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- 3.9 OPERATION AND MAINTENANCE

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Use of electronic communication is encouraged.

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## PART 1 GENERAL

### 1.1 REFERENCES

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

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

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

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

#### AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 410	(2001) Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 430	(1999) Central-Station Air-Handling Units
ARI 620	(1996) Self Contained Humidifiers for Residential Applications

#### AIR DIFFUSION COUNCIL (ADC)

ADC 1062:GRD	(2000) Test Codes for Grilles, Registers, and Diffusers
ADC-01	(2001) Directory of ADC Certified Products

#### AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 210	(1999) Laboratory Methods of Testing Fans for Rating
AMCA 300	(1996) Reverberant Room Method for Sound Testing of Fans
AMCA 500	(1999) Test Methods for Louvers, Dampers

and Shutters

AMCA 99 (1991; AMCA 99-0401) Standards Handbook

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11 (1990; R 2000) Load Ratings and Fatigue Life for Roller Bearings

ABMA 9 (1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

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

ASHRAE 90.1 (2001) Energy Conservation in New Building Design

ASHRAE-02 (1999) Handbook, HVAC Applications (IP Edition)

ASHRAE-03 (1997) Handbook, Fundamentals (IP Edition)

ASHRAE-04 (1997) Handbook, Fundamentals (SI Edition)

ASHRAE-05 (1999) Handbook, HVAC Applications (SI Edition)

ASHRAE-Hdbk SE-SI (2000) Handbook, HVAC Systems and Equipment (SI Edition)

ASME INTERNATIONAL (ASME)

ASME B16.3 (1998) Malleable Iron Threaded Fittings Classes 150 and 300

ASME B16.5 (2003) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24

ASME B16.9 (2003) Factory-Made Wrought Steel Buttwelding Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A 197/A 197M (2000) Standard Specification for Cupola Malleable Iron

ASTM A 234/A 234M (2003) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperatures

ASTM A 278 (1993) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 Degrees F

ASTM A 278M (2001) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 345 Degrees C (Metric)

ASTM A 527/A 527M	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM A 53/A 53M	(2004a) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 694/A 694M	(2003) Standard Specification for Forgings, Carbon and Alloy Steel, for Pipe Flanges, Fittings, Valves and Parts for High Pressure Transmission Service
ASTM B 62	(2002) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM C 1071	(2000) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C 534	(2003) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 547	(2003) Standard Specification for Mineral Fiber Preformed Pipe Insulation
ASTM C 916	(1985; R 2000e1) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM D 1785	(2005) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2466	(2002) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2564	(2004) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D 2855	(1996; R 2002) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D 579	(1997) Standard Specification for Greige Woven Glass Fabrics

#### INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerance
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MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS  
INDUSTRY (MSS)

MSS SP-58 (2002) Pipe Hangers and Supports -  
Materials, Design and Manufacture

MSS SP-69 (2002) Pipe Hangers and Supports -  
Selection and Application

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6 (1993; R 2001) Industrial Control and  
Systems Enclosures

NEMA MG 1 (2003) Motors and Generators

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB TABES (1998) Procedural Standards for Testing,  
Adjusting and Balancing of Environmental  
Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220 (1999) Standard on Types of Building  
Construction

NFPA 255 (2000) Standard Method of Test of Surface  
Burning Characteristics of Building  
Materials

NFPA 70 (2005) National Electrical Code 2005  
Edition

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

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

SMACNA 1117 (2003) Fibrous Glass Duct Construction  
Standard

SMACNA 1481 (1995; 6th Ed) HVAC Duct Construction  
Standards - Metal and Flexible

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 3779 (1990) Tape Adhesive, Pressure Sensitive  
Thermal Radiation Resistant

UNDERWRITERS LABORATORIES (UL)

UL 181 (1996; R 2003) Standard Factory-Made Air  
Ducts and Air Connectors

UL 465 (1982; 7th Ed; Rev thru Dec 24, 1987)  
Central Cooling Air Conditioners

## U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD 209

(Rev C) Clean Room and Work Station  
Requirements, Controlled Environment

## 1.2 SYSTEM DESCRIPTION

Control Diagrams shall be submitted for chilled water air conditioning systems showing the physical and functional relationship of equipment. Electrical diagrams shall show size, type, and capacity of the system.

Contractor shall submit samples of Color Chips.

## 1.2.1 Design Requirements

Contractor shall 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

## 1.2.2 Performance Requirements

HVAC system, when properly installed, shall be tested and balanced per NEBB TABES to deliver air flows from each supply register within 10 percent of design specification.

Equipment and Performance Data shall be submitted for chilled water air conditioning systems consisting of fan sound power data in accordance with AMCA 300.

## 1.3 SUBMITTALS

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**NOTE:** Review Submittal Description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

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

For submittals requiring Government approval on Army



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

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

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01330 SUBMITTAL PROCEDURES:

#### SD-02 Shop Drawings

Connection diagrams shall be submitted indicating the relations and connections of the following items. Drawings shall indicate the general physical layout of all controls, and internal tubing and wiring details.

Pipes, Valves and Specialties  
Ductwork  
Air Handling Unit  
Humidifiers  
Controls and Instrumentation

Control Diagrams shall be submitted for chilled water air conditioning systems in accordance with paragraph entitled, "System Description," of this section.

#### SD-03 Product Data

Equipment and Performance Data shall be submitted in accordance with paragraph entitled, "Performance Requirements," of this section.

Manufacturer's catalog data shall be submitted for the following items in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Centrifugal Fan  
Pipes, Valves and Specialties  
Ductwork  
Air Diffusion Devices  
Filters  
Insulation  
Vibration Isolators  
Spare Parts

#### SD-04 Samples

Samples of Color Chips shall be submitted in accordance with paragraph entitled, "System Description," of this section.

#### SD-06 Test Reports

Test reports shall be submitted for the following tests in accordance with the paragraph entitled, "Tests," of this section.

Pressure  
Leakage Testing  
Operation

#### SD-07 Certificates

Certificates shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Centrifugal Fan  
Pipes, Valves and Specialties  
Ductwork  
Air Diffusion Devices  
Filters  
Insulation  
Vibration Isolators  
Air Handling Unit  
Humidifiers  
Controls and Instrumentation

#### SD-08 Manufacturer's Instructions

Manufacturer's Instructions for installation of chilled water air conditioning systems shall be submitted in accordance with paragraph entitled, "General Installation Requirements," of this section.

#### SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals shall be submitted in accordance with paragraph entitled, "Operation and Maintenance," of this section.

### PART 2 PRODUCTS

#### 2.1 MATERIALS

##### 2.1.1 Ductwork Materials

Spare Parts lists and information for chilled water air conditioning systems shall be provided, meeting referenced standards within this section.

##### 2.1.1.1 Galvanized Steel Ductwork Materials

[Steel ductwork shall be hot dip galvanized carbon steel of lock forming quality, with regular spangle type zinc coating conforming to ASTM A 527/A 527M, G-90. Construction, metal thickness and reinforcement thickness

shall conform to ASHRAE-05, ASHRAE-Hdbk SE-SI, and SMACNA 1481.]

#### 2.1.1.2 Rigid Fibrous Glass Ductwork Materials

[Rigid fibrous glass duct system, including tapes, adhesives, vapor barriers and joint sealers, shall have a minimum density of 80 kilogram per cubic meter 5 pounds per cubic foot, conform to requirements of NFPA 90A, and be labeled as having FM approval and UL 181, Class 1 airduct listing. System shall have a thermal conductivity of [ 0.45 watt per meter per degrees K0.26 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. Materials shall be odorless and nonallergenic when in service. Vapor barrier shall be factory applied, and construction shall be in accordance with SMACNA 1117.]

#### 2.1.1.3 Flexible Duct

[Wire reinforced flexible duct runouts to air outlets shall consist of a factory fabricated chloroprene or vinyl impregnated and coated fibrous glass cloth bonded to and supported by a corrosion protected spring steel helix. Fabric may be a laminate of metallic film and fibrous glass. Runout shall not exceed [\_\_\_\_\_] meter [\_\_\_\_\_] feet in length and shall comply with NFPA 90A and UL 181. Working pressure rating of ducting shall be not less than three times maximum system pressure, and temperature range shall be minus 30 to plus 80 degrees C minus 20 to plus 175 degrees F.]

#### 2.1.2 Insulation - Ductwork and Pipe

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

##### 2.1.2.1 Acoustic Duct Lining

Acoustic duct lining shall be [50] millimeter [2] inch [\_\_\_\_\_] thick fibrous glass conforming to ASTM C 1071. Liner composition shall be deeply impregnated with chloroprene on the surface exposed to the airstream and shall conform to fire hazard requirements of NFPA 90A. Air stream side of the liner shall be capable of withstanding air velocities of 20 meter per second 4,000 feet per minute without delamination or erosion.

Mineral fiber shall conform to ASHRAE-04 ASHRAE-03, Chapter 20, ASHRAE-05, Chapter 21, ASHRAE-Hdbk SE-SI,, ASHRAE-02 and ASTM C 1071, Form A, Class 1 for rigid boards, and Form B, Class 6 for flexible blankets.

Mineral fiber pipe insulation shall conform to ASTM C 547, Class 1, [jacketed] [plain].

Cellular elastomer shall conform to ASTM C 534, except that the water vapor permeability shall not exceed 10.16 nanogram per pascal second square meter 0.30 perms.

#### 2.1.2.2 Adhesives

Fire resistant adhesive for attaching fibrous glass insulation to metal surfaces shall be a nonflammable solvent base, synthetic rubber type, conforming to ASTM C 916 and SAE AMS 3779 Class 2.

Fire resistant adhesive for bonding fibrous glass cloth to itself and to other fibrous glass insulation materials shall conform to ASTM C 916 and SAE AMS 3779 Class 1.

Adhesive for cellular elastomer insulation shall be a solvent cutback chloroprene elastomer conforming to ASTM C 916 and SAE AMS 3779 Type II, Class 1, and shall be a type approved by the insulation manufacturer.

#### 2.1.2.3 Jacketing and Vapor Barriers

Jacketing for mineral fiber duct insulation shall be a 3-ply laminate of 35 pounds per 100 square feet 17 kilogram per 10 square meter white bleached kraft bonded to not less than 0.025 millimeter 1-mil thick aluminum foil and reinforced with glass fiber. With foil exposed, flame spread rating shall be [5] [\_\_\_\_\_] and smoke developed rating shall be [0] [\_\_\_\_\_] . With kraft exposed, flame spread rating shall be [25] [\_\_\_\_\_] and smoke developed rating shall be [15] [\_\_\_\_\_] . Water vapor permeance of the composite shall be 0.012 nanogram per pascal second square meter 0.02 perm.

Vapor barrier material for mineral fiber pipe insulation shall conform to ASHRAE-04 ASHRAE-03, Chapter 20, ASHRAE-05, Chapter 21, ASHRAE-Hdbk SE-SI ASHRAE-02, and ASTM C 1071, Type 1 (low vapor transmission, high puncture resistance).

Glass reinforcing cloth shall conform to ASTM D 579.

### 2.2 FACTORY FABRICATED AIR HANDLING UNIT

Unit shall be 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.

Unit shall be certified as complying with provisions of ARI 430 and UL 465, as applicable.

#### 2.2.1 Centrifugal Fan

\*\*\*\*\*  
NOTE: Fan and Motor balance shall conform to ISO  
1940-1 - (1986) Balance Quality Requirements of  
Rigid Rotors - Determination of Permissible Residual  
Unbalance unless otherwise noted. Motor vibration  
levels shall conform to NEMA Specification MG-1,  
Motors and Generators, Part 7 unless otherwise noted.  
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\*\*\*\*\*  
NOTE: When possible the use of sealed bearings is  
encouraged. One of the major causes of bearing  
failures is overlubrication and lubrication  
\*\*\*\*\*

contamination. Using sealed bearings helps to eliminate this failure mode.

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NOTE: Fans driven by motors rated over 7.5 HP [5.6 KW] shall be furnished with access doors and other provisions necessary to permit field balancing of the rotating elements, addition of corrective weights, and measurement of residual unbalance.

\*\*\*\*\*

Fans shall be fully enclosed, [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, and shall be tested and rated in accordance with AMCA 210. Standard AMCA arrangement, rotation, discharge, and motor location shall be as indicated. Fan wheel shall be statically and dynamically balanced to ISO 1940-1. Bearings shall be self aligning [antifriction] [sleeve] type, and shall be [grease] [oil] [permanently] lubricated. Bearings shall 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 shall be [direct] [by V-belt], designed for not less than [150] [140] [120] percent of the connected driving capacity. Permanent sheaves shall be of fixed type. Adjustable sheaves shall only be used for system balancing. Removable metal guards shall be provided for exposed [shaft ends] [and] [couplings] [V-belt drives]. Guards shall have speed test openings at the center of shafts. [V-belt drives shall be adjustable to provide not less than 20 percent fan speed variation, and shall produce the specified fan capacity when set at the approximate midpoint of adjustment. Motors for V-belt drives shall be provided with adjustable rails or bases.]

Motors shall conform to NEMA MG 1, not exceed 1800 rpm, and shall have [open] [drip-proof] [totally enclosed] [explosion-proof] enclosures. Motor starters shall be [manual] [magnetic] [across-the-line] [reduced voltage] type with [general purpose] [weather resistant] [watertight] enclosure. [Remote manual switch with pilot indicating light shall be provided where indicated.] Fans shall be provided with personnel screens or guards on both suction and supply ends, except that, screens are not required where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration isolation supports or mountings as specified herein.

#### 2.2.2 Coils

Coils shall conform to the provisions of ARI 410. Water coils shall be fin and tube type constructed of seamless [aluminum] [or] [copper] tubes, and [uncoated] [phenolic coated] [aluminum] [or] [copper] fins mechanically bonded or soldered to tubes. Each coil shall be factory tested under water at not less than 1700 kilopascal 250 psi air pressure and shall be suitable for 1350 kilopascal 200 psi working pressure at 121 degrees C 250 degrees F.

Coils shall be mounted for counterflow service. Casing and tube support sheets shall be not lighter than 1.6 millimeter 16-gage galvanized steel, formed to provide structural strength, and multiple tube supports shall be provided when required to prevent tube sag. Cooling coil ends shall be enclosed by the cabinet and shall be drained to drain pan, or factory insulated against sweating.

### 2.2.3 Enclosure

Unit cabinet shall be suitable for AMCA 99 pressure class indicated and shall have leak tight joints, closures, penetrations, and access doors. Cabinet shall not expand or contract during starting or stopping of fans, and shall not pulsate during operation. Cabinet surfaces with deflections in excess of [1/240] [1/360] of unsupported span shall be reinforced prior to acceptance. Pulsating panels shall be stiffened to raise natural frequency to an easily attenuated level.

Plenums shall be constructed 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, cabinet floor shall be strengthened to permit entry without damage to any component. [A pushbutton station to stop the supply fan shall be located inside the cabinet where indicated.] Access doors as large as the space will accommodate shall be provided in each section of the cabinet and shall be shall swing so that fan suction or pressure holds door in closed position.

Enclosure shall be fabricated from [mill galvanized] [or] [primed and painted carbon steel] sheet. Mill galvanized sheet metal shall conform to ASTM A 527/A 527M and shall be coated with not less than 380 gram per square meter 1.25 ounces of zinc per square foot of two sided surface. Mill rolled structural steel shall be [hot dip galvanized] [or] [primed and painted]. Cut edges, burns, and scratches in galvanized surfaces shall be corrosion protected.

Interior surfaces of cabinets constructed of mill galvanized steel shall require no further protection. Exterior surfaces of cabinets constructed of mill galvanized steel shall be [left unpainted] [prepared by a phosphatizing treatment and painted with two coats of the manufacturer's standard enamel finish in color selected by the Contracting Officer.]

Each section shall be acoustically and thermally insulated at the factory with not less than [50] millimeter [2] inch [\_\_\_\_\_] thick fibrous glass insulation material conforming to ASTM C 1071, Type I. Insulation to be enclosed using double-walled construction of all panels and doors.

### 2.2.4 Drain Pans

Intermediate coil, 75 millimeter 3 inch deep drip pans shall be provided for each tiered coil bank. Top pan shall extend 300 millimeter 12 inches beyond face of coil, and bottom pan shall extend not less than 600 millimeter 24 inches beyond face of coil. Where more than two pans are used, pan extension shall be proportional. Adequate supports shall be made of the same type material as the pans, or of hot-dip galvanized angle iron with isolation at interface. Pan material shall be 0.76 millimeter 22-gage AISI Type 304 stainless steel with silver-soldered joints. Minimum size of drain opening shall be 32 millimeter 1-1/4 inches.

Integral cabinet drain pan shall extend under all areas where condensate must be collected and shall be watertight with welded or brazed joints, piped to drain, corrosion protected in the condensate collection area, and insulated against sweating. Sheet metal shall be 2 millimeter 14-gage, minimum, except that 1.6 millimeter 16-gage double drain pan construction shall be acceptable.

## 2.2.5 Electrical Requirements

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

\*\*\*\*\*

Each section shall be equipped with a main power panel and shall include complete branch circuit protection for every electrical component. Main power panel shall completely protect the unit from primary single phasing and overcurrent. Fuses and protective devices shall be provided by the manufacturer and installed at the factory. Components shall be designated with a code and shall be called out on a wiring diagram for servicing of the power panel. Panel shall have terminal blocks, with the terminals clearly identified for easy connection, for the main power supply and all auxiliary connections.

Access to the main power panel shall be possible without interrupting the operation of the unit. Access shall be sufficient to safely check the voltage and current of each component. There shall be separate doors for access to the main power terminal block and the auxiliary terminals. All components of the main power panel and all control devices shall be UL listed. Power and control devices, including motor starters, relays, timers, fuses, circuit breakers, switches, and other items shall be in accordance with Section 16286S OVERCURRENT PROTECTIVE DEVICES. Internal wiring shall be not less than [ 1.6 millimeter (No. 14 AWG)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)No. 18 AWG, 105 degree C, 0.8 millimeter 2/64 inch insulation] [\_\_\_\_\_] wire for control wiring. Wiring shall be in accordance with UL and NFPA 70 requirements. Each wire shall be identified at every termination with a wire number matching the wiring diagram and control schematic. Wire identification shall utilize preprinted heat-shrink wire sleeves. Hand lettering or marking is not acceptable.

All motors shall have copper windings, be equipped with heavy duty ball bearings, have internal overload protection, have protection against primary single phasing, and be UL listed. Motors shall be sized by the manufacturer and be rated in accordance with the requirements of Section 16225S MOTORS.

Equipment shall operate on [208] [230] [\_\_\_\_\_] volt, [single] [3] phase, 60 hertz electrical service.

## 2.3 HUMIDIFIERS

[Self contained, atomizing, electrically operated humidifiers conforming to ARI 620 shall be provided.]

## 2.4 DUCTWORK COMPONENTS AND ACCESSORIES

### 2.4.1 Flexible Connectors

Connectors shall be UL listed, 20 ounce per square foot 6.1 kilogram per square meter, fire-retardant, airtight, woven fibrous glass cloth impregnated with chloroprene. Clear width, not including clamping section, shall be 75 to 125 millimeter 3 to 5 inches.

### 2.4.2 Dampers

Damper construction shall conform to ASHRAE-05, ASHRAE-Hdbk SE-SI, and SMACNA 1481, unless otherwise specified.

Balancing dampers shall be of the opposed blade type, designed for [manual] [electric motor] [pneumatic] operation.

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

Fire dampers shall be [electric motor] [pneumatic] operated and shall be constructed and labeled in accordance with UL 555. For link loads in excess of 90 newton 20 pounds, UL-approved quartzoid links shall be provided.

Where required, [zoning] [face and bypass] [and] [mixing box] dampers shall be of materials and finish identical to the unit enclosure. Individual damper blades shall not exceed 200 millimeter 8 inches in width, or 1189 millimeter 42 inches in length, and shall not be less lighter than 1.2 millimeter thick 18-gage. Damper shafts shall rotate in [nylon] [\_\_\_\_\_] bushings. Shafts and all interconnecting damper linkages shall be [corrosion resistant steel] [galvanized steel] of the bell crank type having no backlash. Air leakage around the damper shall be 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.

Manually operated dampers shall be equipped with an indicating quadrant regulator, with locking feature, externally located and easily accessible for adjustment. Where damper rod lengths exceed 750 millimeter 30 inches, a quadrant regulator shall be provided at each end of the damper shaft.

[Electric motor operators shall be split-phase type with oil immersed gear train, and shall provide smooth proportional control under operating conditions normal to the system.] [Pneumatic operators shall close dampers to failsafe position indicated. Positioners shall be provided where two or more operators are controlled from the same controller, and where indicated. Positioners shall be mounted directly on the driven device. Starting point shall be adjustable from [2] [\_\_\_\_\_] to [12] [\_\_\_\_\_] psi, and operating span shall be adjustable from [10] [\_\_\_\_\_] to [85] kilopascal [30] [\_\_\_\_\_] to [95] [\_\_\_\_\_] kilopascal [5] [\_\_\_\_\_] to [13] [\_\_\_\_\_] psi.]

Operators shall be provided for each automatic damper or valve. Each operator shall be [full proportioning] [two position] type and shall be



provided with spring return for normally [closed] [or] [open] position, as indicated, for fire, freeze, or moisture protection on power interruption. All proportioning operators shall be provided with positive positioning devices or indicators. Valve and damper operating speeds shall be selected or adjusted so that the operators will remain in step with the controller without hunting, regardless of load variations. Operators acting in sequence with other operators shall have adjustment of the control sequence as required by the operating characteristics of the system.

#### 2.4.3 Air Diffusion Devices

Louvers shall be furnished for installation in exterior walls which are directly connected by duct work to air handling equipment. Louver blades shall be fabricated from anodized aluminum or galvanized steel sheets, and shall be provided with a frame of galvanized steel or aluminum structural shapes. Louver shall be provided 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 shall conform to AMCA 500.

Diffusers, registers, and grilles shall be identified on the drawings and shall be listed in latest ADC-01, or be certified as having been tested and rated in accordance with ADC 1062:GRD.

Construction and mounting shall prevent flutter, rattle, or vibration. Gaskets shall be provided for terminal supply air devices mounted in finished surfaces.

[Color selection shall [match architectural background] [be from manufacturer's standard color chips.]]

##### 2.4.3.1 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.

##### 2.4.3.2 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.

##### 2.4.3.3 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.

#### 2.4.3.4 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.

#### 2.4.3.5 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.

#### 2.4.3.6 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 dampers with removable key operator, operable from face. In gymnasiums, blades shall be front pivoted, welded in place or securely fastened to be immobile.

#### 2.4.3.7 Ceiling Grid Core Exhaust and Return Registers/Grilles

Fixed grilles shall 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.

#### 2.4.3.8 Ceiling Linear Exhaust and Return Grilles

Streamlined blades shall 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.

#### 2.4.3.9 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.]

#### 2.4.3.10 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, blades shall be front pivoted, welded in place or securely fastened to be immobile.

#### 2.4.3.11 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.

#### 2.4.3.12 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.

#### 2.4.3.13 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.

#### 2.4.3.14 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.

#### 2.4.3.15 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.

#### 2.4.3.16 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.

#### 2.4.3.17 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.

#### 2.4.4 Duct Hangers

Duct hangers and mill rolled steel in contact with galvanized surfaces shall be galvanized steel or painted with inorganic zinc.

### 2.5 FILTERS

Air filters shall be rated in accordance with UL 900. High efficiency particulate air filters of 99.97 percent efficiency rating by the DOP Test method shall meet the requirements of UL 586.

[Air filter gages or manometers shall be provided for each filter assembly. Gages shall be 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, and shall 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 shall incorporate a screw operated zero adjustment and shall be 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.]

### 2.5.1 Replaceable Type

Sectional disposable filters shall be [25] [50] millimeter [1] [2] inch thick panel, 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. [A stiffener bar shall be provided for additional support.]

### 2.5.2 High Efficiency Particulate Air (HEPA)

HEPA filters shall be individually tested in accordance with FED-STD 209 and certified to have an efficiency of not less than [95] [99.97] percent. Clean air static pressure drop shall not exceed [125] [250] pascal [0.5] [1] inch water gage when operating at rated air capacity at 21 degrees C 70 degrees F.

Interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer shall be cemented to the perimeter of the [upstream] [downstream] face of the filter frame. Adhesive sealer shall be of self extinguishing rubber base type. Filter frame shall be [ 20 millimeter 3/4 inch thick exterior grade fire retardant plywood] [cadmium plated steel] [galvanized steel] assembled in a rigid manner. Overall frame dimensions shall be correct to 1.5 millimeter 1/16 inch, and squareness shall be maintained to within 3 millimeter 1/8 inch. Spring loaded fasteners or other devices shall secure the filter. Air capacity and depth of the filter shall be as indicated. Each filter shall be installed in a factory pre-assembled side access housing, or a sectional supporting frame as indicated.

## 2.6 PIPES, VALVES AND SPECIALTIES

### 2.6.1 Pipe

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

#### 2.6.1.1 Pipe Insulation

Pipe insulation system shall be mineral fiber with vapor barrier jacket as specified herein, except that cellular elastomer system may be used on cold water and condensate drain piping at the Contractor's option.

#### 2.6.1.2 Carbon Steel

Pipe DN50 2 inches (nominal o.d.) and under shall be Schedule 40 carbon steel conforming to ASTM A 53/A 53M. Pipe DN65 2-1/2 inches and larger shall be seamless or electric resistance welded carbon steel conforming to ASTM A 53/A 53M, Type E, Grade B, or Type S, Grade B.

Flanges shall be 1050 kilopascal 150 psi forged steel conforming to ASTM A 694/A 694M and ASME B16.5.

Fittings DN50 2 inches and smaller shall be 1050 kilopascal 150 psi, screwed, malleable iron conforming to ASTM A 197/A 197M, ASTM A 234/A 234M and ASME B16.3. Fittings DN65 2-1/2 inches and larger shall be steel conforming to ASTM A 234/A 234M, and ASME B16.9.

Unions DN50 2 inches and under shall be 1750 kilopascal 250 psi, female, screwed, malleable iron with brass-to-iron seat and ground joint.

#### 2.6.1.3 Polyvinylchloride (PVC) Pipe

PVC pipe shall be Schedule 40, and conform to ASTM D 1785.

Fittings shall be Socket Type, Schedule 40, PVC material conforming to ASTM D 2466.

Solvent cement for pipe and fittings shall conform to ASTM D 2564. Thread lubricant shall be as recommended by manufacturer of pipe and fittings.

#### 2.6.2 Valves and Specialties

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

Valves shall be 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 shall be [two] [or] [three] way pattern of the [modulating] [or] [two position] type as required for the sequence specified. Valve bodies shall be rated at 850 kilopascal 125 psi minimum for [hot] [chilled] water service. [Valves for modulating service shall have a contoured plug with removable discs, matched to the characteristics of the coil for effective control, and shall be provided with valve stem travel indicator or other means of indicating position of the valve.] Valve stem packing shall be tetrafluoroethylene, spring loaded, and self adjusting.

Drain, vent, and gage cocks shall be T-head or lever handle, ground key type, with washer and screw, constructed of polished ASTM B 62 bronze, and rated 850 kilopascal 125 psi working steam pressure (wsp). End connections shall suit the service, with or without union and nipple, as required.

Strainers shall be bronze, conforming to ASTM B 62, or cast iron, conforming to ASTM A 278M ASTM A 278, Class 30, with removable basket. Strainers larger than DN50 2-inches shall be fitted with manufacturer's standard ball type blow down valve.

#### 2.6.3 Thermometers and Pressure Gages

Thermometer shall be dial type, 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. Thermometer wells of the separable socket type shall be provided for each thermometer with direct type bulb.

Pressure gages shall be 90 millimeter 3-1/2 inches nominal diameter and equipped with gage isolators. Case shall be corrosion resistant steel. Gages shall be equipped with damper screw adjustment in inlet connection, and service rating shall be at midpoint of gage range.

#### 2.7 VIBRATION ISOLATION PROVISIONS

Equipment vibration isolation shall be [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 shall be natural rubber. Elastomer shall be chloroprene. Shore A durometer measurement of both materials shall range between 40 and 60.

Inorganic materials such as precompressed, high density, fibrous glass encased in resilient moisture impervious membrane may be provided in lieu of natural rubber and elastomers.

## 2.8 CONTROLS AND INSTRUMENTATION

Automatic controls for temperature, air flow, and humidity shall be [electric,] [electronic,] [solid state electronic,] [pneumatic] type, [or a combination thereof] that will provide the required sequence of operation control. Electrical signals shall be in the [0-5Vdc] [4-20mA] [\_\_\_\_\_] range, and pneumatic signals shall be in the [20-110] [\_\_\_\_\_] kilopascal [3-15] [\_\_\_\_\_] psig range.

Space thermostat shall be [low voltage] [adjustable proportioning] type with Fan Auto-Off and Heat-Off-Cool settings for heating and cooling temperature control. Thermostat location shall be as indicated. Thermostat shall conform to requirements established by ASHRAE 90.1.

Duct humidistats shall be of the insertion, proportioning type, reverse acting, with adjustable minimum throttling range no greater than 2 percent relative humidity, and shall be 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.

Unit control panels shall be constructed 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. Panel shall contain remote pushbutton stations protective devices, gages, and other control devices that are not normally furnished integral with the equipment. Electric wiring shall consist of insulated conductors installed in raceways. Instruments on the panel shall be identified 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 will not be permitted. Control instruments, piping, wiring, and terminals shall be within the cabinet, except that switches, pilot lights, and pushbuttons may be mounted on the cabinet doors. Doors shall be equipped with piano hinges, latches and locks.

## 2.9 COATINGS

Finish coating for cellular elastomer insulation shall be a polyvinyl chloride lacquer approved by the insulation manufacturer.

## PART 3 EXECUTION

### 3.1 GENERAL INSTALLATION REQUIREMENTS

Manufacturer's Instructions for installation of chilled water air conditioning systems shall be submitted showing the manufacturer's recommended method and sequence of installation.

Equipment shall be installed 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. Materials, including offsets, bends, elbows, or other elements that may be required for the work shall be provided and installed by the Contractor, subject to approval by the Contracting Officer.

[Brass] [Aluminum] [\_\_\_\_\_] identification tags carrying manufacturer's name, address, equipment type or style, catalog number or model, and serial number, shall be securely attached to major equipment components.

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

### 3.2 DUCTWORK

Duct strength shall prevent distortion under pressure or vacuum created by fast closure of ductwork devices. Ducts shall be secured to the building and shall be supported to prevent vibration and pulsation under operating conditions.

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

Flanged joints shall be gasketed with chloroprene full face gaskets.

Turning vanes shall be installed at 90 degree elbows. Short radius elbows having radius of 1.0 times the duct width or diameter, or square elbows with factory fabricated turning vanes may be used where space does not permit installation of standard elbows.

Where the size or shape of a duct changes, the transition shall not exceed 15 degrees from the straight run of duct connected thereto.

Balancing dampers of the splitter, butterfly, or multi-louver type, shall be provided where indicated to balance each respective main and branch duct. Control dampers shall be installed under the supervision of the automatic temperature control manufacturer or his authorized agent. Blank-off plates or transitions required to install the dampers in the duct system shall be provided as part of the ductwork.

Fan inlets and outlets shall be connected to upstream and downstream components by treated woven cloth flexible connectors. Connectors shall be installed only after system fans are operative and vibration isolators have been adjusted.



Duct supports shall be vibration isolated from structure. Selection of the hanging system shall, in general, be at the Contractor's option. After system startup, any duct support device that vibrates or could cause failure of a member or damage to ducting shall be replaced, or the condition alleviated, at no added cost to the government.

#### 3.2.1 Metal Ductwork

Sheet metal ductwork installation shall be in accordance with ASHRAE-05, ASHRAE-Hdbk SE-SI, and SMACNA 1481, NFPA 90A, and as indicated.

Dampers located behind architectural intake or exhaust louvers shall be enclosed by a rigid sheet metal collar and sealed to building construction with elastomers for complete air tightness.

Outside air intake ducts and plenums shall be sheet metal and shall have soldered watertight joints.

Access doors shall be provided 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. Construction shall be in accordance with ASHRAE-05, ASHRAE-Hdbk SE-SI, and SMACNA 1481. Doors that leak shall be made airtight at no additional cost to the government.

Friction rod assemblies and perforated strap hangers are not acceptable.

#### 3.2.2 Fibrous Glass Ductwork

Fibrous glass ductwork shall be in accordance with SMACNA 1117, NFPA 90A, and manufacturer's instructions.

Minimum thickness of rectangular duct shall be 25 millimeter 1 inch. Duct reinforcement shall be in accordance with SMACNA 1117.

Cut ends and edges of duct to be joined in the field shall be coated with a suitable mastic or cement to prevent delamination or erosion. Longitudinal joints shall appear as straight lines.

Control rods and similar shaft penetrations shall be made through sheet metal reinforcements on both sides of duct.

Rectangular ducts shall be supported either from joint reinforcement or by trapeze hangers installed to prevent edge cutting of duct.

Fibrous glass duct shall have internal metal reinforcement around entire duct perimeter at points of access, and openings shall be framed with sheet metal.

#### 3.2.3 Flexible Ductwork

Flexible duct runouts shall be no longer than necessary for the application, [ ] meter [ ] feet maximum, and shall be fully extended when installed.

Flexible duct shall be joined and attached in accordance with ASHRAE-05, ASHRAE-Hdbk SE-SI, and SMACNA 1481.

#### 3.2.4 Air Diffusion Devices

Wall mounted supply registers shall be mounted 150 millimeter 6 inches below ceiling.

Wall mounted return registers shall be mounted 150 millimeter 6 inches above the finished floor.

Registers and grilles installed in vertical surfaces shall have horizontal face bars set downward at approximately 35 degrees from vertical.

Registers and grilles installed in horizontal surfaces shall have 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, radius tap-ins shall be constructed in accordance with ASHRAE-05, ASHRAE-Hdbk SE-SI, and SMACNA 1481.

#### 3.3 PIPE INSTALLATION

Pipe support elements shall conform to requirements of MSS SP-58 and MSS SP-69 except as otherwise noted herein. C-clamps shall not be used. Piping, including that which is painted, insulated, or concealed in accessible spaces, shall be labeled to designate service and flow direction.

Connections between steel and copper piping shall be electrically isolated from each other with dielectric couplings (or unions), or flanged with gaskets rated for the service.

Final connections to equipment shall be made with unions or flanges.

Sleeves shall be provided where piping passes through roofs and masonry or concrete walls and floors. Sleeves shall be caulked watertight.

PVC piping shall be installed as indicated and in accordance with the manufacturer's instructions. Joints shall be threaded or solvent cemented in conformance with ASTM D 2855.

Drain piping shall include a P-Trap in line.

#### 3.4 INSULATION

Insulation shall not be applied to system or component surfaces until they have been tested and approved.

Materials shall be applied in accordance with the recommendations of the manufacturer, except as otherwise specified.

Surfaces shall be clean and free of oil and grease before insulation adhesives or mastics are applied.

Contours on exposed work shall be smooth and continuous. Adhesives shall be applied for full coverage.

##### 3.4.1 Acoustic Duct Lining System

Acoustic duct lining shall be applied in cut to size pieces attached to the interior of ductwork with fire resistant adhesive conforming to ASTM C 916

and SAE AMS 3779, Class 2. Top and bottom pieces shall lap the side pieces and, in addition, shall be secured 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. Pins and washers shall be flush with the surface of the duct liner, and all breaks and punctures of the liner shall be sealed with fire-resistant adhesive. Exposed edges of the coated liner, and at joints where the lining will be subject to erosion, shall be heavily brush-coated with adhesive 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, lining shall be secured by pins or adhered clips as specified for cut to size lining.

#### 3.4.2 Mineral Fiber with Glass Cloth Jacket

Piping shall be covered with a mineral fiber, pipe insulation with factory attached, presized, white, glass cloth. Jackets, jacket laps, flaps, and bands shall be securely cemented in place with vapor barrier adhesive. Jacket overlap shall be not less than 40 millimeter 1-1/2 inches. Jacketing bands for butt joints shall be 75 millimeter 3 inches wide.

Exposed to view fittings shall be covered with preformed mineral fiber fitting insulation of the same thickness as the pipe insulation and temporarily secured in place with light cord ties. Impregnated glass lagging tape shall be installed with indoor vapor barrier on 50 percent overlap basis and the tape shall be blended smoothly into the adjacent jacketing. Additional coating shall be applied as needed, and rubber gloved to a smooth contour. Ends of insulation shall be taped to the pipe at valves DN50 2 inches and smaller. On the job fabricated insulation for concealed fittings and special configurations shall be built up from mineral fiber combined with insulating cement mixed with lagging adhesive, diluted with 3 parts water. Surfaces shall be finished with glass cloth or tape lagging.

Valves DN65 2-1/2 inches and larger and all flanges shall be covered with preformed insulation of the same thickness as the adjacent insulation.

Exposed to view insulation shall be finished with a minimum 0.15 millimeter 6 mil dry film thickness of non-vapor barrier coating suitable for painting.

#### 3.4.3 Cellular Elastomer

Refrigerant suction line piping surfaces [and] [condensate drains] [and] [humidifier dispersion piping] shall be covered with [10] [13] millimeter [3/8] [1/2] inch thick flexible cellular elastomer preformed insulation. Vapor seal shall be maintained. Insulation shall be cemented into continuous material with a solvent cutback chloroprene adhesive applied for 100 percent coverage to both surfaces.

Insulation on cold water piping shall be sealed 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. Insulation shall be continuous through pipe supports and shall be protected against compression damage by load bearing inserts at supports.

[Surfaces exposed to view or ultraviolet light shall be finished with a 0.051 millimeter 2 mil minimum dry film thickness of a polyvinyl chloride lacquer, with a minimum of 2 coats.]

#### 3.4.4 Flexible Mineral Fiber with Jacket

Sheet metal duct not lined internally with acoustic duct lining shall be covered with flexible mineral fiber duct insulation with factory attached vapor barrier jacket. Vapor seal shall be maintained. Jacket overlap shall not be less than 50 millimeter 2 inches.

[Insulation shall be cemented to sheet metal surfaces with vapor barrier adhesive.]

Insulation on rectangular or square ducting with side or bottom surface dimensions over 750 millimeter 30 inches shall be impaled on pins secured to the duct surface and then locked by means of flush pin caps. Pins shall be clipped flush with face of cap. Pins shall be 300 millimeter 12 inches on center, placed not more than 50 millimeter 2 inches from duct edges, and there shall be not less than 2 rows of pins per surface. Pins shall be sealed with outdoor vapor barrier coating and vapor barrier duct tape.

When insulation is in place, total thickness shall not be reduced by more than 13 millimeter 0.5 inches, and no condensation shall appear on any surface while the system is operating.

Jackets, jacket flaps, and bands shall be securely cemented in place with vapor barrier adhesive. Jacketing bands for butt joints shall 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.

[Rigid board mineral fiber insulation shall be used where penetrations through sleeves or prepared openings occur.]

Duct insulation at fire dampers shall be as indicated.

Duct insulation terminating at insulated or uninsulated sheet metal and equipment surfaces, supports, damper fittings, walls and any other similar penetration construction points shall be sealed with outdoor vapor-barrier coating and, where lengths exceed 600 millimeter 24 inches, be flashed with glass cloth tape and sheet metal trimming. Glass cloth tape shall be 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.

#### 3.5 VIBRATION ISOLATION

Air handling unit shall be vibration isolated from building structure using vibration isolators and from connecting ductwork using flexible connectors.

Refer to Section 15072S VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT if design may induce vibration considerations.

#### 3.6 CONTROLS AND INSTRUMENTATION

##### 3.6.1 Tubing

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

Hard drawn copper tubing shall be used in all exposed areas. Where concealed, either hard drawn or annealed tubing shall be used. Tubing

shall be cut square, burrs removed, and surfaces cleaned before assembly of joints. Copper joints shall be pressure tested. Copper joints that fail pressure tests shall be remade with new materials, including pipe or tubing fittings and filler metal.

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

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

### 3.6.2 Control Indicating Devices

Each controller, except space thermostats and space humidity controllers, shall be provided with a permanent indicating device at the controller to indicate the exact point at which the controller is operating. Indicating device shall have adjustable setpoint. For individually mounted controllers, the indicating device shall be permanently mounted. For central panel mounted controllers, [individual permanently mounted devices] [or] [a single indicating device having suitable switching means to permit connecting the device to any controller on the panel] shall be provided.

### 3.6.3 Thermostats

Thermostats shall be [full proportioning] [or] [two position] type and shall take full control action for a temperature change of plus or minus 0.5 degrees C 1 degree F of the thermostat setting.

#### 3.6.3.1 Space Thermostat

Space thermostats shall be enclosed with separate locking covers (guards) and shall be mounted 1500 millimeter 60 inches above the floor. [Thermostats shall be provided with proper heating and cooling anticipation to maintain desired space conditions.]

#### 3.6.3.2 Remote Thermostats

Remote thermostats shall be 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. Sensing element shall be secured in the controlled medium flow stream to respond to overall temperature within the duct or pipe. Outdoor compensating thermostat sensing element shall be provided with a protective metal shield or weatherproof housing, and shall be secured where indicated. Controller mechanism shall be mounted indoors where indicated. Reset ratios of the indoor-outdoor compensating thermostat shall be as indicated.

### 3.6.4 Humidistats

Humidistats shall be mounted [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. Humidistats shall be capable of maintaining relative humidity within the limits of the throttling range for relative humidity of [20] [\_\_\_\_\_] to [80] [\_\_\_\_\_] percent and temperatures to [43] [\_\_\_\_\_] degrees C [110] [\_\_\_\_\_] degrees F. [Sensing element shall be suitable for installation location.]

### 3.6.5 Unit Control Panels

Instruments shall be [flush mounted] [or] [back mounted] and shall be completely piped, and wired to properly identified terminal strips. Piping and wiring shall be on the rear of the panel. Electric wiring shall consist of insulated conductors installed in raceways.

### 3.6.6 Controls

Provisions shall be made 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.

Pilot lights, of the front removable type, shall be provided for each piece of motor driven equipment, and a single switch shall be provided 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.

Temperature checkpoints shall be provided [where indicated].

Temperature reset points shall be provided [where indicated].

Start-stop switches and pilot lights shall be provided [where indicated].

Alarm and status indicators shall be provided [where indicated] by:  
[lights] [audible alarm] [printout] [\_\_\_\_\_].

### 3.7 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.**  
\*\*\*\*\*

Entire air-handling and distribution system shall be tested and balanced per NEBB TABES 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.

Duct systems and piping shall be tested in the presence of the Contracting Officer prior to insulation of surfaces, painting, and concealment of work. Water system tests shall be hydrostatic, using potable water supplied by the Government. Contractor shall provide for disposal of contaminated water.

Duct systems shall be structurally tested at static pressures [\_\_\_\_\_] [50] percent in excess of total fan pressure.

Leakage testing shall be at a pressure [normal to the portion of system

under test] [25 percent higher than normal operating pressure]. System will be 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].

Fire dampers shall be tested for proper operation in presence of the Contracting Officer, by activating fusible link with localized heat.

### 3.8 ACCEPTANCE TESTS

Contractor shall use an FFT analyzer to measure vibration levels. It shall have 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.

An accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk(or finished surface) shall be used with the FFT analyzer to collect data. The mass of the accelerometer and its mounting shall have minimal influence on the frequency response of the system over the selected measurement range.

Prior to final acceptance, vibration analysis shall verify motors and fans conformance to specifications. Vibration levels shall not be more than 075 in/sec at 1 times run speed and at pump frequency, and .04 in/sec at other multiples of run speed. Vibration data shall be provided as part of the final test data.

Final test reports shall be provided to the Contracting Officer. Reports shall 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."

### 3.9 OPERATION AND MAINTENANCE

Contractor shall submit [6] [\_\_\_\_\_] copies of the Operation and Maintenance Manuals 30 calendar days prior to testing the chilled water air conditioning systems. Data shall be updated and resubmitted for final approval no later than 30 calendar days prior to contract completion.

-- End of Section --