Preparing Activity: NASA Superseding
UFGS-42 22 00.00 40 (May 2014)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 42 - PROCESS HEATING, COOLING, AND DRYING EQUIPMENT

SECTION 42 22 00.00 40

PROCESS CHILLERS AND COOLERS

05/17

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USACE / NAVFAC / AFCEC / NASA **UFGS-42 22 00.00 40 (May 2017)**

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SECTION 42 22 00.00 40

PROCESS CHILLERS AND COOLERS
05/17

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NOTE: This specification covers the requirements for medium scope Central-Station Air-Conditioning Systems using existing sources of chilled and hot water. The following Sections were edited and condensed to produce this Section and should not be needed:

Section 23 05 15 COMMON PIPING FOR HVAC

Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS

Section 22 07 19.00 40 PLUMBING PIPING INSULATION

Section 23 30 00 HVAC AIR DISTRIBUTION

Section 23 31 13.00 40 METAL DUCTS

Section 23 37 13.00 40 DIFFUSERS, REGISTERS, AND GRILLS

Section 23 41 13.00 40 PANEL FILTERS

Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC

Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

Motors are covered in Section 26 60 13.00 40 LOW-VOLTAGE MOTORS

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

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 be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

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.

AIR DUCT COUNCIL (ADC)

ADC Standards Manual	(2008; 5th Edition) Flexible Duct Performance Installation Standards

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 99	(2016) Standards Handbook
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 500-L	(2015) Laboratory Methods of Testing

Louvers for Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430 I-P	(2014) Performance Rating of Central Station Air-handling Unit Supply Fans
AHRI 431 SI	(2014) Performance Rating of Central Station Air-handling Unit Supply Fans
ANSI/AHRI 620 I-P	(2014) Performance Rating of Self-Contained Humidifiers for Residential Applications
ANSI/AHRI 621 SI	(2014) Performance Rating of Self-Contained Humidifiers for Residential Applications

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

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

ASHRAE 62.1	(2016) Ventilation for Acceptable Indoor Air Quality
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
ASHRAE EQUIP SI HDBK	(2012) Handbook, HVAC Systems and Equipment (SI Edition)
ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2021) Fundamentals Handbook, SI Edition
ASHRAE HVAC APP IP HDBK	(2016) HVAC Applications Handbook, I-P Edition
ASHRAE HVAC APP SI HDBK	(2019) HVAC Applications Handbook, SI Edition

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A197/A197M	(2000; R 2019) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2023a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A278/A278M	(2001; R 2020) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A694/A694M	(2016; R 2022) Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission Service
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM C534/C534M	(2023) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2022a) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D579/D579M	(2015) Standard Specification for Greige Woven Glass Fabrics
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe,

	Schedules 40, 80, and 120
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances
ISO 14644-1	(2015) Cleanrooms and Associated Controlled Environments Part 1: Classification of Air Cleanliness
ISO 14644-2	(2015) Cleanrooms and Associated Controlled Environments Part 2: Specifications for Testing and Monitoring to Prove Continued Compliance with ISO 14644-1

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB PROCEDURAL STANDARDS	(2015) Procedural Standards for TAB (Testing, Adjusting and Balancing) Environmental Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 90A	(2024) Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 220	(2024) Standard on Types of Building Construction
NFPA 255	(2006; Errata 2006) Standard Method of Test of Surface Burning Characteristics of Building Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1884	(2003) Fibrous Glass Duct Construction Standards, 7th Edition
SMACNA 1966	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 3779	(2016; Rev B) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant, Aluminum Foil/Glass Cloth

UNDERWRITERS LABORATORIES (UL)

UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 586	(2009; Reprint Sep 2022) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 900	(2015; Reprint Aug 2022) UL Standard for SafetyStandard for Air Filter Units
UL 1995	(2015; Reprint Aug 2022) UL Standard for Safety Heating and Cooling Equipment

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.

****

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

Connection Diagrams; G[, [____]]

Control Diagrams; G[, [____]]

SD-02 Shop Drawings

Ductwork; G[, [____]]

Air-Handling Unit; G[, [____]]

Controls and Instrumentation; G[, [____]]

SD-03 Product Data

Centrifugal Fan; G[, [____]]

Pipes, Valves and Specialties; G[, [____]]

Ductwork; G[, [____]]

Air Diffusion Devices; G[, [____]]

Filters; G[, [____]]

Insulation; G[, [____]]

Vibration Isolators; G[, [____]]

Humidifiers; G[, [____]]

Spare Parts List; G[, [____]]

SD-04 Samples

Color Chip; G[, [____]]

SD-06 Test Reports

Pressure; G[, [____]]

Leakage Test; G[, [____]]

Test and Balance; G[, [____]]

Final Test Reports; G[, [____]]

SD-07 Certificates

Performance Data; G[, [____]]

Air-Handling Unit Certification; G[, [____]]

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit connection diagrams indicating the relations and connections of the components. Indicate on the drawings the general physical layout of all controls, and internal tubing and wiring details.

Submit control diagrams for chilled water air-conditioning systems showing the physical and functional relationship of equipment. Show electrical diagrams with the size, type, and capacity of the system.

Submit color chip samples for approval by the Contracting Officer.

2.1.1 Design Requirements

Furnish labor, materials, equipment and services to construct, install, and test an air-handling and distribution system using chilled water and hot water to achieve the following design specifications:

	Outdoor	Indoor
Winter	[3][38] [_____] degrees C F DB	[20.0][68] [_____] degrees C F DB
Summer	[32][90] [_____] degrees C F DB [26][78] [_____] degrees C F WB	[25.6][78] [_____] degrees C F DB [57] [_____] percent RH

	Outdoor	Indoor
Winter	[3][_____] degrees C DB	[20][_____] degrees C DB
Summer	[32][_____] degrees C DB	[25.6][_____] degrees C DB
	[26][_____] degrees C WB	[57] [_____] percent RH

	Outdoor	Indoor
Winter	[38] [_____] degrees F DB	[68] [_____] degrees F DB
Summer	[90] [_____] degrees F DB	[78] [_____] degrees F DB
	[78] [_____] degrees F WB	[57] [_____] percent RH

2.1.2 Performance Requirements

Test and balance the HVAC system, after installation, in accordance with NEBB PROCEDURAL STANDARDS to deliver air flows from each supply register within 10 percent of the design specification.

Submit performance data for chilled water air conditioning systems[consisting of fan sound power data in accordance with AMCA 300].

2.2 MATERIALS

2.2.1 Ductwork Materials

[2.2.1.1 Galvanized Steel Ductwork Materials

Provide hot-dipped galvanized carbon steel ductwork of lock-forming quality, with a regular spangle zinc coating conforming to ASTM A653/A653M, G-90. Ensure that the construction, metal thickness, and reinforcement thickness conforms to ASHRAE HVAC APP SI HDBK, ASHRAE EQUIP SI HDBK, and SMACNA 1966.

][2.2.1.2 Rigid Fibrous Glass Ductwork Materials

Provide a rigid fibrous glass duct system, including tapes, adhesives, vapor barriers, and joint sealers. Ensure that the duct has a minimum density of 80 kilogram per cubic meter 5 pounds per cubic foot, and conforms to requirements of NFPA 90A. Ensure that labels have a FM approval and an ASHRAE 62.1, Class 1 airduct listing. Ensure that the system has a thermal conductivity of[0.45 watt per meter per degrees K 0.26 Btu foot per hour per square foot per degree F] [_____] at 24 degrees C 75 degrees F mean temperature, a noise reduction coefficient of 0.070, and a vapor transmission rate less than 1.15 nanogram per pascal per second per meter square 0.02 grains per square foot per hour per inch mercury pressure differential for a 25 millimeter 1 inch thickness. Use materials that are odorless and non-allergenic when in service. Provide a factory-applied vapor barrier, that is constructed in accordance with SMACNA 1884.

][2.2.1.3 Flexible Duct

Provide wire-reinforced flexible duct runouts to air outlets consisting of a factory-fabricated chloroprene or vinyl-impregnated and coated fibrous glass cloth. Ensure that the duct is bonded to and supported by a

corrosion protected spring steel helix. Fabric may be a laminate of metallic film and fibrous glass. Ensure that the runout does not exceed [_____] meter [_____] feet in length and complies with NFPA 90A and ASHRAE 62.1. Ensure that the working pressure rating of the ducting is at least three times the maximum system pressure, and the ducting has a temperature range between minus 30 to plus 80 degrees C minus 20 to plus 175 degrees F.

]2.2.2 Insulation - Ductwork and Pipe

Use noncombustible thermal insulation system materials, as defined by NFPA 220, unless otherwise specified. Provide adhesives, coatings, jacketing, and other thermal insulating materials, except cellular elastomers, with a flame spread classification not to exceed [25] [_____], and a smoke-developed classification not to exceed [50] [_____], as determined in accordance with NFPA 255. Use adhesives, coatings, and sealants with published or certified temperature ratings suitable for the range of temperatures that are normal for the surfaces to which the materials are to be applied.

2.2.2.1 Acoustic Duct Lining

Use acoustic duct lining with [50] millimeter [2] inch [_____]-thick fibrous glass conforming to ASTM C1071. Deeply impregnate the liner composition with chloroprene on the surface exposed to the airstream, and ensure the liner meets the fire hazard requirements of NFPA 90A. Ensure the air stream side of the liner is can of withstand air velocities of 20 meter per second 4,000 feet per minute without delaminating or eroding.

Use mineral fiber conforming to ASHRAE FUN SI ASHRAE FUN IP, Chapter 20, ASHRAE HVAC APP SI HDBK, Chapter 21, ASHRAE EQUIP SI HDBK ASHRAE HVAC APP IP HDBK and ASTM C1071, Form A, Class 1, for rigid boards, and Form B, Class 6, for flexible blankets.

Use mineral fiber pipe insulation conforming to ASTM C547, Class 1, [jacketed] [plain].

Use cellular elastomer conforming to ASTM C534/C534M, except that the water vapor permeability cannot exceed 10.16 nanogram per pascal second square meter 0.30 perms.

2.2.2.2 Adhesives

Use a synthetic rubber fire-resistant adhesive with a nonflammable solvent base for attaching fibrous glass insulation to the metal surfaces, conforming to ASTM C916 and SAE AMS 3779 Class 2.

Ensure the fire-resistant adhesive for bonding fibrous glass cloth to itself and to other fibrous glass insulation materials conforms to ASTM C916 and SAE AMS 3779 Class 1.

Ensure that adhesive for cellular elastomer insulation is a solvent cutback chloroprene elastomer conforming to ASTM C916 and SAE AMS 3779 Type II, Class 1. Use an adhesive approved by the insulation manufacturer.

2.2.2.3 Jacketing and Vapor Barriers

Provide a 3-ply laminate of 17 kilogram per 10 square meter 35 pounds per 100 square feet white bleached kraft jacketing for mineral fiber duct

insulation. Bond the jacketing to at least 0.025 millimeter 1-mil thick aluminum foil and reinforced with glass fiber. With the foil exposed, meet a flame spread rating of [5] [_____] and a smoke developed rating of [0] [_____]. With the kraft exposed, meet a flame spread rating of [25] [_____] and a smoke developed rating of [15] [_____]. Ensure that the water vapor permeance of the composite is 0.012 nanogram per pascal second square meter 0.02 perm.

For mineral fiber pipe insulation, use vapor barrier material conforming to ASHRAE FUN SI ASHRAE FUN IP, Chapter 20, ASHRAE HVAC APP SI HDBK, Chapter 21, ASHRAE EQUIP SI HDBK ASHRAE HVAC APP IP HDBK, and ASTM C1071, Type 1 (low vapor transmission, high puncture resistance).

Ensure that glass reinforcing cloth conforms to ASTM D579/D579M.

2.2.3 Coatings

Provide a polyvinyl chloride lacquer finish coating for cellular elastomer insulation approved by the insulation manufacturer.

2.3 COMPONENTS

2.3.1 Factory-Fabricated Air-Handling Unit

Provide a unit that is a [horizontal] [vertical], [low] [medium] [high]-pressure, [blow] [draw]-through, [single] [multi]-zone, floor-mounted, factory-made central station assembly. Ensure that the unit consists of a centrifugal fan, fan drive, coils, filters, enclosure, vibration isolators, and appurtenances required for the specified operation.

Ensure that the air-handling unit certification complies with provisions of AHRI 431 SI AHRI 430 I-P and UL 1995, as applicable.

Provide a spare parts list for the unit.

2.3.1.1 Centrifugal Fan

****
NOTE: Fan and motor balance should conform to ISO 1940-1 Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels conform to NEMA Specification MG-1, Motors and Generators, Part 7, unless otherwise noted.
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NOTE: The use of sealed bearings when possible 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.
****

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NOTE: Furnish fans driven by motors rated over 7.5 hp [5.6 kW] with access doors and other provisions necessary to permit field balancing of the rotating

elements, addition of corrective weights, and measurement of residual unbalance.
****

Fully enclose fans, [single-width, single-inlet] [double-width, double-inlet], centrifugal scroll, having an AMCA 99 Pressure Class [I] [II] [III] rating as required for the design system pressure. Ensure that the rating is in accordance with AMCA 210. Ensure that the standard AMCA arrangement, rotation, discharge, and motor location is as indicated. Statically and dynamically balance the fan wheel to ISO 1940-1. Use self-aligning [antifriction] [sleeve], and [grease] [oil] [permanently] lubricated bearings. Ensure that bearings have an L-10 rated life of at least [30,000] [50,000] [80,000] [_____] hours in accordance with ABMA 9 or ABMA 11.

Fan drive is [direct] [by V-belt], designed for at least [150] [140] [120] percent of the connected driving capacity. Ensure that permanent sheaves are of fixed type. Use only adjustable sheaves for system balancing. Provide removable metal guards for exposed [shaft ends] [and] [couplings] [V-belt drives]. Provide guards with speed test openings at the center of the shafts. [Provide adjustable V-belt drives with a fan speed variation of at least 20 percent, and producing the specified fan capacity when set at the approximate midpoint of adjustment. Provide motors for V-belt drives with adjustable rails or bases.]

Ensure motors conform to NEMA MG 1, do not exceed [1800] [_____] rpm, and have [open] [drip-proof] [totally enclosed] [explosion-proof] enclosures. Provide [manual] [magnetic] [across-the-line] [reduced-voltage] motor starters with a [general-purpose] [weather-resistant] [watertight] enclosure. [Provide a remote manual switch with a pilot indication light where indicated.] Provide fans with personnel screens or guards on both suction and supply ends, except when screens are not required where ducts are connected to the fan. Provide fan and motor assemblies with vibration isolation supports or mountings.

2.3.1.2 Coils

Ensure that coils meet the provisions of AHRI 410. Provide fin and tube water coils, constructed of seamless [aluminum] [or] [copper] tubes, and [uncoated] [phenolic coated] [aluminum] [or] [copper] fins mechanically bonded or soldered to tubes. [Factory test each coil under water with at least 1700 kilopascal 250 psi air pressure.]that coils are suitable for 1350 kilopascal 200 psi working pressure at 121 degrees C 250 degrees F.

Mount coils for counterflow service. Install casing and tube support sheets of 1.6 millimeter 16-gage or heavier galvanized steel, formed to provide structural strength. Provide multiple tube supports when required to prevent the tube from sagging. Enclose the cooling coil ends by the cabinet and ensure that these ends are drained to the drain pan, or factory-insulated against sweating.

2.3.1.3 Enclosure

Provide a unit cabinet suitable for the AMCA 99 pressure class indicated with leak-tight joints, closures, penetrations, and access doors. Ensure that the cabinet does not expand or contract during starting or stopping of fans, and that the cabinet does not pulsate during operation of the fan. Reinforce the cabinet surfaces where deflections are in excess of [1/240] [1/360] of an unsupported span prior to acceptance. Stiffen the

pulsating panels to raise the natural frequency to an easily attenuated level.

Construct the plenums to have the following minimum widths:

a. 150 millimeter 6 inches for mounting temperature controls and to separate two or more coils of different size, and mounted in series

b. 350 millimeter 14 inches between face and bypass dampers and upstream accessories, and at changes of cross section

c. 600 millimeter 24 inches for access sections

Where the cabinet size accommodates personnel access, strengthen the cabinet floor to permit entry without damage to components. [Locate a pushbutton station to stop the supply fan inside the cabinet where indicated.]Provide access doors as large as the space can accommodate in each section of the cabinet. Ensure that doors swing so that fan suction or pressure holds the door in the closed position.

Fabricate the enclosure from a [mill-galvanized] [or] [primed and painted carbon steel] sheet. Ensure that the mill-galvanized sheet metal conforms to ASTM A653/A653M and is coated with at least 380 gram per square meter 1.25 ounces of zinc per square foot of the two-sided surface. Use [hot-dipped galvanized] [or] [primed and painted] mill-rolled structural steel. Ensure that edges, burns, and scratches in galvanized surfaces have been protected from corrosion.

Interior surfaces of cabinets constructed of mill-galvanized steel do not require further protection. [Leave unpainted][Prepare the interior surfaces by a phosphatizing treatment and paint the surfaces with two coats of the manufacturer's standard enamel finish in a color selected by the Contracting Officer]. Ensure that exterior surfaces of cabinets are constructed of mill-galvanized steel.

Acoustically and thermally insulate each section at the factory with at least [50] millimeter [2] inch [_____]-thick fibrous glass insulation material conforming to ASTM C1071, Type I. Enclose insulation by using double-walled construction on panels and doors.

2.3.1.4 Drain Pans

Provide an intermediate coil, 75 millimeter 3 inch deep drip pans for each tiered coil bank. Extend the top pan 300 millimeter 12 inches beyond the face of the coil, and extend the bottom pan at least 600 millimeter 24 inches beyond the face of the coil. Increase the pan extension proportionally when more than two pans are used. Make adequate supports of the same material as the pans, or of hot-dipped galvanized angle iron with isolation at the interface. Ensure that the pan material is 0.76 millimeter 22-gage AISI Type 304 stainless steel with silver-soldered joints. Ensure that the drain opening is 32 millimeter at least 1-1/4 inches wide.

Extend the integral cabinet drain pan under areas where condensate is collected. Ensure that the drain pan is watertight with welded or brazed joints, piped to drain, corrosion-protected in the condensate collection area, and insulated against sweating. Ensure that the minimum thickness for the sheet metal is2 millimeter 14-gage, although 1.6 millimeter 16-gage double drain pan construction is acceptable.

2.3.1.5 Electrical Requirements

****

NOTE: The 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.

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Equip each section with a main power panel and include complete branch circuit protection for every electrical component. Use the main power panel to completely protect the unit from primary single-phasing and overcurrent. Ensure that the manufacturer provided fuses and protective devices have been installed at the factory. Designate components with a code and call-out on a wiring diagram for servicing of the power panel. Provide panel terminal blocks, with the terminals clearly identified for easy connection, for the main power supply and all auxiliary connections.

Ensure access to the main power panel is possible without interrupting the operation of the unit. Provide sufficient access to safely check the voltage and current of each component. Provide separate doors for access to the main power terminal block and the auxiliary terminals. Provide UL-listed components of the main power panel and all control devices. Ensure that power and control devices, including motor starters, relays, timers, fuses, circuit breakers, switches, and other items are in accordance with [Section 26 05 70.00 40 HIGH-VOLTAGE OVERCURRENT PROTECTIVE DEVICES][Section 26 05 71.00 40 LOW-VOLTAGE OVERCURRENT PROTECTIVE DEVICES]. Provide internal wiring with at least[1.6 millimeter No. 14 AWG,105 degree C, 2 millimeter 5/64 inch insulation, appliance] [_____] wire for power wiring, and at least[1 millimeter No. 18 AWG, 105 degree C, 0.8 millimeter 2/64 inch insulation] [_____] wire for control wiring. Wire in accordance with UL and NFPA 70 requirements. Identify each wire at every termination with a wire number that matches the wiring diagram and control schematic. Use preprinted heat-shrink wire sleeves for wire identification. Do not use hand lettering or marking.

Use copper windings for all motors. Equip motors with: heavy-duty ball bearings, internal overload protection, protection against primary single-phasing, and ensure that the motors are UL-listed. Use the size motors recommended by the manufacturer and rated in accordance with the requirements of Section 26 60 13.00 40 LOW-VOLTAGE MOTORS.

Operate equipment on [208] [230] [_____] volt, [single] [3] phase, 60 hertz electrical service.

[2.3.2 Humidifiers

Provide self-contained, atomizing, electrically operated humidifiers conforming to ANSI/AHRI 621 SI ANSI/AHRI 620 I-P.

]2.3.3 Ductwork Components and Accessories

2.3.3.1 Flexible Connectors

Ensure that connectors are UL-listed, 6.1 kilogram per square meter 20 ounce per square foot, fire-retardant, airtight, woven fibrous glass cloth impregnated with chloroprene. Ensure that the clear width, not including the clamping section, is 75 to 125 millimeter 3 to 5 inches.

2.3.3.2 Dampers

Conform damper construction to ASHRAE HVAC APP SI HDBK, ASHRAE EQUIP SI HDBK, and SMACNA 1966, unless otherwise specified.

Provide balancing dampers that have opposed blade, and that are designed for [manual] [electric motor] [pneumatic] operation.

Ensure that relief dampers are parallel and have multiple blades, adjustable counterweights, and 90-degree limit stops, and the dampers close automatically under no-flow conditions.

Install fire dampers with [electric motor] [pneumatic] operation that have been constructed and labeled in accordance with UL 555. For link loads more than 90 newton 20 pounds, provide UL-approved quartzoid links.

Where required, provide [zoning] [face and bypass] [and] [mixing box] dampers with materials and a finish identical to the unit enclosure. Individual damper blades size are not to exceed 200 millimeter 8 inches in width, or 1189 millimeter 42 inches in length, and no less lighter than 1.2 millimeter thick 18-gage. Ensure that damper shafts rotate in [nylon] [_____] bushings. Ensure that the shafts and all interconnecting damper linkages are [corrosion-resistant steel] [galvanized steel] of the bell crank and have no backlash. Ensure that air leakage around the damper is limited to 1 percent of the design air flow when the damper is in the fully closed position with 6 newton-meter 50 inch-pounds of torque applied by the operator.

Equip manually operated dampers with an indicating quadrant regulator with an externally located locking feature that is easily accessible for adjustment. Where damper rod lengths exceed 750 millimeter 30 inches, provide a quadrant regulator at each end of the damper shaft.

[Ensure that the electric motor operators are split-phase with an oil-immersed gear train, and provide smooth proportional control under the system's normal operating conditions.] [Ensure pneumatic operators close the dampers to the indicated failsafe position. Provide positioners where two or more operators are controlled from the same controller, and where indicated. Mount the positioners directly on the driven device. Ensure that the starting point is adjustable from [10] [_____] to [85] kilopascal [2] [_____] to [12] [_____] psi. Ensure that the operating span is adjustable from [30] [_____] to [95] [_____] kilopascal [5] [_____] to [13] [_____] psi.]

Provide operators for each automatic damper or valve. Ensure that each operator is [full proportioning] [two-position] and provided with a spring return for the normally [closed] [or] [open] position, as indicated, for fire, freeze, or moisture protection on power interruption. Provide proportioning operators with positive positioning devices or indicators. Select or adjust valve and damper operating speeds so that the operators

remain in step with the controller without hunting, regardless of load variations. Ensure that the operators act in sequence with other operators and adjust the control sequence as required for the system operating characteristics.

2.3.3.3 Air-Diffusion Devices

Furnish louvers for installation in exterior walls that are directly connected by duct work to air-handling equipment. Fabricate louver blades from anodized aluminum or galvanized steel sheets. Provide louvers with a frame of galvanized steel or aluminum structural shapes. Provide louvers with a 50 by 50 millimeter 2 by 2 inch mesh, 1.6 millimeter 0.063 inch diameter aluminum wire or 0.08 millimeter 0.031 inch diameter stainless steel wire bird screen. Ensure that the air performance and water penetration ratings conform to AMCA 500-L.

Identify the diffusers, registers, and grilles on the drawings as being listed in latest ADC Standards Manual, or certified as having been tested and rated in accordance with ADC Standards Manual.

Construct and mount devices to prevent flutter, rattle, or vibration. Provide gaskets for terminal supply air devices mounted in finished surfaces.

[Ensure that the color selection [matches the architectural background] [is from the manufacturer's standard color chips.]

] a. Round Ceiling Diffusers

Provide a round, [adjustable pattern,] stamped or spun multicore diffuser to discharge air in a 360-degree pattern, with sectorizing baffles where indicated. Project a diffuser collar [not more than 25 millimeter one inch] above the ceiling face and connect the collar to the duct with a duct ring. [In plaster ceilings, provide a plaster ring and ceiling plaque.] Provide steel diffusers with a factory-applied baked-enamel [off-white] [_____] finish. Provide a [radial opposed-blade] [butterfly] [combination splitter] damper and multi-louvered equalizing grid with a damper that is adjustable from the diffuser face.

b. Rectangular Ceiling Diffusers

Provide a rectangle, [adjustable-pattern,] stamped multicore diffuser to discharge air in a360-degree pattern with sectorizing baffles where indicated. Provide a [surface-mounted] [snap-in] [inverted T-bar] [spline] frame. [In plaster ceilings, provide a plaster frame and ceiling frame.] Provide steel diffusers with a factory-applied baked-enamel [off-white] [_____] finish. Provide a [radial opposed-blade] [butterfly] [combination splitter] damper and multi-louvered equalizing grid with a damper adjustable from diffuser face.

c. Perforated Face Ceiling Diffusers

Provide a perforated face diffuser with a fully adjustable pattern and removable face. Provide a [surface-mounted] [snap-in] [inverted T-bar] [spline] frame. [In plaster ceilings, provide a plaster frame and ceiling frame.] Provide steel diffusers with a steel or aluminum frame and factory-applied baked-enamel [off-white] [_____] finish. Provide a [radial opposed-blade] [butterfly] [combination splitter] damper and multi-louvered equalizing grid with a damper that is adjustable from the

diffuser face.

d. Modified Light Troffer Diffusers

Provide a [single][double] plenum that is constructed independent of light troffers with volume and pattern controllers,and has a [100] [125] [150] millimeter [4] [5] [6] inch round or oval [top] [side] air inlet. Match the diffusers to the light troffers and make an airtight connection without using tools. Provide galvanized steel diffusers with welded or soldered joints and with a matte black finish inside.

e. Ceiling Supply Registers/Grilles

Provide streamlined and individually adjustable curved blades to discharge air along the face of the grille, with [one-way] [two-way] deflection. Fabricate a [25] [32] millimeter [1] [1-1/4] inch margin frame with [countersunk screw] [concealed] mounting and gasket. Provide aluminum extrusions with a factory-applied [clear lacquer] [prime coat] [_____] finish. Provide an integral, gang-operated opposed-blade damper with a removable key operator, operable from the face of the damper.

f. Ceiling Exhaust and Return Registers/Grilles

Provide streamlined blades, with a blade depth of more than 20 millimeter 3/4 inch, with a spring or other device to set the blades, and a [vertical] [horizontal] face. Fabricate a [25] [32] millimeter [1] [1-1/4] inch margin frame with a [countersunk screw] [concealed] mounting. Fabricate a steel frame with a 1.0 millimeter 20-gage minimum thickness, and blades with a 0.76 millimeter 22-gage minimum thickness, a steel and aluminum frame or aluminum extrusions with a 1.0 millimeter 20-gage minimum thickness, with a factory-applied [baked-enamel] [prime-coated] [clear lacquer] [_____] finish. Where not individually connected to the exhaust, provide an integral, gang-operated opposed blade damper with a removable key operator, operable from the face of the damper. In gymnasiums, install front pivot blades, welded in place or securely fastened so that the blades are immobile.

g. Ceiling Grid Core Exhaust and Return Registers/Grilles

Provide fixed grilles that have 13 by 13 by 13 millimeter 1/2 by 1/2 by 1/2 inch louvers. Fabricate an aluminum [25] [32] millimeter [1] [1-1/4] inch margin frame with [countersunk screw mounting.] [concealed mounting.] [lay-in frame for suspended grid ceilings.] Provide a factory-applied [clear lacquer] [baked-enamel] finish. Where not individually connected to exhaust fans, provide an integral, gang-operated opposed-blade damper with a removable key operator, operable from the face of the damper.

h. Ceiling Linear Exhaust and Return Grilles

Provide streamlined blades that have a 90-degree [one-way] [two-way] deflection, 3 by 20 millimeter 1/8 by 3/4 inch on [7] [13] millimeter [1/4] [1/2] inch centers. Fabricate a [25] [32] millimeter [1] [1-1/4] inch margin frame [extra heavy for floor mounting,] with a [countersunk screw] [concealed] mounting. Fabricate a steel frame with a 1.0 millimeter 20-gage minimum thickness and blades with a0.76 millimeter 22-gage minimum thickness, a steel and aluminum frame or aluminum extrusions with a 1.0 millimeter 20-gage minimum thickness, with a factory-applied [baked-enamel] [prime-coated] [clear lacquer] [_____] finish. Where not individually connected to exhaust fans, provide an integral, gang-operated

opposed blade damper with a removable key operator, operable from the face of the damper.

i. Ceiling Slot Diffusers

Provide a continuous [13] [20] [25] millimeter [1/2] [3/4] [1] inch wide slot, [one] [two] [three] [four] slots wide, with adjustable vanes for left, right, or vertical discharge. Fabricate diffusers of aluminum extrusions with a factory-applied [clear lacquer] [baked-enamel] [_____] finish. Fabricate a [25] [32] millimeter [1] [1-1/4] inch margin frame with [countersunk screw] [concealed] [support clips for suspension system] [support clips for T-bar] mounting and gasket, [mitered end border.] [open end construction.] [end cap.]

j. Wall Supply Registers/Grilles

Provide streamlined and individually adjustable blades, with a blade depth and spacing of more than 20 millimeter 3/4 inch, with a spring or other device to set the blades, a [vertical] [horizontal] face, and [single] [double] deflection. Fabricate a [25] [32] millimeter [1] [1-1/4] inch [_____] margin frame with a [countersunk screw] [concealed] mounting and gasket. Fabricate a steel frame with a 1.0 millimeter 20-gage minimum thickness and blades with a 0.76 millimeter 22-gage minimum thickness, a steel and aluminum frame or extrusions with a 1.0 millimeter 20-gage minimum thickness, with a factory-applied [baked-enamel] [prime coat] [clear lacquer] [_____] finish. Provide an integral, gang-operated opposed-blade damper with a removable key operator, operable from the face of the damper. In gymnasiums, supply front pivot blades, welded in place or securely fastened so that the blades are immobile.

k. Wall Supply Registers/Grilles

Provide streamlined and individually adjustable curved blades to discharge air along the face of the grille, with a [one-way] [two-way] deflection. Fabricate a frame with [25] [32] millimeter [1] [1-1/4] inch [_____] margin thickness with a [countersunk screw] [concealed] mounting and gasket. Provide aluminum extrusions with a factory-applied [clear lacquer] [prime coat] [_____] finish. Provide an integral, gang-operated opposed-blade dampers with a removable key operator, operable from the face of the damper.

l. Wall Exhaust and Return Registers/Grilles

Provide streamlined blades, with a blade depth and spacing of more than 20 millimeter 3/4 inch, with a spring or other device to set the blades, and a [vertical] [horizontal] face. Fabricate a [25] [32] millimeter [1] [1-1/4] inch [_____] margin frame with a [countersunk screw] [concealed] mounting. Fabricate a steel frame with a 1.0 millimeter 20-gage minimum thickness, and blades with a 0.76 millimeter 22-gage minimum thickness, a steel and aluminum frame or aluminum extrusions with a 1.0 millimeter 20-gage minimum thickness, with a factory-applied [baked-enamel] [prime-coated] [clear lacquer] [_____] finish. Where not individually connected to exhaust fans, provide an integral, gang-operated opposed-blade damper with a removable key operator, operable from the face of the damper.

m. Wall Grid Core Exhaust and Return Registers/Grilles

Provide fixed grilles with 13 by 13 by 13 millimeter 1/2 by 1/2 by 1/2 inch

louvers. Fabricate [25] [32] millimeter [1] [1-1/4] inch [_____] frame with a [countersunk screw mounting.] [concealed mounting.] [lay-in frame for suspended-grid ceilings.] Fabricate of aluminum with a factory-applied [clear lacquer] [baked-enamel] finish. Where not individually connected to exhaust fans, provide an integral, gang-operated opposed-blade damper with a removable key operator, operable from the face of the damper.

n. Linear Wall Registers/Grilles

Provide streamlined blades with a [0] [15] degree deflection, 3 by 20 millimeter 1/8 by 3/4 inch on [7] [13] millimeter [1/4] [1/2] inch centers. Fabricate of aluminum extrusions, with a factory-applied [clear lacquer] [prime coat] [_____] finish. Fabricate a [25] [32] millimeter [1] [1-1/4] inch [_____] frame that has a [countersunk screw] [concealed] mounting and that is gasketed. Provide an integral [gang-operated opposed-blade] [hinged single-blade] damper with a removable key operator, operable from the face of the damper.

o. Linear Floor Supply Registers/Grilles

Provide streamlined blades with a [0] [15] degree deflection, 3 by 20 millimeter 1/8 by 3/4 inch on [7] [13] millimeter [1/4] [1/2] inch centers. Fabricate of aluminum extrusions with a factory-applied clear lacquer finish. Fabricate a heavy frame with a [25] [32] millimeter [1] [1-1/4] inch [_____] margin and a [countersunk screw mounting] [concealed mounting and gasket] [, and mounting frame.] Provide an integral [gang-operated opposed-blade] [hinged single-blade] damper with a removable key operator, operable from the face of the damper.

p. Floor Supply Registers/Grilles

Provide individually adjustable blades with a wide stamped border, and a single or double-blade damper with a set screw adjustment. Fabricate of welded steel, with a factory-applied baked-enamel finish.

q. Door Grilles

Provide V-shaped louvers of 1.0 millimeter 20-gage steel, 25 millimeter 1 inch deep on 13 millimeter 1/2 inch centers. Provide a 1.0 millimeter 20-gage steel frame with an auxiliary frame to give a finished appearance on both sides of the door, and a factory-applied prime coat finish.

2.3.3.4 Duct Hangers

Ensure that duct hangers and mill-rolled steel that are in contact with galvanized surfaces are made of galvanized steel or painted with inorganic zinc.

2.3.4 Filters

Rate air filters in accordance with UL 900. Ensure high-efficiency particulate air filters have a 99.97 percent efficiency rating by the DOP Test method and meet the requirements of UL 586.

[Provide air filter gages or manometers for each filter assembly. Ensure that gages have dial indicators and are least 98 millimeter 3-7/8 inches in diameter, with white dials and black figures, and graduated to read 0 to 500 pascal 0 to 2 inches wg. Ensure that they have a minimum range of

250 pascal 1 inch wg beyond the specified final resistance for the filter banks on which they are applied. Ensure that each gage incorporates a screw-operated zero adjustment, and is furnished complete with two static-pressure taps with integral compression fittings, two molded-plastic vent valves, two 1.5 meter 5 foot minimum lengths of 6 millimeter 1/4 inch diameter [aluminum] [vinyl] tubing, and all hardware and accessories required for gage mounting.

]2.3.4.1 Replaceable Type

Provide sectional disposable filters that are [25] [50] millimeter [1][2] inch thick panels with throwaway frames and media, that have the standard dust-holding capacity, and that have 1.5 meter per second 350 feet per minute (fpm) maximum face velocity.[Provide a stiffener bar for additional support.]

2.3.4.2 High-Efficiency Particulate Air (HEPA)

Individually test HEPA filters certified to have an efficiency of at least [99.97] percent and in accordance with ISO 14644-1, and ISO 14644-2. Ensure that the clean air static-pressure drop does not exceed [125] [250] pascal [0.5] [1] inch wg when operating at a rated air capacity of 21 degrees C 70 degrees F.

Cement the interlocking, dovetailed, molded neoprene rubber gaskets of 5 to 10 durometers to the perimeter of the [upstream] [downstream] face of the filter frame. Use self-extinguishing rubber base adhesive sealer. Assemble the filter frame with[20 millimeter 3/4 inch thick exterior grade fire-retardant plywood] [cadmium-plated steel] [galvanized steel] in a rigid manner. Ensure that the overall frame dimensions are correct to 1.5 millimeter 1/16 inch, and maintain squareness to within 3 millimeter 1/8 inch. Secure the filter with spring-loaded fasteners or other devices. Ensure that the air capacity and depth of the filter are as indicated. Install each filter in a factory-assembled side access housing, or in a sectional supporting frame as indicated.

2.3.5 Pipes, Valves and Specialties

Use carbon steel piping for all purposes with the exception of drain piping; polyvinyl chloride (PVC) piping may be used for drain piping.

2.3.5.1 Pipe

a. Insulation

Construct a pipe insulation system with a mineral fiber vapor barrier jacket as specified herein, with the exception that a cellular elastomer system may be used on cold water and condensate drain piping.

b. Carbon Steel

For piping, DN50 2 inches (nominal o.d.) and under, use Schedule 40 carbon steel conforming to ASTM A53/A53M. For pipe DN65 2-1/2 inches and larger, use seamless or electric resistance welded carbon steel conforming to ASTM A53/A53M, Type E, Grade B, or Type S, Grade B.

Provide 1050 kilopascal 150 psi flanges of forged steel conforming to ASTM A694/A694M and ASME B16.5.

Ensure fittings DN50 2 inches and smaller are 1050 kilopascal 150 psi, screwed, malleable iron conforming to ASTM A197/A197M, ASTM A234/A234M and ASME B16.3. Fittings DN65 2-1/2 inches and larger are steel conforming to ASTM A234/A234M, and ASME B16.9.

Ensure unions DN50 2 inches and under are 1750 kilopascal 250 psi, female, screwed, malleable iron with brass-to-iron seat and ground joints.

c. Polyvinylchloride (PVC) Pipe

Use Schedule 40 PVC pipe, conforming to ASTM D1785.

Provide socket type, Schedule 40 fittings, made of PVC material conforming to ASTM D2466.

Use solvent cement for pipe and fittings conforming to ASTM D2564. Ensure that the thread lubricant meets the recommendations of the manufacturer of pipe and fittings.

2.3.5.2 Valves and Specialties

Provide bronze valve bodies for valves that are DN50 2 inch iron pipe size (ips) and smaller, with screwed end connections. For valve bodies, DN65 2-1/2 inch ips and larger, use cast iron with flanged end connections.

Ensure valves are single-seated for dead-end service except where otherwise indicated or specified.

Provide control valves for converters, cooling coils, reheat coils, preheat coils, and heating coils, and miscellaneous control valves with a [two] [or] [three]-way pattern of the [modulating] [or] [two-position] type as required for the sequence specified. Ensure that valve bodies are rated at 850 kilopascal 125 psi minimum for [hot] [chilled] water service. [Provide valves for modulating service with a contoured plug with removable discs, matched to the characteristics of the coil for effective control. Provide valves with a valve stem travel indicator or other means of indicating the position of the valve.]Ensure that valve stem packing is spring-loaded, and self-adjusting, and constructed with tetrafluoroethylene.

Provide drain, vent, and gage cocks that are ground key type with a T-head or lever handle and a washer and screw, are constructed of polished ASTM B62 bronze, and are rated at 850 kilopascal 125 psi working steam pressure (wsp). Ensure that end connections suit the service, with or without union and nipple, as required.

Provide bronze strainers conforming to ASTM B62, or cast iron strainers conforming to ASTM A278/A278M, Class 30, with removable basket. Fit strainers larger than DN50 2-inches with the manufacturer's standard ball blow down valve.

2.3.5.3 Thermometers and Pressure Gages

Provide dial thermometers with a diameter of at least 75 millimeter 3 inches in a corrosion protected case, with a remote or direct bulb as required, plus or minus 0.5 degrees C 1 degree F accuracy, and a white face with black digits graduated in 1 degrees C 2 degree F increments. Provide separable socket thermometer wells for each thermometer with a direct type bulb.

Provide pressure gages with 90 millimeter 3-1/2 inches nominal diameter, and equip the gages with gage isolators. Provide a corrosion-resistant steel casing. Equip gages with a damper screw adjustment in the inlet connection, and ensure that the gages have a service rating at the midpoint of the gage range.

2.3.6 Vibration Isolation Provisions

Provide equipment vibration isolation as [recommended by the equipment manufacturer.] [a closed-spring mount with top and bottom housing separated with neoprene rubber stabilizers.] [an open-spring mount with stiff springs (horizontal stiffness equal to vertical stiffness.)] [an open-spring mount with springs, heavy mounting frame, and limit stop.] [a closed-spring mount with stiff springs and limit stop.] [a closed-spring hanger with acoustic washer.] [a closed-spring hanger with 25 millimeter one inch thick acoustic isolator.] [an elastomer mount with threaded insert and hold-down holes.] [neoprene jacketed precompressed molded glass fiber.] [rubber waffle pads, 30 durometer, at least 13 millimeter 1/2 inch thick, with a maximum loading of 275 kilopascal 40 psi. Use neoprene in oil or exterior locations.][Ensure that 13 millimeter 1/2 inch thick rubber waffle pads are bonded to each side of a 6 millimeter 1/4 inch thick steel plate.]

Ensure that rubber is natural rubber. Use chloroprene as the elastomer. Ensure that a Shore A durometer measurement of both materials ranges between 40 and 60.

Inorganic materials such as precompressed, high-density, fibrous glass encased in a resilient moisture-impervious membrane are acceptable in place of natural rubber and elastomers.

2.3.7 Controls and Instrumentation

Provide the required sequence of operation control for temperature, air flow, and humidity using automatic controls that are [electric,] [electronic,] [solid state electronic,] [pneumatic], [or a combination thereof]. Ensure that electrical signals are in the [0-5Vdc] [4-20mA] [_____] range, and pneumatic signals are in the [20-110] [_____] kilopascal [3-15] [_____] psig range.

Provide a [low-voltage] [proportioning] [two-position] space thermostat with Fan Auto-Off and Heat-Off-Cool settings for heating and cooling temperature control. Ensure that thermostats can fully control a temperature change of plus or minus 0.5 degrees C 1 degree F of the thermostat setting. Thermostat locations are as indicated. Ensure that thermostats conform to the requirements in ASHRAE 90.1 - SIASHRAE 90.1 - IP.

Provide duct humidistats of the insertion, proportioning type, that are reverse-acting with an adjustable minimum throttling range of no greater than 2 percent relative humidity. Ensure that the humidistat can maintain relative humidity within this range for a relative humidity of 20 to 80 percent and temperatures to 66 degrees C 150 degrees F.

Construct the unit control panels of [steel not lighter than 1.6 millimeter 16-gage] [aluminum not lighter than 2.8 millimeter 12-gage] and ensure that they conform to NEMA ICS 6, Type 12. Ensure the panel includes remote pushbutton stations protective devices, gages, and other control devices that are not normally furnished with the equipment. Ensure that

the electric wiring consists of insulated conductors installed in raceways. Identify the instruments on the panel by a plastic or metal nameplate attached to, or integral with, the panel, and with engraved or cut lettering in a color that contrasts with the color of the plate. Do not paint lettering directly on the plate or panel. Install piping, wiring, and terminals, within the cabinet control instruments; however switches, pilot lights, and pushbuttons may be mounted on the cabinet doors. Equip the doors with piano hinges, latches, and locks.

PART 3 EXECUTION

3.1 INSTALLATION

Submit the manufacturer's instructions for installation of chilled-water air-conditioning systems, showing the manufacturer's recommended method and sequence of installation.

Install equipment in accordance with the manufacturer's printed instructions and recommendations.

Provide dimensional details on design drawings; however, exact locations of mechanical equipment, ducts, and piping are not necessary. Provide and install materials, including offsets, bends, elbows, or other elements that may be required for the work, subject to approval by the Contracting Officer.

Securely attach [brass][aluminum][_____] identification tags to major equipment components. ensure that the ID tags carry the manufacturer's name and address, equipment type or style, catalog number or model, and serial number.

Tie-in to the existing hot water and chilled-water piping where indicated. Notify the Contracting Officer [5] [_____] days before tying into the system.

3.1.1 Ductwork

Ensure that the duct strength is sufficient to prevent distortion under pressure or a vacuum created by fast closure of ductwork devices. Secure ducts to the building. Support the ducts to prevent vibration and pulsation under operating conditions.

For metal duct sizes through 300 millimeter 12 inches, use either Pittsburgh lock or button punch snap lock corner seams, unless the duct manual indicates that a Pittsburgh lock should be used. For duct sizes 325 millimeter 13 inches and larger, use only Pittsburgh corner locks. Use an Acme lock for sheet joining where sheets are not cross-broken.

Gasket the flanged joints with chloroprene full-face gaskets.

Install the turning vanes at 90 degree elbows. Use short-radius elbows with a radius of 1.0 times the duct width or diameter, or use square elbows with factory-fabricated turning vanes where space does not permit installation of standard elbows.

Where the size or shape of a duct changes, do not exceed a 15-degrees transition from the straight run of the duct connection.

Provide splitter, butterfly, or multi-louver balancing dampers where

indicated to balance each respective main and branch duct. Install control dampers under the supervision of the automatic temperature control manufacturer or an authorized agent. Provide blank-off plates or transitions required to install the dampers in the duct system as part of the ductwork.

Connect fan inlets and outlets to upstream and downstream components by treated woven-cloth flexible connectors. Install the connectors only after system fans are operative and vibration isolators have been adjusted.

Isolate duct supports from structure vibration. If any duct support device vibrates after system startup or could cause a component to fail or damage to ducting, replace the device or alleviate the condition, at no added cost to the Government.

3.1.1.1 Metal Ductwork

Install sheet metal ductwork in accordance with ASHRAE HVAC APP SI HDBK, ASHRAE EQUIP SI HDBK, and SMACNA 1966, NFPA 90A, and as indicated.

Enclose dampers located behind architectural intake or exhaust louvers by a rigid sheet metal collar, which is sealed to the building construction with elastomers for complete air tightness.

Provide outside air intake ducts and plenums made of sheet metal with soldered watertight joints.

Provide access doors in ductwork at air flow measuring primaries, automatic dampers, fire dampers, fire doors, coils, thermostats, and other apparatus requiring service or inspection in the duct system. Construct airtight doors in accordance with ASHRAE HVAC APP SI HDBK, ASHRAE EQUIP SI HDBK, and SMACNA 1966.

Do not use friction rod assemblies and perforated strap hangers.

3.1.1.2 Fibrous Glass Ductwork

Install fibrous glass ductwork in accordance with SMACNA 1884, NFPA 90A, and manufacturer's instructions.

Ensure that rectangular ducts are at least 25 millimeter 1 inch thick. Install duct reinforcement in accordance with SMACNA 1884.

Coat cut-ends and edges of ducts that are joined in the field with a mastic or cement to prevent delamination or erosion. Ensure that longitudinal joints appear as straight lines.

Make control rods and similar shaft penetrations through the sheet metal reinforcements on both sides of the duct.

Support rectangular ducts either from joint reinforcement or by trapeze hangers installed to prevent the edges of the duct from being cut.

Provide internal metal reinforcement for fibrous glass duct around the entire duct perimeter at points of access, and frame the openings with sheet metal.

3.1.1.3 Flexible Ductwork

Ensure flexible duct runouts are no longer than necessary for the application, [_____] meter[_____] feet maximum, and fully extend when installed.

Join and attach flexible duct in accordance with ASHRAE HVAC APP SI HDBK, ASHRAE EQUIP SI HDBK, and SMACNA 1966.

3.1.1.4 Air-Diffusion Devices

Install wall-mounted supply registers 150 millimeter 6 inches below ceiling.

Install wall-mounted return registers 150 millimeter 6 inches above the finished floor.

For registers and grilles installed on vertical surfaces, provide horizontal face bars set downward at approximately 35 degrees from vertical.

For registers and grilles installed in horizontal surfaces, provide face bars set straight and parallel to the short dimension.

Where an air-diffusion device is shown as being installed on the side, top, or bottom of a duct, and whenever a branch takeoff is not of the splitter type, construct radius tap-ins in accordance with ASHRAE HVAC APP SI HDBK, ASHRAE EQUIP SI HDBK, and SMACNA 1966.

3.1.2 Pipe

Ensure support elements conform to requirements of MSS SP-58 except as otherwise noted herein. Do not use C-clamps. Label piping, including that which is painted, insulated, or concealed in accessible spaces, to designate service and flow direction.

Electrically isolate connections between steel and copper piping from each other with dielectric couplings (or unions), or flanged with gaskets rated for the service.

Make final connections to equipment with unions or flanges.

Provide sleeves where piping passes through roofs and masonry or concrete walls and floors. Caulk sleeves to make sleeves watertight.

Install PVC piping as indicated and in accordance with the manufacturer's instructions. Thread or apply solvent to the cement joints in accordance with ASTM D2855.

For drain piping, include a P-trap in the line.

3.1.3 Insulation

Do not apply insulation to system or component surfaces until the system has been tested and approved.

Apply materials in accordance with the recommendations of the manufacturer, except as otherwise specified.

Ensure the surfaces are clean and free of oil and grease before insulation adhesives or mastics are applied.

Ensure the contours of exposed work are smooth and continuous. Apply adhesives for full coverage.

3.1.3.1 Acoustic Duct Lining System

Apply acoustic duct lining in cut-to-size pieces attached to the interior of ductwork with a fire-resistant adhesive conforming to ASTM C916 and SAE AMS 3779, Class 2. Have the top and bottom pieces lap the side pieces and, in addition, secure with pins and speed washers or cup head pins 300 millimeter 12 inches on center, maximum, and within 50 millimeter 2 inches of each edge. Install pins and washers flush with the surface of the duct liner. Seal all breaks and punctures of the liner with fire-resistant adhesive. With adhesive, heavily brush-coat the exposed edges of the coated liner, and at joints where the lining is subject to erosion, and where necessary, with the metal nosing to prevent delamination of the glass fibers. A duct liner may also be applied to flat sheet metal with fire-resistant adhesive before forming the duct through the sheet metal brake. At the top and bottom surfaces of the duct, secure the lining by pins or adhere clips as specified for cut-to-size lining.

3.1.3.2 Mineral Fiber with Glass Cloth Jacket

Cover the piping with a mineral fiber, pipe insulation with factory-attached, presized, white glass cloth. Securely cement the jackets, jacket laps, flaps, and bands in place with a vapor barrier adhesive. Ensure that the jacket overlap is at least 40 millimeter 1-1/2 inches. Ensure that the jacketing bands for butt joints are 75 millimeter 3 inches wide.

Cover the exposed fittings with preformed mineral fiber, fitting insulation of the same thickness as the pipe insulation and temporarily secure the insulation in place with light cord ties. Install impregnated glass lagging tape with an indoor vapor barrier so that the tape overlaps by 50 percent, and blend the tape smoothly into the adjacent jacketing. Apply additional coating as needed, and using rubber gloves, make a a smooth contour. Tape the ends of the insulation to the pipe at valves that are DN50 2 inches in diameter or smaller. Use insulation that is fabricated on the job for concealed fittings, and build up special configurations from mineral fiber combined with insulating cement mixed with lagging adhesive, and diluted with 3-parts water. Finish the surfaces with glass cloth or tape lagging.

Cover with preformed insulation, DN65 2-1/2 inches and larger, and ensure that all flanges are the same thickness as the adjacent insulation.

Finish the exposed insulation with a nonvapor barrier that is coating suitable for painting and that has a dry film thickness of at least 0.15 millimeter 6 mil.

3.1.3.3 Cellular Elastomer

Cover refrigerant suction line piping surfaces [and] [condensate drains] [and] [humidifier dispersion piping] with [10] [13] millimeter [3/8] [1/2] inch thick flexible cellular elastomer preformed insulation. Maintain the vapor seal. Cement insulation into continuous material with a solvent cutback chloroprene adhesive applied for 100 percent coverage to both

surfaces.

Seal the insulation on cold water piping to the pipe for a minimum of 150 millimeter 6 inches at maximum intervals of 3.5 meter 12 feet to form an effective vapor barrier. Provide continuous insulation through pipe supports and protect against compression damage by load-bearing inserts at supports.

[Finish surfaces exposed to view or ultraviolet light with at least 2 coats of a polyvinyl chloride lacquer with a 0.051 millimeter 2 mil minimum dry film thickness.

]3.1.3.4 Flexible Mineral Fiber with Jacket

If sheet metal ducts are not lined internally with duct lining, cover the ducts with acoustic duct lining with flexible mineral fiber duct insulation with a factory-attached vapor barrier jacket. Maintain the vapor seal. Ensure that the jacket overlap is at least 50 millimeter 2 inches.

[Cement insulation to sheet metal surfaces with vapor barrier adhesive.

] Secure to the duct surface, the insulation on rectangular or square ducting when side or bottom surface dimensions are over 750 millimeter 30 inches impaled on pins and then locked by means of flush pin caps. Clip the pins flush with the face of the cap. Install pins 300 millimeter 12 inches on center, placed not more than 50 millimeter 2 inches from the duct edges, and have at least 2 rows of pins per surface. Seal the pins with an outdoor vapor barrier coating and vapor barrier duct tape.

When insulation is in place, do not reduce the total thickness by more than 13 millimeter 0.5 inches, and ensure that no condensation appears on the surface while the system is operating.

Securely cement the jackets, jacket flaps, and bands in place with a vapor barrier adhesive. Ensure that the jacketing bands for butt joints are at least 100 millimeter 4 inches wide. Instead of the jacketing bands, a pressure-sensitive vapor barrier tape at least 75 millimeter 3 inches wide may be used to seal horizontal and transverse seams.

[Use a rigid board mineral fiber insulation where penetrations occur through sleeves or prepared openings.

] Ensure that the duct insulation at fire dampers is as indicated.

Apply an outdoor vapor-barrier coating to seal the duct insulation terminating at insulated or uninsulated equipment surfaces, supports, damper fittings, walls and similar penetration construction points. Where lengths exceed 600 millimeter 24 inches, flash with glass cloth tape and sheet metal trimming. Apply two layers of glass cloth tape with at least 75 millimeter 3 inches of overlap. Imbed the tape in 1.5 millimeter 1/16 inch minimum dry film thickness of outdoor vapor barrier coating.

3.1.4 Vibration Isolation

Vibration-isolate the air-handling unit from the building structure by using vibration isolators, and from the connecting ductwork by using flexible connectors. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT if the design may induce

vibration considerations.

3.1.5 Controls and Instrumentation

3.1.5.1 Tubing

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

Use hard-drawn copper tubing in all exposed areas. Where concealed, use either hard-drawn or annealed tubing. Cut tubing square, remove burrs, and clean surfaces before assembly of joints. Pressure test copper joints in accordance with paragraph BALANCE AND LEAKAGE TESTS. Remake copper joints that fail pressure tests with new materials, including pipe or tubing fittings and filler metal.

Use hard-drawn copper tubing for terminal single lines, unless the run is less than 300 millimeter 12 inches, in which case plastic tubing may be used.

In mechanical rooms or other spaces where copper tubing is exposed run plastic tubing within an adequately supported metal raceway or within metallic or plastic electric conduit.

3.1.5.2 Control Indicating Devices

Provide each controller, except space thermostats and space humidity controllers, with a permanent indicating device at the controller to indicate the exact point at which the controller is operating. Ensure that the indicating device has an adjustable setpoint. For individually mounted controllers, permanently mount the indicating device. For controllers mounted on a central panel, provide [individual permanently mounted devices] [or] [a single indicating device having a suitable means for switching so that the device can be connected to any controller on the panel].

3.1.5.3 Thermostats

Enclose space thermostats with separate locking covers (guards) and mount 1500 millimeter the thermostats 60 inches above the floor.[Provide thermostats with heating and cooling anticipation that can maintain the conditions desired in the space.]

Provide remote immersion or outdoor thermostats that measure air temperature in the duct, with the setpoint and throttling range adjusting mechanism mounted in a metal or approved plastic case outside the duct or pipe. Ensure that the secure sensing element in the controlled medium flow stream can respond to the overall temperature within the duct or pipe. Provide the outdoor compensating thermostat sensing element with a protective metal shield or weatherproof housing, and is secured where indicated. Mount the controller mechanism indoors where indicated. Ensure that reset ratios of the indoor-outdoor compensating thermostat are as indicated.

3.1.5.4 Humidistats

Mount reverse-acting, proportioning, humidistats [on the outside of the duct, with the sensing element within the duct] [as indicated], with the adjustable minimum throttling range no greater than 2 percent relative

humidity. Ensure that the humidistats can maintain relative humidity within the limits of the throttling range for a relative humidity of [20] [_____] to [80] [_____] percent and temperatures to [43] [_____] degrees C [110] [_____] degrees F. [Ensure that the sensing element is suitable for the installation location.]

3.1.5.5 Unit Control Panels

[Flush-mount] [or] [back-mount] instruments. Wire instruments to the identified terminal strips. Install piping and wiring on the rear of the panel. Ensure that electric wiring consists of insulated conductors installed in raceways.

3.1.5.6 Controls

Make provisions for the following: starting and stopping equipment, [precision temperature indication,] [temperature check, with a momentary contact spring return,] [humidity check, with a momentary contact spring return,] [temperature reset and remote adjustment,] [pressure indication and control,] [equipment adjustment control,] recorders, and a [flow meter,] [light canopy,] clock, improper-operating-condition alarm system, and scanning.

Provide front-removable pilot lights for each piece of motor-driven equipment, and provide a single switch to simultaneously check all pilot lights for burnout.

For pneumatic systems, 150 millimeter provide 6 inch dial gages or other devices instead of pushbuttons or momentary contact indicators of temperature, pressure, or humidity.

Provide temperature checkpoints[where indicated].

Provide temperature reset points[where indicated].

Provide start-stop switches and pilot lights[where indicated].

Provide alarm and status indicators[where indicated] by: [lights] [audible alarm] [printout] [_____].

3.2 FIELD QUALITY CONTROL

3.2.1 Balance and Leakage Tests

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NOTE: Variable pitch sheaves should only be used for system balance and adjustment. After balance is determined, replace the variable pitch sheaves with fixed sheaves.
****

Test and balance the entire air-handling and distribution system in accordance with NEBB PROCEDURAL STANDARDS to provide the specified quantities of air, plus or minus 10 percent, and to ensure that each piece of equipment and each system operates in accordance with the manufacturer's instructions.

Test the duct systems and piping in the presence of the Contracting Officer before surfaces are painted or work is concealed. Perform

hydrostatic water system tests, using potable water supplied by the Government. Provide for disposal of contaminated water.

Structurally test the duct systems at static pressures [_____] [50] percent in excess of total fan pressure.

Perform a leakage test at a pressure that is [normal in relation to the portion of system under test] [25 percent higher than normal operating pressure]. The system is acceptable provided [no leakage is audible when the area ambient noise is at a normal-occupancy level,] [no leakage is perceptible to the hand, when placed within 150 millimeter 6 inches of a joint,] [the measured total system leakage does not exceed one half of 1 percent of the total system cubic meter per second cubic feet per minute (cfm) capacity,] [and] [no mechanical defects are visible].

Test fire dampers for proper operation in the presence of the Contracting Officer, by activating the fusible link with localized heat.

3.2.2 Acceptance Tests

Use a FFT analyzer to measure vibration levels with the following characteristics: a dynamic range greater than 70 dB; a minimum 400-line resolution; a frequency response range of 5 Hz to 10 kHz(300 to 600,000 cpm); the capacity to perform ensemble averaging; the capability to use a Hanning window; auto-ranging frequency amplitude; and a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.
Use an accelerometer, either stud-mounted or mounted using a rare-earth, low-mass magnet and sound disk (or finished surface) with the FFT analyzer to collect data. Ensure that the mass of the accelerometer and its mounting have minimal influence on the frequency response of the system over the selected measurement range.

Before final acceptance, use vibration analysis to verify that motors and fans conform to specifications. Vibration levels more than .075 in/sec at 1 times run speed and at pump frequency, and .04 in/sec at other multiples of run speed are not acceptable. Provide vibration data as part of the final test data.

Provide final test reports to the Contracting Officer. Ensure that reports have a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.3 CLOSEOUT ACTIVITIES

3.3.1 Operation and Maintenance

Submit [6] [_____] copies of the operation and maintenance manuals 30 calendar days before testing the system. Update and resubmit data for final approval no later than 30 calendar days before contract completion.

-- End of Section --