb5, conforming to AWS WHB-2.9.

Provide black virgin polyethylene tubing, meeting stress crack test performed in accordance with ASTM D1693. Provide multi-tube harness material as specified above, with polyester film barrier and vinyl jacket not less than [1.57] [_____] millimeter [0.062] [_____] inch thick.

Provide ball-sleeve compression type fittings, [brass] [aluminum], with internal sleeves.

2.5.2 Valves

2.5.2.1 Diaphragm Control and Instrument Valves (DCIV)

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

2.5.2.2 Gage Cocks

Provide [T-head] [lever-handle ground-key type] gage cocks, with washer and screw, constructed of polished ASTM B62 bronze and rated for 860 kilopascal 125-psi saturated-steam service. Provide end connections that suit the service.

2.5.3 Air-Pressure Reducing Stations

2.5.3.1 Pressure-Reducing Stations

Install pressure-reducing station 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

Provide pressure regulator body that is constructed of [zinc] [aluminum] die castings rated for the service. Provide a reinforced air-, oil-, and water-resistant elastomer diaphragm. Provide [nonferrous metallic] [nonmetallic materials] for all components exposed to the fluid stream being controlled. Provide a balanced-construction relieving type valve to automatically prevent excessive pressure buildup. Provide valve that produces an essentially flat, reduced pressure curve for the capacity demand of the system.

2.5.3.3 Particle Filters

Provide filters that are constructed of [zinc] [aluminum] die castings, rated for the service, and furnished with ips connections. Provide aluminum bowl material. Provide filter that is serviceable by quick-disconnect devices. Provide bowl that is equipped with manual draincock. Separate liquid particles by centrifugal and quiet zone action. Remove solid particles, to [15] [_____] micrometer, 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 are 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.
****

Provide a filter with 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. Provide filter pressure/temperature ratings of [1035] [_____] kilopascal and [66] degrees C [150] [_____] psi and [150] [_____] degrees F, respectively.

2.5.3.6 Pressure Relief Valves

Provide pressure relief valves that are 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. Set valve at not more than [20] [_____] percent above the correct low-side pressure. Provide seat material suitable for the service.

2.5.4 Pressure Gages

Provide pressure gages that conform to ASME B40.100 and as indicated. Provide pressure gages that are Type I, gage for air, steam, oil, and water, Class 1, pressure gage, with range as indicated. Provide 90 millimeter 3-1/2 inch nominal diameter sized pressure-gage. Provide AISI 300 series corrosion-resistant steel case with No. 4 standard commercial polish, or better, conforming to ASTM A666. Provide gages that are equipped with adjustable marking pointer and damper screw adjustment in inlet connection. Provide gages that have safety case, safety glass, and blowout plug.

PART 3 EXECUTION

3.1 INSTALLATION

[Install control components using qualified control and instrumentation specialists working under the direction of the manufacturer's representative.

][Install control components using Contractor-certified control and instrumentation specialists.

] Install in accordance with the manufacturer's instructions and as indicated.

Submit installation drawings and include details of equipment room layout and design.

3.1.1 Accessibility

****

NOTE: The following requirement is intended to solicit the installer's help in the prudent location of equipment when he has some control over locations. However, designers should not rely on it at all since enforcing this requirement in the field would be difficult. Therefore, the system designer needs to layout and indicate the locations of equipment, control devices, and access doors so that most of the accessibility questions are resolved inexpensively during design.

****

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

3.1.2 Control- And Instrument-Air Tubing Installation

Conceal tubing, except in mechanical rooms or areas where other piping is exposed.

Neatly nest multiple tube runs.

Mechanically attach tubing to supporting surfaces. Supporting adhesives are not acceptable. See additional requirements under Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND

EQUIPMENT.

Make tubing penetrations in concrete surfaces through minimum, [25] [_____] millimeter [1] [_____] inch ips, Schedule 40, rigid, unplasticized, polyvinylchloride (PVC) sleeves. Extend sleeves [150] [_____] millimeter [6] [_____] inches above floors and [25] [_____] millimeter [1] [_____] inch below bottom surface of slabs. Where water- or vapor-barrier sealing is required, apply [15] [_____] millimeter [1/2] [_____] inch deep elastomer caulk to surfaces cleaned free of oil and other deleterious substances.

Purge tubing 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.

3.1.2.1 Copper Tubing

Cut tubing with mechanical joints square and remove burrs. Do not work-harden copper surfaces. Cut off or anneal tube ends by heating and air cooling in accordance with the manufacturer's instructions.

Cut copper tubing for solder joints square and remove burrs. Clean inside surfaces of fittings and outside surfaces of tubes in joint area before assembly of joint. Apply joint flux, filler material, and heat source in accordance with the manufacturer's instructions. Provide valves in copper piping that have screwed ends with end adaptors to suit mechanical connections, unless solder jointing is otherwise indicated. Remake copper joints that fail pressure tests with new materials, including pipe or tubing fittings and filler metal.

Use hard-drawn copper tubing in all exposed areas. Use [hard drawn] [annealed tubing] where tubing is concealed.

Provide wrought-copper solder-joint type fittings for supply system copper tubing except at connection to apparatus where using specified brass mechanical and ips thread-adapter fittings. Tool-made bends in copper tubing are acceptable in lieu of fittings.

Provide annealed copper-tubing runs embedded in concrete and protect by [metallic] [plastic electric] conduit.

Provide copper tubing horizontal supports for less than three tubes that are rigid [25 by 10] [_____] millimeter [1- by 3/8] [_____] inch metal channel and are proprietary metal tube race for three or more tubes.

[Provide jointless copper tubing runs in soil that are protected by [0.305 millimeter 12-mil thick bituminous coating] [PVC tape wrapping].

]3.1.2.2 Plastic Tubing

Use plastic tubing, [sheathed] [unsheathed], except as otherwise indicated, 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] [_____] degrees C [120] [_____] degrees Fat 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.

Provide color coded or number coded plastic tubing, installed inside or behind control panels. Neatly tie and support tubing. Neatly fasten flexible connections bridging the cabinet and cabinet door along the hinge side and protect against abrasion.

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

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

Use fittings for plastic tubing in accordance with the manufacturer's instructions.

Embedding multiple-tube plastic [harness] [sheathing] in concrete or running it in soil below concrete without additional protection is allowed provided it is jointless, contains [30] [_____] percent spares, and prior approval has been obtained.

Provide terminal single lines made of hard-drawn copper tubing, except that where the run is less than [300] [_____] millimeter [12] [_____] inches, use plastic tubing.

3.1.3 Mechanical Refrigeration Air Dryer Installation

Wall mount through rubber-in-shear mounts. Connect dryer to air compressor outlet with pressure regulator installed downstream of dryer.

3.1.4 Vibration Isolation

To prevent vibration, isolate controllers by location or by mounting devices supplied by the equipment manufacturer.

Install tubing and conduit to prevent the transmission of equipment vibration. Mount single tube runs in aircraft-type clamps containing an elastomer insert, preventing contact with ducting or air handling unit housing, casing, or enclosure. Provide multiple runs that conform to the same isolation requirements, but submit mounting details for approval. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations.

3.2 FIELD QUALITY CONTROL

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NOTE: Provide inspection of the installation by the Systems Engineer/Condition Monitoring Office/Predictive Testing Group 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.
****

Provide equipment to check the calibration of instruments. Recalibrate or replace instruments not in calibration.

Perform tests in accordance with referenced standards in this section.

[Test multizone unit dampers for temperature pickup due to leakage when hot deck is closed and cold deck is open. Provide [1] [_____] degrees C [2] [_____] degrees F maximum temperature rise 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, check systems for continuity.

After completion of control and instrument piping, test and adjust control equipment in terms of design, function, systems balance, and performance, and otherwise make ready for air handling systems acceptance tests. Provide data showing set points and final adjustments of controls.

After air handling system acceptance and after the systems have operated in normal service for [2] [_____] weeks, check the adjustment on instruments and devices. Correct items found to be out of order. When air handling systems are in specified operating condition and when all other pertinent specifications requirements have been met, automatic temperature-control systems are acceptable.

Test pneumatic systems in accordance with ISA 7.0.01. Provide system pressure that does not exceed [200] [_____] kilopascal [30] [_____] psig.

Submit test reports to the Contracting Officer.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Operator Training

Provide written operating instructions and not less than [8] [_____] hours of operator training.

Provide classroom and field instructions in operation and maintenance of systems equipment where required by the technical provisions. Direct these services using the manufacturer's factory trained personnel or qualified representative. Give the Contracting Officer [seven] [_____] calendar days written notice of scheduled instructional services. Make instructional materials belonging to the manufacturer or vendor available to the Contracting Officer.

3.3.2 Special Tools

Provide special tools as required for the operation and adjustment of controllers, instruments, or other control system devices. Provide the list of special tools for acceptance to the Contracting Officer.

3.3.3 Operation and Maintenance

Provide operation and maintenance manuals that are consistent with

manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions. Submit manuals in electronic format.

-- End of Section --