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Preparing Activity: NASA Superseding
UFGS-42 22 00.00 40 (May 2011)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2015

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DIVISION 42 - PROCESS HEATING, COOLING, AND DRYING EQUIPMENT

SECTION 42 22 00.00 40

PROCESS CHILLERS AND COOLERS

05/14

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PROCESS CHILLERS AND COOLERS 05/14

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 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS

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 items(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 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 DIFFUSION COUNCIL (ADC)

ADC Standards Manual	(2008; 5th Edition) Flexible Duct Performance Installation Standards
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AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 210	(2007) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2008) Reverberant Room Method for Sound Testing of Fans
AMCA 500-L	(2012) Laboratory Methods of Testing Louvers for Rating
AMCA 99	(2010) Standards Handbook

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	(2009) Central-Station Air-Handling Units
ANSI/AHRI 620	(2004) Performance Rating of Self-Contained Humidifiers for Residential Applications

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; ERTA 2012; S 2013) Load Ratings and Fatigue Life for Ball Bearings

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

ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE EQUIP SI HDBK	(2012) Handbook, HVAC Systems and Equipment (SI Edition)
ASHRAE FUN IP	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2013; Addenda and Corrigendum 2013) Fundamentals Handbook, SI Edition
ASHRAE HVAC APP IP HDBK	(2011) HVAC Applications Handbook, I-P Edition
ASHRAE HVAC APP SI HDBK	(2011) HVAC Applications Handbook, SI Edition

ASME INTERNATIONAL (ASME)

ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A197/A197M	(2000; R 2011) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2013; E 2014) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A278/A278M	(2001; R 2011) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A694/A694M	(2014) Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission Service
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM C1071	(2012) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C534/C534M	(2014) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2012) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C916	(2014) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2466	(2013) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D579	(2010) Standard Specification for Greige Woven Glass Fabrics

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 14644-1	(1999) Cleanrooms and Associated Controlled Environments Part 1: Classification of Air Cleanliness
ISO 14644-2	(2000) Cleanrooms and Associated Controlled Environments Part 2: Specifications for Testing and Monitoring to Prove Continued Compliance with ISO 14644-1
ISO 1940-1	(2003; Cor 2005) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance

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

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2011; Errata 2012) Motors and Generators

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB PROCEDURAL STANDARDS	(2005) Procedural Standards for TAB (Testing, Adjusting and Balancing) Environmental Systems
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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(2015) Standard on Types of Building Construction
NFPA 255	(2006; Errata 2006) Standard Method of Test of Surface Burning Characteristics of Building Materials
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

NFPA 90A (2015) Standard for the Installation of Air Conditioning and Ventilating Systems

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

SMACNA 1884 (2003) Fibrous Glass Duct Construction Standards, 7th Edition

SMACNA 1966 (2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 3779 (1990; Rev A; R 1994) Tape Adhesive, Pressure Sensitive Thermal Radiation Resistant, Aluminum Foil/Glass Cloth

UNDERWRITERS LABORATORIES (UL)

UL 181 (2013) Factory-Made Air Ducts and Air Connectors

UL 1995 (2011) Heating and Cooling Equipment

UL 555 (2006; Reprint May 2014) Standard for Fire Dampers

UL 586 (2009; Reprint Sep 2014) Standard for High-Efficiency Particulate, Air Filter Units

UL 900 (2004; Reprint Feb 2012) Standard for Air Filter Units

1.2 SUBMITTALS

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

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office

(Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. 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

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

Ductwork[; G[, [____]]]

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

Humidifiers[; 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[, [____]]]

Spare Parts Lists[; G[, [____]]]

SD-04 Samples

Color Chip[; G[, [____]]]

SD-06 Test Reports

Equipment and Performance Data[; G[, [____]]]

Pressure[; G[, [____]]]

Leakage Test[; G[, [____]]]

Operation Of Fire Dampers [; G[, [____]]]

Test and Balance[; G[, [____]]]

SD-07 Certificates

Centrifugal Fan[; G[, [____]]]

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

Ductwork[; G[, [____]]]

Air Diffusion Devices[; G[, [____]]]

Filters[; G[, [____]]]

Insulation[; G[, [____]]]

Vibration Isolators[; G[, [____]]]

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

Humidifiers[; G[, [____]]]

Controls and Instrumentation[; G[, [____]]]

SD-08 Manufacturer's Instructions

Manufacturer's Instructions[; G[, [____]]]

SD-10 Operation and Maintenance Data

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

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 size, type, and capacity of the system.

Submit Color Chip samples.

2.1.1.1 Design Requirements

Furnish labor, materials, equipment and services to construct, install, and test an air handling and distribution system utilizing 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

2.1.2 Performance Requirements

Test and balance HVAC system, when properly installed, per NEBB PROCEDURAL STANDARDS to deliver air flows from each supply register within 10 percent of design specification.

Submit equipment and 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

Provide spare parts lists and information for chilled water air conditioning systems, meeting referenced standards within this section.

[2.2.1.1 Galvanized Steel Ductwork Materials

Steel ductwork is hot dip galvanized carbon steel of lock forming quality, with regular spangle type zinc coating conforming to ASTM A653/A653M, G-90. 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 rigid fibrous glass duct system, including tapes, adhesives, vapor barriers and joint sealers, having a minimum density of 80 kilogram per cubic meter 5 pounds per cubic foot, and conforming to requirements of NFPA 90A. Ensure labels have FM approval and UL 181, Class 1 airduct listing. Ensure 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 25 millimeter 1 inch thickness. Use materials that are odorless and non-allergenic when in service. Provide a factory applied vapor barrier, and 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 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 runout does exceed [_____] meter [_____] feet in length and complies with NFPA 90A and UL 181. Working pressure rating of ducting is not less than three times maximum system pressure, and with a temperature range between minus 30 to plus 80 degrees C minus 20 to plus 175 degrees F.

2.2.2.2 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 a published or certified temperature ratings suitable for the range of temperatures normal for the surfaces to which they 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 liner composition with chloroprene on the surface exposed to the airstream and conform to fire hazard requirements of NFPA 90A. Ensure air stream side of the liner is capable of withstanding air velocities of 20 meter per second 4,000 feet per minute without delamination or erosion.

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 does not exceed 10.16 nanogram per pascal second square meter 0.30 perms.

2.2.2.2 Adhesives

Use a nonflammable solvent base, synthetic rubber type fire resistant adhesive for attaching fibrous glass insulation to 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 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 jacketing to not less than 0.025 millimeter 1-mil thick aluminum foil and reinforced with glass fiber. With foil exposed, flame spread rating is [5] [_____] and smoke developed rating of [0] [_____] . With kraft exposed, flame spread rating is [25] [_____] and smoke developed rating of [15] [_____] . 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 glass reinforcing cloth conforms to ASTM D579.

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 type assembly, consisting of a centrifugal fan, fan drive, coils, filters, enclosure, vibration isolators, and appurtenances required for specified operation.

Provide certification the unit complies with provisions of AHRI 430 and UL 1995, as applicable.

2.3.1.1 Centrifugal Fan

NOTE: Fan and Motor balance conforms to ISO 1940-1
- (1986) 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.

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.

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 type, having AMCA 99 Pressure Class [I] [II] [III] rating as required for the design system pressure. Test and rate in accordance with AMCA 210. Standard AMCA arrangement, rotation, discharge, and motor location is as indicated. Statically and dynamically balance fan wheel to ISO 1940-1. Use self aligning [antifriction] [sleeve] type, and [grease] [oil] [permanently] lubricated bearings. Ensure bearings have an L-10 rated life of not less than [30,000] [50,000] [80,000] [_____] hours in accordance with ABMA 9 or ABMA 11.

Fan drive is [direct] [by V-belt], designed for not less than [150] [140] [120] percent of the connected driving capacity. Permanent sheaves are of fixed type. Only use 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 shafts. [Provide adjustable V-belt drives with not less than 20 percent fan speed variation, 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, not exceed 1800 rpm, and have [open] [drip-proof] [totally enclosed] [explosion-proof] enclosures. Provide [manual] [magnetic] [across-the-line] [reduced voltage] motor starters type with [general purpose] [weather resistant] [watertight] enclosure. [Provide remote manual switch with pilot indication light where indicated.] Provide fans with personnel screens or guards on both suction and supply ends, except that, screens are not required where ducts are connected to the fan. Provide fan and motor assemblies with vibration isolation supports or mountings as specified herein.

2.3.1.2 Coils

Ensure coils conform to the provisions of AHRI 410. Provide fin and tube type 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 at not less than 1700 kilopascal 250 psi air pressure. Ensure 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 not lighter than 1.6 millimeter 16-gage galvanized steel, formed to provide structural strength. Provide multiple tube supports when required to prevent tube sag. Enclose cooling coil ends by the cabinet and drained to 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 cabinet does not expand or contract during starting or stopping of fans, and not pulsate during operation. Reinforce cabinet surfaces with deflections in excess of [1/240] [1/360] of unsupported span prior to acceptance. Stiffen the pulsating panels to raise natural frequency to an easily attenuated level.

Construct the plenums to have the following minimum widths:

150 millimeter 6 inches for mounting temperature controls and to

separate two or more coils of different size, and mounted in series

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

600 millimeter 24 inches for access sections

Where cabinet size is such that personnel access is possible, strengthen cabinet floor to permit entry without damage to any component. [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 doors swing so that fan suction or pressure holds door in closed position.

Fabricate the enclosure from [mill galvanized] [or] [primed and painted carbon steel] sheet. Ensure mill galvanized sheet metal conforms to ASTM A653/A653M and coated with not less than 380 gram per square meter 1.25 ounces of zinc per square foot of two sided surface. Use [hot dip galvanized] [or] [primed and painted] mill rolled structural steel. Corrosion protect edges, burns, and scratches in galvanized surfaces.

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

Acoustically and thermally insulate each section at the factory with not less than [50] millimeter [2] inch [_____] thick fibrous glass insulation material conforming to ASTM C1071, Type I. Insulation to be enclosed using double-walled construction of all panels and doors.

2.3.1.4 Drain Pans

Provide intermediate coil, 75 millimeter 3 inch deep drip pans for each tiered coil bank. Extend top pan 300 millimeter 12 inches beyond face of coil, and extend the bottom pan not less than 600 millimeter 24 inches beyond face of coil. Proportion pan extension when more than two pans are used. Make adequate supports of the same type material as the pans, or of hot-dip galvanized angle iron with isolation at interface. Ensure pan material is 0.76 millimeter 22-gage AISI Type 304 stainless steel with silver-soldered joints. Minimum size of drain opening is 32 millimeter 1-1/4 inches.

Extend integral cabinet drain pan under all areas where condensate is collected. Ensure the drain pan is watertight with welded or brazed joints, piped to drain, corrosion protected in the condensate collection area, and insulated against sweating. Minimum thickness for sheet metal is 2 millimeter 14-gage, except that 1.6 millimeter 16-gage double drain pan construction is acceptable.

2.3.1.5 Electrical Requirements

NOTE: Ability to open and/or remove access covers is required for maintenance activities. In addition, access may be required to inspect this device while circuits are energized (for example, using infrared imaging). Minimum distances to

energized circuits is specified in OSHA Standards Part 1910.333 (Electrical - Safety-Related work practices). OSHA Standards are available on the internet.

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 manufacturer provided fuses and protective devices are installed at the factory. Designate components with a code and call out on a wiring diagram for servicing of the power panel. 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 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 and Section 26 05 71.00 40 LOW-VOLTAGE OVERCURRENT PROTECTIVE DEVICES. Provide internal wiring with not less than[1.6 millimeter No. 14 AWG,105 degree C, 2 millimeter 5/64 inch insulation, appliance type] [_____] wire for power wiring, and not less than[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 matching the wiring diagram and control schematic. Utilize preprinted heat-shrink wire sleeves for wire identification. Hand lettering or marking is not acceptable.

For all motors use copper windings. Equip motors with: heavy duty ball bearings, internal overload protection, protection against primary single phasing, and be UL listed. Size motors by the manufacturer and be 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 620.

]2.3.3 Ductwork Components and Accessories

2.3.3.1 Flexible Connectors

Ensure 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. Clear width, not including 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 of the opposed blade type, designed for [manual] [electric motor] [pneumatic] operation.

Relief dampers are parallel, multiblade, adjustable counterweight type, with 90-degree, limit stops, and close automatically under no-flow conditions.

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

Where required, provide [zoning] [face and bypass] [and] [mixing box] dampers with materials and 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 not less lighter than 1.2 millimeter thick 18-gage. Damper shafts rotate in [nylon] [_____] bushings. Shafts and all interconnecting damper linkages are [corrosion resistant steel] [galvanized steel] of the bell crank type having no backlash. Air leakage around the damper is limited to 1 percent of the design air flow when in the full 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 locking feature, externally located and easily accessible for adjustment. Where damper rod lengths exceed 750 millimeter 30 inches, provide a quadrant regulator at each end of the damper shaft.

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

Provide operators for each automatic damper or valve. Each operator is [full proportioning] [two position] type and provided with spring return for normally [closed] [or] [open] position, as indicated, for fire, freeze, or moisture protection on power interruption. Provide all 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 operators acting in sequence with other operators have adjustment of the control sequence as required by the operating characteristics of the system.

2.3.3.3 Air Diffusion Devices

Furnish louvers for installation in exterior walls which are directly connected by duct work to air handling equipment. Fabricate louver blades from anodized aluminum or galvanized steel sheets, and provide 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. Air performance and water penetration ratings conform to

AMCA 500-L.

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

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

[Ensure color selection [matches architectural background] [be from manufacturer's standard color chips.]

] a. Round Ceiling Diffusers

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

b. Rectangular Ceiling Diffusers

Rectangular, [adjustable pattern,] stamped, multicore type diffuser to discharge air in 360 degree pattern with sectorizing baffles where indicated. Provide [surface mount] [snap in] [inverted T-bar] [spline] type frame. [In plaster ceilings, provide plaster frame and ceiling frame.] Fabricate of steel with factory applied baked enamel [off white] [_____] finish. Provide [radial opposed blade] [butterfly] [combination splitter] damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

c. Perforated Face Ceiling Diffusers

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

d. Modified Light Troffer Diffusers

[Single] [Double] plenum type constructed independent of light troffers with volume and pattern controllers, [100] [125] [150] millimeter [4] [5] [6] inch round or oval [top] [side] air inlet. Match diffusers to light troffers and connect in airtight connection without tools. Fabricate of galvanized steel with welded or soldered joints and finish matte black inside.

e. Ceiling Supply Registers/Grilles

Streamlined and individually adjustable curved blades to discharge air along face of grille, [one-way] [two-way] deflection. Fabricate [25] [32] millimeter [1] [1-1/4] inch margin frame with [countersunk screw] [concealed] mounting and gasket. Fabricate of aluminum extrusions with

factory applied [clear lacquer] [prime coat] [_____] finish. Provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

f. Ceiling Exhaust and Return Registers/Grilles

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

g. Ceiling Grid Core Exhaust and Return Registers/Grilles

Fixed grilles have 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 margin frame with [countersunk screw mounting.] [concealed mounting.] [lay-in frame for suspended grid ceilings.] Fabricate of aluminum with factory applied [clear lacquer] [baked enamel] finish. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

h. Ceiling Linear Exhaust and Return Grilles

Streamlined blades have 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 [25] [32] millimeter [1] [1-1/4] inch margin frame [extra heavy for floor mounting,] with [countersunk screw] [concealed] mounting. Fabricate of steel with 1.0 millimeter 20-gage minimum frames and 0.76 millimeter 22-gage minimum blades, steel and aluminum with 1.0 millimeter 20-gage minimum frame, or aluminum extrusions, with factory applied [baked enamel] [prime coated] [clear lacquer] [_____] finish. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

i. Ceiling Slot Diffusers

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 of aluminum extrusions with factory applied [clear lacquer] [baked enamel] [_____] finish. Fabricate [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

Streamlined and individually adjustable blades, depth of which exceeds 20 millimeter 3/4 inch maximum spacing with spring or other device to set blades, [vertical] [horizontal] face, [single] [double] deflection. Fabricate [25] [32] millimeter [1] [1-1/4] inch [_____] margin frame with

[countersunk screw] [concealed] mounting and gasket. Fabricate of steel with 1.0 millimeter 20-gage minimum frames and 0.76 millimeter 22-gage minimum blades, steel and aluminum with 1.0 millimeter 20-gage minimum frame, or aluminum extrusions, with factory applied [baked enamel] [prime coat] [clear lacquer] [_____] finish. Provide integral, gang-operated opposed blade dampers with removable key operator, operable from face. In gymnasiums, supply front pivot blades, welded in place or securely fastened to be immobile.

k. Wall Supply Registers/Grilles

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

l. Wall Exhaust and Return Registers/Grilles

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

m. Wall Grid Core Exhaust and Return Registers/Grilles

Fixed grilles of 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 [countersunk screw mounting.] [concealed mounting.] [lay-in frame for suspended grid ceilings.] Fabricate of aluminum with factory applied [clear lacquer] [baked enamel] finish. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

n. Linear Wall Registers/Grilles

Streamlined blades with [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 factory applied [clear lacquer] [prime coat] [_____] finish. Fabricate [25] [32] millimeter [1] [1-1/4] inch [_____] frame with [countersunk screw] [concealed] mounting and gasket. Provide integral [gang-operated opposed blade] [hinged single blade] damper with removable key operator, operable from face.

o. Linear Floor Supply Registers/Grilles

Streamlined blades with [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 factory applied clear lacquer finish. Fabricate [25] [32] millimeter [1] [1-1/4] inch [_____] margin heavy frame with [countersunk screw mounting] [concealed mounting and gasket] [, and

mounting frame.] Provide integral [gang-operated opposed blade] [hinged single blade] damper with removable key operator, operable from face.

p. Floor Supply Registers/Grilles

Individually adjustable blades, wide stamped border, single or double blade damper with set screw adjustment. Fabricate of steel, welded construction, with factory applied baked enamel finish.

q. Door Grilles

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

2.3.3.4 Duct Hangers

Ensure duct hangers and mill rolled steel, in contact with galvanized surfaces, be 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 of 99.97 percent efficiency rating by the DOP Test method meet the requirements of UL 586.

[Provide air filter gages or manometers for each filter assembly. Ensure gages are the dial indicator type at least 98 millimeter 3-7/8 inches in diameter, with white dials and black figures, graduated to read 0 to 500 pascal 0 to 2 inches wg. Ensure 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. 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 for gage mounting.

]2.3.4.1 Replaceable Type

Sectional disposable filters are [25] [50] millimeter [1] [2] inch thick panels, replaceable type having throwaway frames and media, standard dust holding capacity, and 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 not less than [95] [99.97] percent and in accordance with ISO 14644-1, ISO 14644-2. Ensure the clean air static pressure drop does not exceed [125] [250] pascal [0.5] [1] inch water gage when operating at rated air capacity at 21 degrees C 70 degrees F.

Cement interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer to the perimeter of the [upstream] [downstream] face of the filter frame. Use self extinguishing rubber base type adhesive sealer. Assemble filter frame with [20 millimeter 3/4 inch thick exterior grade fire retardant plywood] [cadmium plated steel] [galvanized steel] in a rigid manner. Ensure 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. Air capacity and depth of the filter is as indicated. Install each filter in a factory pre-assembled side access housing, or a sectional supporting frame as indicated.

2.3.5 Pipes, Valves and Specialties

Use carbon steel piping, as specified in paragraph entitled, "Carbon Steel," except that polyvinyl chloride (PVC) piping may be used for drain piping.

2.3.5.1 Pipe

a. Insulation

Construct pipe insulation system with a mineral fiber vapor barrier jacket as specified herein, except that 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.

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.

Fittings are Socket Type, Schedule 40, PVC material conforming to ASTM D2466.

Solvent cement for pipe and fittings conforms to ASTM D2564. Ensure thread lubricant is as recommended by manufacturer of pipe and fittings.

2.3.5.2 Valves and Specialties

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

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

Control valves for converters, cooling coils, reheat coils, preheat coils, and heating coils, and miscellaneous control valves are [two] [or] [three] way pattern of the [modulating] [or] [two position] type as required for

the sequence specified. Rate valve bodies 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 position of the valve.] Valve stem packing is spring loaded, and self adjusting constructed with tetrafluoroethylene.

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

Install 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 manufacturer's standard ball type blow down valve.

2.3.5.3 Thermometers and Pressure Gages

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

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

2.3.6 Vibration Isolation Provisions

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

Rubber is natural rubber. Use chloroprene as elastomer. Ensure 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 may be provided in lieu of natural rubber and elastomers.

2.3.7 Controls and Instrumentation

Provide the required sequence of operation control using automatic controls for temperature, air flow, and humidity using [electric,] [electronic,] [solid state electronic,] [pneumatic] type, [or a combination thereof].

Ensure electrical signals are in the [0-5Vdc] [4-20mA] [_____] range, and pneumatic signals in the [20-110] [_____] kilopascal [3-15] [_____] psig range.

Provide [low voltage] [proportioning] [two position] type space thermostat with Fan Auto-Off and Heat-Off-Cool settings for heating and cooling temperature control. Ensure thermostats take full control action for a temperature change of plus or minus 0.5 degrees C 1 degree F of the thermostat setting. Thermostat location are as indicated. Ensure thermostat conforms to requirements established by ASHRAE 90.1 - IP and ASHRAE 90.1 - SI.

Provide duct humidistats of the insertion, proportioning type, reverse acting, with adjustable minimum throttling range no greater than 2 percent relative humidity. Ensure the humidistat is capable of maintaining relative humidity within this range for relative humidity of 20 to 80 percent and temperatures to 66 degrees C 150 degrees F.

Construct unit control panels of [steel not lighter than 1.6 millimeter 16-gage] [aluminum not lighter than 2.8 millimeter 12-gage] and conform to NEMA ICS 6, Type 12. Include in the panel, remote pushbutton stations protective devices, gages, and other control devices that are not normally furnished integral with the equipment. Ensure electric wiring consists of insulated conductors installed in raceways. Identify instruments on the panel by a plastic or metal nameplate attached to, or integral with, the panel, and with engraved or cut lettering contrasting in color with the plate. Painting of lettering directly on the plate or panel is not permitted. Install within the cabinet control instruments, piping, wiring, and terminals, except that switches, pilot lights, and pushbuttons may be mounted on the cabinet doors. Equip doors with piano hinges, latches and locks.

PART 3 EXECUTION

3.1 INSTALLATION

Submit 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 manufacturer's printed instructions and recommendations.

Except where shown in dimensional detail, exact locations of mechanical equipment, ducts, and piping are not shown on design drawings. 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 carrying manufacturer's name, address, equipment type or style, catalog number or model, and serial number, to major equipment components.

Tie-in to existing hot water and chilled water where indicated. Tie-ins require [5] [_____] calendar days prior notification to the Contracting Officer.

3.1.1 Ductwork

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

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

Gasket flanged joints with chloroprene full face gaskets.

Install the turning vanes at 90 degree elbows. Use short radius elbows having radius of 1.0 times the duct width or diameter, or 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 15 degrees transition from the straight run of duct connected thereto.

Provide balancing dampers of the splitter, butterfly, or multi-louver type, where indicated to balance each respective main and branch duct. Install control dampers under the supervision of the automatic temperature control manufacturer or his 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. Replace, after system startup, any duct support device that vibrates or could cause failure of a member or damage to ducting, 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 and sealed to building construction with elastomers for complete air tightness.

Provide sheet metal outside air intake ducts and plenums 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 in accordance with ASHRAE HVAC APP SI HDBK, ASHRAE EQUIP SI HDBK, and SMACNA 1966. Make airtight doors that leak at no additional cost to the government.

Friction rod assemblies and perforated strap hangers are not acceptable.

3.1.1.2 Fibrous Glass Ductwork

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

Minimum thickness of rectangular duct is 25 millimeter 1 inch. Duct reinforcement is in accordance with SMACNA 1884.

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

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

Support rectangular ducts either from joint reinforcement or by trapeze hangers installed to prevent edge cutting of duct.

Provide internal metal reinforcement for fibrous glass duct around entire duct perimeter at points of access, and frame 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 in 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 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 watertight.

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

For drain piping, include a P-Trap in line.

3.1.3 Insulation

Do not apply insulation to system or component surfaces until they have been tested and approved.

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

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

Ensure contours on 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 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, and seal all breaks and punctures of the liner with fire-resistant adhesive. Heavily brush-coat with adhesive, exposed edges of the coated liner, and at joints where the lining is subject to erosion and, where necessary, with metal nosing to prevent delamination of the glass fibers. Duct liner may also be applied to flat sheet metal with fire resistant adhesive prior to forming duct through the sheet metal brake. At top and bottom surfaces of the duct, secure lining by pins or adhered clips as specified for cut-to-size lining.

3.1.3.2 Mineral Fiber with Glass Cloth Jacket

Cover 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 vapor barrier adhesive. Ensure jacket overlap is not less than 40 millimeter 1-1/2 inches. Jacketing bands for butt joints is 75 millimeter 3 inches wide.

Cover exposed to view fittings with preformed mineral fiber fitting insulation of the same thickness as the pipe insulation and temporarily secured in place with light cord ties. Install impregnated glass lagging tape with indoor vapor barrier on 50 percent overlap basis and blend the tape smoothly into the adjacent jacketing. Apply additional coating as needed, and rubber gloved to a smooth contour. Tape ends of insulation to the pipe at valves DN50 2 inches and smaller. On the job fabricated insulation for concealed fittings, and special configurations are built up

from mineral fiber combined with insulating cement mixed with lagging adhesive, 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 all flanges of the same thickness as the adjacent insulation.

Finish exposed to view insulation with a minimum 0.15 millimeter 6 mil dry film thickness of non-vapor barrier coating suitable for painting.

3.1.3.3 Cellular Elastomer

Cover with [10] [13] millimeter [3/8] [1/2] inch thick flexible cellular elastomer preformed insulation refrigerant suction line piping surfaces [and] [condensate drains] [and] [humidifier dispersion piping]. Maintain 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 a 0.051 millimeter 2 mil minimum dry film thickness of a polyvinyl chloride lacquer, with a minimum of 2 coats.

3.1.3.4 Flexible Mineral Fiber with Jacket

Cover the sheet metal duct not lined internally with acoustic duct lining with flexible mineral fiber duct insulation with factory attached vapor barrier jacket. Maintain vapor seal. Ensure jacket overlap is not less than 50 millimeter 2 inches.

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

] Secure to the duct surface, insulation on rectangular or square ducting with side or bottom surface dimensions over 750 millimeter 30 inches impaled on pins and then locked by means of flush pin caps. Clip pins flush with face of cap. Install pins 300 millimeter 12 inches on center, placed not more than 50 millimeter 2 inches from duct edges, and have not less than 2 rows of pins per surface. Seal pins with 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 no condensation appears on any surface while the system is operating.

Securely cement jackets, jacket flaps, and bands in place with vapor barrier adhesive. Ensure jacketing bands for butt joints are not less than 100 millimeter 4 inches wide. In lieu of jacketing bands, pressure sensitive vapor barrier tape not less than 75 millimeter 3 inches wide may be used to seal horizontal and transverse seams.

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

] Duct insulation at fire dampers is as indicated.

Seal with outdoor vapor-barrier coating, duct insulation terminating at insulated or uninsulated sheet metal and equipment surfaces, supports, damper fittings, walls and any other similar penetration construction points. Where lengths exceed 600 millimeter 24 inches, flash with glass cloth tape and sheet metal trimming. Apply glass cloth tape in 2 layers with minimum 75 millimeter 3 inches of overlap imbedded in 1.5 millimeter 1/16 inch minimum dry film thickness with outdoor vapor barrier coating.

3.1.4 Vibration Isolation

Vibration isolate the air handling unit from both the building structure using vibration isolators, and from connecting ductwork using flexible connectors. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT if 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, with burrs removed, and surfaces cleaned before assembly of joints. Pressure test copper joints in accordance with paragraph, entitled, "Balance and Leakage Tests," of this section. 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, except that where the run is less than 300 millimeter 12 inches, plastic tubing may be used.

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

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 indicating device has an adjustable setpoint. For individually mounted controllers, permanently mount the indicating device. For central panel mounted controllers, provide [individual permanently mounted devices] [or] [a single indicating device having suitable switching means to permit connecting the device to any controller on the panel].

3.1.5.3 Thermostats

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

Provide remote thermostats of the duct, immersion or outdoor type, with the set point and throttling range adjusting mechanism for the duct and immersion type mounted in a metal or approved plastic case outside of the

duct or pipe. Secure sensing element in the controlled medium flow stream to respond to overall temperature within the duct or pipe. Provide outdoor compensating thermostat sensing element with a protective metal shield or weatherproof housing, and be secured where indicated. Mount controller mechanism indoors where indicated. Reset ratios of the indoor-outdoor compensating thermostat are as indicated.

Mount humidistats [on outside of duct, with sensing element within duct] [as indicated], reverse acting, proportioning type, with adjustable minimum throttling range no greater than 2 percent relative humidity. Ensure humidistats are capable of maintaining relative humidity within the limits of the throttling range for relative humidity of [20] [_____] to [80] [_____] percent and temperatures to [43] [_____] degrees C [110] [_____] degrees F. [Ensure sensing element is suitable for installation location.]

3.1.5.4 Unit Control Panels

[Flush mount] [or] [back mount] instruments and be completely piped, and wired to properly identified terminal strips. Install piping and wiring on the rear of the panel. Electric wiring consists of insulated conductors installed in raceways.

3.1.5.5 Controls

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

Provide pilot lights, of the front removable type, 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 6 inch dial gages or other devices may be provided in lieu of pushbuttons or momentary contact indication 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

NOTE: Variable pitch sheaves should only be used
for system balance and adjustment purposes. After
balance is determined they should be replaced with
fixed sheaves.

Test and balance entire air-handling and distribution system per NEBB PROCEDURAL STANDARDS to provide 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 duct systems and piping in the presence of the Contracting Officer prior to insulation of surfaces, painting, and concealment of work. Perform hydrostatic water system tests, using potable water supplied by the Government. Provide for disposal of contaminated water.

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

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

Test for proper operation of fire dampers in presence of the Contracting Officer, by activating 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 of 400 line resolution; a frequency response range of 5 Hz-10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; 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 the mass of the accelerometer and its mounting have minimal influence on the frequency response of the system over the selected measurement range.

Prior to final acceptance, use vibration analysis to verify motors and fans conformance 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. 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 prior to testing the chilled water air conditioning systems.

Update and resubmit data for final approval no later than 30 calendar days prior to contract completion.

-- End of Section --