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USACE / NAVFAC / AFCEA UFGS-15895 (November 2003)  
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Preparing Activity: USACE Superseding  
UFGS-15895 (February 2003)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

Latest change indicated by CHG tags

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SECTION 15895

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM

11/03

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### SECTION 15895

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM  
11/03

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NOTE: This guide specification covers the requirements for air supply, distribution, ventilation, and exhaust portion of an HVAC system.

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

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

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

This guide specification includes tailoring options for air systems equipment, air handling units, terminal units, and energy recovery devices. Selection or deselection of a tailoring option will include or exclude that option in the section, but editing the resulting section to fit the project is still required.

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## PART 1 GENERAL

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NOTE: The use of this specification will be coordinated with other sections, as appropriate, in order to specify a complete HVAC built-up system.

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## 1.1 REFERENCES

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NOTE: Issue (date) of references included in  
project specifications need not be more current than  
provided by the latest guide specification. Use of  
SpecsIntact automated reference checking is  
recommended for projects based on older guide  
specifications.  
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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 CONTRACTORS OF AMERICA (ACCA)

ACCA Manual 4 (2001) Installation Techniques for  
Perimeter Heating & Cooling; 11th Edition

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

AMCA 210 (1999) Laboratory Methods of Testing Fans  
for Aerodynamic Performance Rating

AMCA 300 (1996) Reverberant Room Method for Sound  
Testing of Fans

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

ARI 260 (2001) Sound Rating of Ducted Air Moving  
and Conditioning Equipment

ARI 350 (2000) Sound Rating of Non-Ducted Indoor  
Air-Conditioning Equipment

ARI 410 (2001; Addendum 2002) Forced-Circulation  
Air-Cooling and Air-Heating Coils

ARI 430 (1999) Central-Station Air-Handling Units

ARI 440 (1998) Room Fan-Coils

ARI 880 (1998) Air Terminals

ARI Guideline D (1996) Application and Installation of  
Central Station Air-Handling Units

### AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11 (1990; R 1999) Load Ratings and Fatigue  
Life for Roller Bearings

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

### AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S12.32 (1990; R 2001) Precision Methods for the

Determination of Sound Power Levels of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms (Note: was ASA92, but that document refers to ANSI S12.32.)

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

|             |   |
|-------------|---|
| ASHRAE 15   | (2001; Errata 2002) Safety Standard for Refrigeration Systems   |
| ASHRAE 52.2 | (1999) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size |
| ASHRAE 68   | (1997) Laboratory Method of Testing to Determine the Sound Power In a Duct                                |
| ASHRAE 70   | (1991) Method of Testing for Rating the Performance of Air Outlets and Inlets                             |
| ASHRAE 84   | (1991) Method of Testing Air-to-Air Heat Exchangers   |

AMERICAN WATER WORKS ASSOCIATION (AWWA)

|           |                                      |
|-----------|--------------------------------------|
| AWWA C606 | (1997) Grooved and Shouldered Joints |
|-----------|--------------------------------------|

AMERICAN WELDING SOCIETY (AWS)

|                |  |
|----------------|--|
| AWS D1.1/D1.1M | (2002) Structural Welding Code - Steel |
|----------------|--|

ASME INTERNATIONAL (ASME)

|              |   |
|--------------|---|
| ASME B1.20.1 | (1983; R 2001) Pipe Threads, General Purpose, Inch                    |
| ASME B16.11  | (2002) Forged Fittings, Socket-Welding and Threaded                   |
| ASME B16.18  | (2002) Cast Copper Alloy Solder Joint Pressure Fittings               |
| ASME B16.21  | (1992) Nonmetallic Flat Gaskets for Pipe Flanges                      |
| ASME B16.22  | (2002) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings |
| ASME B16.26  | (1988) Cast Copper Alloy Fittings for Flared Copper Tubes             |
| ASME B16.3   | (1998) Malleable Iron Threaded Fittings                               |
| ASME B16.39  | (1998) Malleable Iron Threaded Pipe Unions                            |
| ASME B16.5   | (1996) Pipe Flanges and Flanged Fittings                              |



|              |  |
|--------------|--|
| ASME B16.9   | (2001) Factory-Made Wrought Steel<br>Buttwelding Fittings                                    |
| ASME B31.1   | (2001) Power Piping  |
| ASME B40.100 | (2000) Pressure Gauges and Gauge<br>Attachments  |
| ASME BPVC IX | (2001) Boiler and Pressure Vessel Code;<br>Section IX, Welding and Brazing<br>Qualifications |

ASTM INTERNATIONAL (ASTM)

|                   |  |
|-------------------|--|
| ASTM A 106        | (2002a) Seamless Carbon Steel Pipe for<br>High-Temperature Service   |
| ASTM A 123/A 123M | (2002) Zinc (Hot-Dip Galvanized) Coatings<br>on Iron and Steel Products  |
| ASTM A 167        | (1999) Stainless and Heat-Resisting<br>Chromium-Nickel Steel Plate, Sheet, and<br>Strip                        |
| ASTM A 181/A 181M | (2001) Carbon Steel Forgings, for<br>General-Purpose Piping  |
| ASTM A 183        | (2003) Carbon Steel Track Bolts and Nuts   |
| ASTM A 193/A 193M | (2003) Alloy-Steel and Stainless Steel<br>Bolting Materials for High-Temperature<br>Service                    |
| ASTM A 234/A 234M | (2002) Piping Fittings of Wrought Carbon<br>Steel and Alloy Steel for Moderate and<br>High Temperature Service |
| ASTM A 47/A 47M   | (1999) Ferritic Malleable Iron Castings  |
| ASTM A 53/A 53M   | (2002) Pipe, Steel, Black and Hot-Dipped,<br>Zinc-Coated, Welded and Seamless                                  |
| ASTM A 536        | (1984; R 1999e1) Ductile Iron Castings   |
| ASTM A 733        | (2003) Welded and Seamless Carbon Steel<br>and Austenitic Stainless Steel Pipe Nipples                         |
| ASTM A 924/A 924M | (1999) General Requirements for Steel<br>Sheet, Metallic-Coated by the Hot-Dip<br>Process                      |
| ASTM B 117        | (2002) Operating Salt Spray (Fog) Apparatus  |
| ASTM B 62         | (2002) Composition Bronze or Ounce Metal<br>Castings   |
| ASTM B 650        | (1995; R 2002) Electrodeposited<br>Engineering Chromium Coatings on Ferrous<br>Substrates                      |

|             |  |
|-------------|--|
| ASTM B 75   | (2002) Seamless Copper Tube  |
| ASTM B 75M  | (1999) Seamless Copper Tube (Metric)   |
| ASTM B 813  | (2000e1) Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube   |
| ASTM B 88   | (2002) Seamless Copper Water Tube  |
| ASTM B 88M  | (1999) Seamless Copper Water Tube (Metric)   |
| ASTM C 1071 | (2000) Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)                                       |
| ASTM C 553  | (2002) Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications                               |
| ASTM C 916  | (1985; R 2001e1) Adhesives for Duct Thermal Insulation   |
| ASTM C 920  | (2002) Elastomeric Joint Sealants  |
| ASTM D 1384 | (2001) Corrosion Test for Engine Coolants in Glassware   |
| ASTM D 1654 | (1992; R 2000) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments                             |
| ASTM D 1785 | (1999) Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120  |
| ASTM D 2000 | (2001) Rubber Products in Automotive Applications  |
| ASTM D 2466 | (2002) Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40   |
| ASTM D 2564 | (2002) Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems   |
| ASTM D 2855 | (1996; R 2002) Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings                          |
| ASTM D 3359 | (2002) Measuring Adhesion by Tape Test   |
| ASTM D 520  | (2000) Zinc Dust Pigment   |
| ASTM E 84   | (2003) Surface Burning Characteristics of Building Materials   |
| ASTM F 1199 | (1988; R 1998) Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum) |

ASTM F 1200 (1988; R 1998) Fabricated (Welded) Pipe  
Line Strainers (Above 150 psig and 150  
degrees F)

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds (2003) EJMA Standards

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)

IEST RP-CC-001.3 (1993) HEPA and ULPA Filters

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

MSS SP-110 (1996) Ball Valves Threaded,  
Socket-Welding, Solder Joint, Grooved and  
Flared Ends

MSS SP-25 (1998) Standard Marking System for Valves,  
Fittings, Flanges and Unions

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

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

MSS SP-70 (1998) Cast Iron Gate Valves, Flanged and  
Threaded Ends

MSS SP-71 (1997) Gray Iron Swing Check Valves,  
Flanged and Threaded Ends

MSS SP-72 (1999) Ball Valves with Flanged or  
Butt-Welding Ends for General Service

MSS SP-80 (2003) Bronze Gate, Globe, Angle and Check  
Valves

MSS SP-85 (2002) Cast Iron Globe & Angle Valves,  
Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2003) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

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

NFPA 96 (2001) Ventilation Control and Fire  
Protection of Commercial Cooking Operations

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

|             |  |
|-------------|--|
| NAIMA AH115 | (2002, 5th Ed) Fibrous Glass Duct Construction Standards |
|-------------|--|

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

|                               |   |
|-------------------------------|---|
| SMACNA Arch. Manual           | (2003, 6th Ed) Architectural Sheet Metal Manual                                     |
| SMACNA HVAC Duct Const Stds   | (1995, 2nd Ed) HVAC Duct Construction Standards - Metal and Flexible                |
| SMACNA Industry Practice      | (1975, 1st Ed) Accepted Industry Practice for Industrial Duct Construction          |
| SMACNA Install Fire Damp HVAC | (2002, 5th Ed) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems |
| SMACNA Leakage Test Mnl       | (1985, 1st Ed) HVAC Air Duct Leakage Test Manual                                    |

UNDERWRITERS LABORATORIES (UL)

|                    |   |
|--------------------|---|
| UL 181             | (1996; Rev thru May 2003) Factory-Made Air Ducts and Air Connectors                                       |
| UL 1995            | (1995; Rev thru Aug 1999) Heating and Cooling Equipment   |
| UL 214             | (1997; Rev thru Aug 2001) Tests for Flame-Propagation of Fabrics and Films                                |
| UL 555             | (1999; Rev thru Jan 2002) Fire Dampers  |
| UL 586             | (1996; Rev thru Apr 2000) High-Efficiency, Particulate, Air Filter Units                                  |
| UL 705             | (2004) Power Ventilators  |
| UL 723             | (2003) Test for Surface Burning Characteristics of Building Materials                                     |
| UL 900             | (1994; Rev thru Oct 1999) Air Filter Units  |
| UL 94              | (1996; Rev thru Dec 2003) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances |
| UL Bld Mat Dir     | (2004) Building Materials Directory   |
| UL Elec Const Dir  | (2003) Electrical Construction Equipment Directory  |
| UL Fire Resist Dir | (2004) Fire Resistance Directory  |

## 1.2 COORDINATION OF TRADES

Ductwork, piping offsets, fittings, and accessories shall be furnished as required to provide a complete installation and to eliminate interference with other construction.

## 1.3 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

## 1.4 FIELD MEASUREMENTS

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

## 1.5 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy 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.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

#### SD-02 Shop Drawings

Drawings[; G][; G, [\_\_\_\_]]  
Installation[; G][; G, [\_\_\_\_]]

Drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of all guides and anchors, the load imposed on each support or anchor, and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

#### SD-03 Product Data

##### Components and Equipment

Manufacturer's catalog data included with the detail drawings for the following items. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with contract requirements for the following:

- a. Piping Components
- b. Ductwork Components
- c. Air Systems Equipment
- d. Air Handling Units
- e. Energy Recovery Devices
- f. Terminal Units

Test Procedures[; G][; G, [\_\_\_\_]]

Proposed test procedures for piping hydrostatic test, ductwork leak test, and performance tests of systems, at least 2 weeks prior to the start of related testing.

Welding Procedures[; G][; G, [\_\_\_\_]]

A copy of qualified welding procedures, at least 2 weeks prior to the start of welding operations.

Diagrams[; G][; G, [\_\_\_\_]]

Proposed diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment,

piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

#### Manufacturer's Experience

Statement demonstrating successful completion of similar services on at least 5 projects of similar size and scope, at least 2 weeks prior to submittal of other items required by this section.

#### Welded Joints

A list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations.

Performance Tests[; G][; G, [\_\_\_\_]]

Proposed test schedules for hydrostatic test of piping, ductwork leak test, and performance tests, at least 2 weeks prior to the start of related testing.

Field Training[; G][; G, [\_\_\_\_]]

Proposed schedule for field training, at least 2 weeks prior to the start of related training.

#### SD-06 Test Reports

Performance Tests  
Testing, Adjusting, and Balancing

Test reports for the piping hydrostatic test, ductwork leak test, and performance tests in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

#### SD-07 Certificates

##### Bolts

Written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, and the number of each type of bolt to be furnished.

#### SD-10 Operation and Maintenance Data

##### Operating and Maintenance Instructions

[Six] [\_\_\_\_] manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of

parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing [4] [\_\_\_\_\_] hour onsite response to a service call on an emergency basis.

## PART 2 PRODUCTS

### 2.1 STANDARD PRODUCTS

Components and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year manufacturer's experience shall include applications of components and equipment under similar circumstances and of similar size. The 2 years must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization.

### 2.2 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products shall not be used.

### 2.3 NAMEPLATES

Equipment shall have a nameplate installed by the manufacturer that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

### 2.4 EQUIPMENT GUARDS AND ACCESS

\*\*\*\*\*  
**NOTE: Catwalks, ladders, and guardrails may be required. If so, select the applicable item and indicate on drawings. If not applicable, delete the entire sentence.**  
\*\*\*\*\*

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. [Catwalks,] [operating platforms,] [ladders,] [and] [guardrails] shall be provided where shown and shall be constructed according to Section 05500A MISCELLANEOUS METAL.

### 2.5 PIPING COMPONENTS

#### 2.5.1 Steel Pipe

Steel pipe shall conform to ASTM A 53/A 53M, Schedule 40, Grade A or B,



Type E or S.

## 2.5.2 Joints and Fittings For Steel Pipe

Joints shall be welded, flanged, threaded, or grooved as indicated. If not otherwise indicated, piping 25 mm1 inch and smaller shall be threaded; piping larger than 25 mm1 inch and smaller than 80 mm3 inches shall be either threaded, grooved, or welded; and piping 80 mm3 inches and larger shall be grooved, welded, or flanged. Rigid grooved mechanical joints and fittings may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 110 degrees C230 degrees F. Flexible grooved joints shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein. The manufacturer of each fitting shall be permanently identified on the body of the fitting according to MSS SP-25.

### 2.5.2.1 Welded Joints and Fittings

Welded fittings shall conform to ASTM A 234/A 234M, and shall be identified with the appropriate grade and marking symbol. Butt-welded fittings shall conform to ASME B16.9. Socket-welded fittings shall conform to ASME B16.11.

### 2.5.2.2 Flanged Joints and Fittings

Flanges shall conform to ASTM A 181/A 181M and ASME B16.5, Class 150. Gaskets shall be nonasbestos compressed material according to ASME B16.21, 2.0 mm1/16 inch thickness, full face or self-centering flat ring type. The gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.5. Bolts shall be high or intermediate strength material conforming to ASTM A 193/A 193M.

### 2.5.2.3 Threaded Joints and Fittings

Threads shall conform to ASME B1.20.1. Unions shall conform to ASME B16.39, Class 150. Nipples shall conform to ASTM A 733. Malleable iron fittings shall conform to ASME B16.3, type as required to match piping.

### 2.5.2.4 Dielectric Waterways

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

### 2.5.2.5 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 862 kPa125 psig service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12; or steel conforming to ASTM A 106, Grade B or ASTM A 53/A 53M. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D 2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 110 degrees C230 degrees F or Grade No.

M3BA610A15B44Z for circulating medium up to 93 degrees C200 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183.

### 2.5.3 Copper Tube

Copper tube shall conform to ASTM B 88, and ASTM B 88M, Type K or L.

### 2.5.4 Joints and Fittings For Copper Tube

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Grooved mechanical joints and fittings shall be designed for not less than 862 kPa125 psig service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A 536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D 2000 for circulating medium up to 110 degrees C230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A 183.

### 2.5.5 Valves

Valves shall be Class 125 and shall be suitable for the intended application. Valves shall meet the material, fabrication and operating requirements of ASME B31.1. Chain operators shall be provided for valves located 3 meters10 feet or higher above the floor. Valves in sizes larger than 25 mm1 inch and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be provided by the same manufacturer as the grooved pipe joint and fitting system.

#### 2.5.5.1 Gate Valves

Gate valves 65 mm2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with rising stem and threaded, solder, or flanged ends. Gate valves 80 mm3 inches and larger shall conform to MSS SP-70 and shall be cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

#### 2.5.5.2 Globe Valves

Globe valves 65 mm2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Globe valves 80 mm3 inches and larger shall conform to MSS SP-85 and shall be cast iron with bronze trim and flanged, or threaded ends.

#### 2.5.5.3 Check Valves

Check valves 65 mm2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Check valves 80 mm3 inches and larger shall conform to MSS SP-71 and shall be cast iron

with bronze trim and flanged or threaded ends.

#### 2.5.5.4 Angle Valves

Angle valves 65 mm2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Angle valves 80 mm3 inches and larger shall conform to MSS SP-85 and shall be cast iron with bronze trim and flanged, or threaded ends.

#### 2.5.5.5 Ball Valves

\*\*\*\*\*  
**NOTE: Ball valves should be used only for drain valves or in makeup waterlines.**  
\*\*\*\*\*

Ball valves 15 mm1/2 inch and larger shall conform to [MSS SP-72] [or] [MSS SP-110], and shall be ductile iron or bronze with threaded, soldered, or flanged ends.

#### 2.5.5.6 Butterfly Valves

Butterfly valves shall be 2 flange or lug wafer type, and shall be bubble-tight at 1.03 MPa150 psig. Valve bodies shall be cast iron, malleable iron, or steel ASTM A 167, Type 404 or Type 316, corrosion resisting steel stems, bronze or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 200 mm 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 200 mm8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

#### 2.5.5.7 Balancing Valves

\*\*\*\*\*  
**NOTE: Automatic flow control valves may be deleted.**

A supplemental flow measuring scheme or device must be used to measure flow with a manual balancing valve. A calibrated balancing valve incorporates a flow measuring element and can be used in place of a manual balancing valve and a flow measuring device. An automatic flow control valve offers complete flow control in many applications; however, the flow control range is dependent on inlet pressure being within a given range, the flow selection is limited, and, in some cases it may require pump power slightly more than alternative balancing means.

In any facility where typical load imbalances cannot be tolerated and there is a need for automatic control insuring constant hydronic flow, the design will incorporate automatic flow-control valves. The location and capacity of the automatic control valves will be shown on the drawings.

\*\*\*\*\*

Balancing valves 50 mm2 inches or smaller shall be bronze with NPT

connections for black steel pipe and brazed connections for copper tubing. Valves 25 mm1 inch or larger may be all iron with threaded or flanged ends.

The valves shall have a square head or similar device and an indicator arc and shall be designed for 120 degrees C250 degrees F. Iron valves shall be lubricated, nonlubricated, or tetrafluoroethylene resin-coated plug valves.

In lieu of plug valves, ball valves may be used. Plug valves and ball valves 200 mm8 inches or larger shall be provided with manual gear operators with position indicators. [In lieu of balancing valves specified] [Where indicated], automatic flow control valves may be provided to maintain constant flow, and shall be designed to be sensitive to pressure differential across the valve to provide the required opening. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves shall control the flow within 5 percent of the tag rating. Valves shall be suitable for the maximum operating pressure of 862 kPa125 psig or 150 percent of the system operating pressure, whichever is the greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, the system pump head capability shall be appropriately increased. Where flow readings are provided by remote or portable meters, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve. A portable meter furnished with accessory kit as recommended by the automatic valve manufacturer shall be provided. Automatic flow control valve specified may be substituted for venturi tubes or orifice plate flow measuring devices.

#### 2.5.5.8 Air Vents

\*\*\*\*\*  
**NOTE: Air vents will be shown on drawings;  
distinguish between manual and automatic air vents.**  
\*\*\*\*\*

Manual air vents shall be brass or bronze valves or cocks suitable for pressure rating of piping system and furnished with threaded plugs or caps. Automatic air vents shall be float type, cast iron, stainless steel, or forged steel construction, suitable for pressure rating of piping system.

#### 2.5.6 Strainers

\*\*\*\*\*  
**NOTE: Reference ASTM F 1199 when the operating  
conditions are at 150 psig and 150 degrees F or  
less; otherwise reference ASTM F 1200.**  
\*\*\*\*\*

Strainer shall be in accordance with [ASTM F 1199] [ASTM F 1200], except as modified herein. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. The strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with removable cover and sediment screen. The screen shall be made of minimum 0.8 mm (22 gauge) 22 gauge [brass sheet,] [monel,] [corrosion-resistant steel,] with small perforations numbering not less than 60 per square centimeter400 per square inch to provide a net free area through the basket of at least 3.3 times that of the entering pipe. The

flow shall be into the screen and out through the perforations.

#### 2.5.7 Chilled Water System Accessories

\*\*\*\*\*  
**NOTE: Coordinate this paragraph with the appropriate component specifications and reference as applicable.**  
\*\*\*\*\*

Chilled water system accessories such as pumps, combination strainer and suction diffusers, and expansion tanks shall be as specified in Section [\_\_\_\_\_].

#### 2.5.8 Water or Steam Heating System Accessories

Water or steam heating accessories such as expansion tanks and steam traps shall be as specified in Section 15569A WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 20 MBTUH.

#### 2.5.9 Glycol

\*\*\*\*\*  
**NOTE: When glycol is used, equipment capacities should be adjusted for changes in specific heat and viscosity as shown in the ASHRAE Handbook "HVAC Systems and Equipment". Ethylene glycol should be used unless there is a possibility of contamination of the potable water system, in which case propylene glycol should be used. The concentration required should be based on the anticipated ambient or operating temperature.**  
\*\*\*\*\*

The glycol shall be tested according to ASTM D 1384 and shall cause less than 0.0125 mm0.5 mils penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicon based inhibitors shall not be used. The solution shall be compatible with all wetted items within the system.

#### 2.5.10 Backflow Preventers

Backflow preventers shall be according to Section 15400A PLUMBING, GENERAL PURPOSE.

#### 2.5.11 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 862 kPa125 psi or 1034 kPa 150 psi service as appropriate for the static head plus the system head, and [120 degrees C,250 degrees F,] [110 degrees C230 degrees F] for grooved end flexible connectors. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. The flexible section shall be suitable for intended service with end connections to match adjacent piping. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer.

Covers to protect the bellows shall be provided where indicated.

#### 2.5.12 Pressure Gauges

Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 85 mm3-1/2 inches in diameter and shall have a range from 0 kPa0 psig to approximately 1.5 times the maximum system working pressure.

#### 2.5.13 Thermometers

Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 225 mm9 inch scale, and shall have rigid stems with straight, angular, or inclined pattern.

#### 2.5.14 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or setscrews.

#### 2.5.15 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

#### 2.5.16 Expansion Joints

\*\*\*\*\*  
**NOTE: Expansion loops, offsets, and bends will be used where possible instead of expansion joints. All expansion provisions, including necessary details, will be shown on the drawings. Expansion joints should be located in serviceable areas.**  
\*\*\*\*\*

##### 2.5.16.1 Slip Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the traverse indicated. The joints shall be designed for working temperature and pressure suitable for the application, but not less than 1034 kPa150 psig, and shall be according to applicable requirements of EJMA Stds and ASME B31.1. End connections shall be flanged or beveled for welding as indicated. Joint shall be provided with an anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip shall be seamless steel plated with a minimum of 0.058 mm2 mils of hard chrome according to ASTM B 650. All joint components shall be suitable for the intended service. Initial setting shall be made according to the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall be not more than 100 mm4 inches or smaller, guides shall be installed not more than 600 mm2 feet from the joint. Service outlets shall be provided where indicated.

##### 2.5.16.2 Flexible Ball Joints

\*\*\*\*\*

**NOTE: The ball joint only moves in an angular offset or rotation mode. The configuration of the ball joint link will require a 2 or 3 ball joint offset to absorb axial and/or lateral movement.**

\*\*\*\*\*

Flexible ball joints shall conform to EJMA Stds and ASME B31.1 and be constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint shall be designed for packing injection under full line pressure to contain leakage. The joint ends shall be threaded to 50 mm2 inches only, grooved, flanged, or beveled for welding as indicated or required and shall be capable of absorbing a minimum of 15-degree angular flex and 360 degree rotation. Balls and sockets shall be suitable for the intended service. The exterior spherical surface of carbon steel balls shall be plated with mils of hard chrome according to ASTM B 650. The ball type joints shall be designed and constructed according to EJMA Stds and ASME B31.1 where applicable. Where required, flanges shall conform to ASME B16.5.

#### 2.5.16.3 Bellows Type Joints

Bellows type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows type expansion joints shall conform to the applicable requirements of EJMA Stds with internal sleeves. Guiding of piping on both sides of expansion joint shall be according to the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but not less than 1034 kPa150 psig.

#### 2.5.17 Insulation

Shop and field applied insulation shall be as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

#### 2.5.18 Condensate Drain Lines

Condensate drainage shall be provided for each item of equipment that generates condensate as specified for drain, waste, and vent piping systems in Section 15400A PLUMBING, GENERAL PURPOSE.

### 2.6 ELECTRICAL WORK

\*\*\*\*\*

**NOTE: Electrical characteristics, motor starter type, enclosure type, and maximum rpm should be shown on the drawings in the equipment schedules.**

\*\*\*\*\*

Electrical motor-driven equipment specified shall be provided complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be according to Section 16402 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 745 W1 hp and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary. Each motor shall be according to NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control

and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 7.45 kW10 hp or less. Adjustable frequency drives shall be used for larger motors.

## 2.7 CONTROLS

Controls shall be provided as specified in Section 15950A HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS.

## 2.8 DUCTWORK COMPONENTS

\*\*\*\*\*

NOTE: The appropriate pressure classification from SMACNA HVAC Duct Const Stds, including points of changes in pressure classification, will be noted on the drawings. Indicate pitch of ductwork, low spots in ductwork, and means of disposing of condensate, where required. Outdoor air intakes should be sized so that rain and snow are not drawn into the ductwork. Watertight intakes shall be sloped to a drain line with provisions made to dispose of the water. The requirement that outdoor air intake ducts and plenums be fabricated watertight with soldered or brazed joints and seams may be eliminated where it is not anticipated that rain or snow will be drawn into the outdoor air intake.

The use of flexible duct should be limited due to the inordinate pressure drop and corresponding fan energy consumption that it causes. The extent of flexible duct will be shown on the drawings. The designer should also ensure that the restrictions in these standards pertaining to the use of non-metallic materials in air distribution plenums are adhered to.

The flammability and combustibility of non-metallic duct materials is controlled by NFPA 90A, 90B, and 91. The extent of non-metallic duct that can be used should be shown on the drawings when these standards limit its use.

\*\*\*\*\*

### 2.8.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA HVAC Duct Const Stds unless otherwise specified. Elbows shall be radius type with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, and 500 Pa (1/2, 1, and 2 inch w.g.) 1/2, 1, and 2 inch w.g. ductwork shall meet the requirements of Seal Class C. Class 750 through 2500 Pa (3 through 10 inch w.g.) 3 through 10 inch w. g. shall meet the requirements of Seal Class A. All ductwork in VAV systems upstream of



the VAV boxes shall meet the requirements of Seal Class A. Sealants shall conform to fire hazard classification specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS and shall be suitable for the range of air distribution and ambient temperatures that it will be exposed to. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA HVAC Duct Const Stds. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 50 mm<sup>2</sup> inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable. Outdoor air intake ducts and plenums shall be fabricated with watertight soldered or brazed joints and seams.

#### 2.8.1.1 Transitions

Diverging air flow transitions shall be made with each side pitched out a maximum of 15 degrees, for an included angle of 30 degrees. Transitions for converging air flow shall be made with each side pitched in a maximum of 30 degrees, for an included angle of 60 degrees, or shall be as indicated. Factory-fabricated reducing fittings for systems using round duct sections when formed to the shape of the ASME short flow nozzle, need not comply with the maximum angles specified.

#### 2.8.1.2 Metallic Flexible Duct

Metallic type duct shall be single-ply [galvanized steel] [Type 316 stainless steel] [two-ply aluminum] [, self supporting to 2.4 m<sup>8</sup> foot spans]. Duct shall be of corrugated/interlocked, folded and knurled type seam construction, bendable without damage through 180 degrees with a throat radius equal to 0.5 duct diameter. Duct shall conform to UL 181 and shall be rated for positive or negative working pressure of 3.75 kPa<sup>15</sup> inches water gauge at 177 degrees C<sup>350</sup> degrees F when duct is aluminum, and 343 degrees C<sup>650</sup> degrees F when duct is galvanized steel or stainless steel.

#### 2.8.1.3 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runout length shall be as shown on the drawings, but shall in no case exceed 3 m<sup>10</sup> feet. Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

#### 2.8.1.4 General Service Duct Connectors

A flexible duct connector approximately 150 mm<sup>6</sup> inches in width shall be provided where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, the flexible material shall be secured by stainless steel or zinc-coated, iron

clinch-type draw bands. For rectangular ducts, the flexible material locked to metal collars shall be installed using normal duct construction methods. The composite connector system shall comply with UL 214 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

#### 2.8.1.5 High Temperature Service Duct Connections

Material shall be approximately 2.38 mm3/32 inch thick, 1.2 to 1.36 kg per square meter (35 to 40-ounce per square yard)35 to 40-ounce per square yard weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 650 degrees C1200 degrees F.

#### 2.8.2 Fibrous Glass Ductwork

\*\*\*\*\*  
**NOTE: Fibrous glass ducts will not be used in  
air-conditioning systems for medical facilities or  
in clean rooms with requirements equal to or  
exceeding Class 100 or in unconditioned spaces in  
cooling only systems, i.e., cooling only ducts  
installed in attics.**  
\*\*\*\*\*

Fibrous glass ductwork may be provided in lieu of sheet metal ductwork except that fibrous glass ductwork will not be allowed in fan and equipment rooms, where subject to traffic or weather damage, for outside air intakes, for risers of more than two stories, in kitchen or fume exhaust ducts, to convey solids or corrosive gases, in concrete, for burial below grade, as casings or housings, or in systems used for life support systems. Fibrous glass ductwork, including all components, shall be fabricated according to NAIMA AH115 where the velocity and the static pressure are within its scope. Where the velocity or static pressure exceeds these limits, the ductwork manufacturer shall certify that the ductwork is intended for the velocities and pressures to be encountered, and that the proposed installation meets all performance criteria specified herein for metal ductwork. Fibrous glass ductwork shall have the thermal equivalent of the insulation specified for metal ductwork in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Field or factory fabricated fibrous glass ductwork shall conform to UL 181, Class 1. Duct wall penetrations, transverse joints and longitudinal seams shall be sealed as instructed by the manufacturer by one of the methods prescribed by NAIMA AH115, where applicable, except that pressure sensitive tape shall not be used as a sealant. All items necessary for a complete installation shall be provided as specified for sheet metal duct systems.

#### 2.8.3 Ductwork Accessories

##### 2.8.3.1 Duct Access Doors

\*\*\*\*\*  
**NOTE: Provide duct access doors at regular  
intervals to facilitate the cleaning of duct systems  
for applications requiring clean air supplies, such  
as hospitals, laboratories, electronics servicing  
and similar activities.**  
\*\*\*\*\*

Access doors shall be provided in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers,

coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA HVAC Duct Const Stds. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 x 450 mm, 15 x 18 inches, unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 x 600 mm, 24 x 24 inches or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

#### 2.8.3.2 Fire Dampers

\*\*\*\*\*  
**NOTE: The designer must indicate on the drawings the location of each fire damper and details of the damper installations. Fire dampers must be provided according to NFPA 90A. Three-hour rated fire dampers must be specifically identified on plans.**  
\*\*\*\*\*

Fire dampers shall be 1.5 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. The Contractor shall perform the fire damper test as outlined in NFPA 90A. A pressure relief damper shall be provided upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then this pressure relief damper shall be factory insulated. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specific application, and shall be installed according to their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resist Dir. Fire dampers shall be [curtain type with damper blades] [in the air stream] [out of the air stream] [or] [single blade type] [or] [multi-blade type]. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA Install Fire Damper HVAC and in manufacturer's instructions for fire dampers shall be followed. Acceptance testing of fire dampers shall be performed per paragraph Fire Damper Acceptance Test and NFPA 90A.

#### 2.8.3.3 Splitters and Manual Balancing Dampers

\*\*\*\*\*  
**NOTE: Designer will indicate all volume dampers on the drawings. Diffuser and register volume dampers will not be used for balancing.**  
\*\*\*\*\*

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portions of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 5 mm 3/16 inch

rod brought through the side of the duct with locking setscrew and bushing. Two rods are required on splitters over 200 mm8 inches. Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm12 inches. Access doors or panels shall be provided for all concealed damper operators and locking setscrews. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

#### 2.8.3.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors or extractors for branch connections. All air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein. Fixed air deflectors, also called turning vanes, shall be provided in 90 degree elbows.

#### 2.8.4 Duct Sleeves, Framed Prepared Openings, Closure Collars

##### 2.8.4.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 375 mm15 inches in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm15 inches in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) 20 gauge galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, ASTM A 53/A 53M, Schedule 20 shall be used. Sleeve shall provide 25 mm1 inch clearance between the duct and the sleeve

or 25 mm1 inch clearance between the insulation and the sleeve for insulated ducts.

#### 2.8.4.2 Framed Prepared Openings

Openings shall have 25 mm1 inch clearance between the duct and the opening or 25 mm1 inch clearance between the insulation and the opening for insulated ducts.

#### 2.8.4.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm4 inches wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm15 inches in diameter or less shall be fabricated from 1.0 mm (20 gauge)20 gauge galvanized steel. Collars for round ducts larger than 375 mm15 inches and square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge)18 gauge galvanized steel. Collars shall be installed with fasteners on maximum 150 mm6 inch centers, except that not less than 4 fasteners shall be used.

#### 2.8.5 Plenums and Casings for Field-Fabricated Units

\*\*\*\*\*  
**NOTE: If field-fabricated air handling units are not used, delete this paragraph entirely. Delete inapplicable sentences or items. Delete the push-button station if not required.**  
\*\*\*\*\*

#### 2.8.5.1 Plenum and Casings

Plenums and casings shall be fabricated and erected as shown in SMACNA HVAC Duct Const Stds, as applicable. Unless otherwise indicated, system casing shall be constructed of not less than 1.6 mm (16 gauge)16 gauge galvanized sheet steel. Cooling coil drain pans with 25 mm1 inch threaded outlet shall be provided to collect condensation from the cooling coils. Drain pans shall be fabricated of not lighter than 1.6 mm (16 gauge)16 gauge steel, galvanized after fabrication or of 1.3 mm (18 gauge)18 gauge corrosion-resisting sheet steel conforming to ASTM A 167, Type 304, welded and stiffened. Drain pans exposed to the atmosphere shall be thermally insulated to prevent condensation. Insulation shall be coated with a flame resistant waterproofing material. Separate drain pans shall be provided for each vertical coil section, and a separate drain line shall be provided for each pan. Pans shall be generously sized to ensure capture of entrained moisture on the downstream-air side of the coil. Openings in the casing, such as for piping connections, shall be sealed and covered to prevent air leakage. Water seal for the drain shall provide at least 500 Pa 2 inch water gauge greater than the maximum negative pressure in the coil space.

#### 2.8.5.2 Casing

Casings shall be terminated at the curb line and anchored by the use of galvanized angle iron sealed and bolted to the curb, as indicated in SMACNA

HVAC Duct Const Stds.

#### 2.8.5.3 Access Doors

\*\*\*\*\*  
NOTE: Designer should determine whether an electrical push-button to stop the fan by a person inside the casing is required. If required, the drawings will be checked to ensure that the item is shown, and properly coordinated with electrical drawings.  
\*\*\*\*\*

Access doors shall be provided in each section of the casing. Door frames shall be welded in place, and each door shall be neoprene gasketed, hinged with minimum of two brass hinges, and fastened with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, doors shall be 900 x 450 mm36 x 18 inches located 450 mm18 inches above the floor. Where the space available will not accommodate doors of this size, doors as large as the space will accommodate shall be provided. Doors shall swing so that fan suction or pressure holds door in closed position, and shall be airtight. A push-button station to stop the supply fan shall be located inside the casing where indicated.

#### 2.8.5.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components may be used for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Panels shall be of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Panel joints shall be sealed and insulated access doors shall be provided and gasketed to prevent air leakage. Panel construction shall be not less than 1.0 mm (20 gauge)20 gauge galvanized sheet steel and shall be assembled with fasteners treated against corrosion. Standard length panels shall deflect not more than 13 mm1/2 inch under operation. Details of construction, including joint sealing, not specifically covered shall be as indicated in SMACNA HVAC Duct Const Stds. The plenums and casings shall be constructed to withstand the specified internal pressure of the air systems.

#### 2.8.5.5 Duct Liner

Unless otherwise specified, duct liner shall conform to ASTM C 1071, Type I or II.

#### 2.8.6 Sound Attenuation Equipment

\*\*\*\*\*  
NOTE: Sound attenuators or acoustical duct liner will be used only where acoustical treatment is required and there are no other suitable alternatives. Acoustical duct liner will not be used in systems where the total pressure is above 1000 Pa (4 inches water gauge) in any portion of the air-conditioning system in medical facilities for Army construction.  
  
Refer to TM 5-805-4, Noise and Vibration Control for Mechanical Equipment, for noise criteria. Sound power levels required should be included in the

appropriate schedule on the drawings.

\*\*\*\*\*

- a. Systems With Total Pressure Above 1 kPa (4 Inches Water Gauge)  
4 Inches Water Gauge:

Sound attenuators shall be provided on the discharge duct of each fan operating at a total pressure above 1 kPa (4 inch water gauge), 4 inch water gauge, and, when indicated, at the intake of each fan system. Sound attenuators shall be provided elsewhere as indicated. The sound attenuators shall be factory fabricated and shall be tested by an independent laboratory for sound and performance characteristics. Net sound reduction shall be as indicated. Maximum permissible pressure drop shall not exceed 157 Pa (0.63 inch water gauge) 0.63 inch water gauge. Traps shall be constructed to be airtight when operating under an internal static pressure of 2.5 kPa 10 inch water gauge. Air-side surface shall be capable of withstanding air velocity of 50 m/s (10,000 fpm) 10,000 fpm. The Contractor shall certify that the sound reduction values specified will be obtained after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Sound absorbing material shall conform to ASTM C 1071, Type I or II. Sound absorbing material shall meet the fire hazard rating requirements for insulation specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. A duct transition section shall be provided for connection to ductwork. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system may be provided in lieu of factory fabricated sound attenuators, and shall comply with requirements specified for factory fabricated sound attenuators. The double-walled duct and fittings shall be constructed of an outer metal pressure shell of zinc-coated steel sheet, 25 mm 1 inch thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Sufficient length of run shall be provided to obtain the noise reduction coefficient specified. The Contractor shall certify that the sound reduction value specified will be obtained within the length of duct run provided. The outer sheet metal of the double-walled duct shall have welded, or spiral lock, seams to prevent water vapor penetration. The outer sheet of the duct and fittings shall conform to the metal thickness of high pressure spiral and round ducts and fittings shown in SMACNA HVAC Duct Const Stds. The acoustical insulation shall have a thermal conductivity "k" of not more than 0.0389 W/m-K (0.27 Btu/inch/square foot/hour/degree F) 0.27 Btu/inch/square foot/hour/degree F at 24 degrees C 75 degrees F mean temperature. The internal perforated zinc-coated metal liner shall be not less than 0.7 mm (24 gauge) 24 gauge with perforations not larger than 6.35 mm 1/4 inch in diameter providing a net open area not less than 10 percent of the surface.

- b. System With Total Pressure of 1000 Pa (4 Inch Water Gauge) 4 Inch Water Gauge and Lower:

Sound attenuators shall be provided only where indicated, or in lieu of lined ducts. Factory fabricated sound attenuators shall be constructed of galvanized steel sheets. Outer casing shall be not less than 0.85 mm (22 gauge) 22 gauge. Acoustical fill shall be fibrous glass. Net sound reduction shall be as indicated. Values shall be obtained on a test unit not less than 600 by 600 mm 24 by 24 inches outside dimensions made by a certified nationally recognized independent acoustical laboratory. Air flow capacity shall be as indicated or required. Pressure drop through the attenuator shall not exceed the value indicated, or shall not be in excess of 15 percent of the total external static pressure of the air handling

system, whichever is less. Sound attenuators shall be acoustically tested with metal duct inlet and outlet sections while under the rated air flow conditions. Noise reduction data shall include the effects of flanking paths and vibration transmission. Sound attenuators shall be constructed to be airtight when operating at the internal static pressure indicated or specified for the duct system, but in no case less than 500 Pa (2 inch water gauge) 2 inch water gauge.

c. Acoustical Duct Liner:

Acoustical duct lining shall be fibrous glass designed exclusively for lining ductwork and shall conform to the requirements of ASTM C 1071, Type I and II. Liner composition may be uniform density, graduated density, or dual density, as standard with the manufacturer. Lining shall be coated, not less than 25 mm 1 inch thick. Where acoustical duct liner is used, liner or combination of liner and insulation applied to the exterior of the ductwork shall be the thermal equivalent of the insulation specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Duct sizes shown shall be increased to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, acoustically equivalent lengths of fibrous glass duct or factory fabricated double-walled internally insulated duct with perforated liner may be provided. Net insertion loss value, static pressure drop, and air flow velocity capacity data shall be certified by a nationally recognized independent acoustical laboratory.

2.8.7 Diffusers, Registers, and Grilles

\*\*\*\*\*

**NOTE: Coordinate with paragraph Sound Attenuation Equipment.**

**If diffusers or registers or grilles are not required, reference to the omitted items will be deleted. Specified performance characteristics peculiar to the omitted items will be deleted. If any one or two of the three types of units are omitted, the corresponding subparagraph will be deleted.**

\*\*\*\*\*

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified according to ASHRAE 70. Inlets and outlets shall be sound rated and certified according to ASHRAE 70. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m 7 feet above the floor, they shall be protected by a grille or screen according to NFPA 90A.



#### 2.8.7.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Elec Const Dir for the interchangeable use as cooled or heated air supply diffusers or return air units. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

#### 2.8.7.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm6 inches below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 150 mm6 inches above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

#### 2.8.8 Louvers

\*\*\*\*\*  
**NOTE: The designer will ensure that louver  
selection includes consideration of parameters such  
as pressure drop and water penetration.**  
\*\*\*\*\*

Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in SMACNA Arch. Manual.

#### 2.8.9 Air Vents, Penthouses, and Goosenecks

Air vents, penthouses, and goosenecks shall be fabricated from galvanized steel [or aluminum] sheets with galvanized [or aluminum] structural shapes. Sheet metal thickness, reinforcement, and fabrication shall conform to SMACNA HVAC Duct Const Stds. Louver blades shall be accurately fitted and secured to frames. Edges of louver blades shall be folded or beaded for rigidity and baffled to exclude driving rain. Air vents, penthouses, and goosenecks shall be provided with bird screen.

#### 2.8.10 Bird Screens and Frames

Bird screens shall be No. 2 mesh, aluminum or stainless steel. Aluminum screens shall be rated "medium-light". Stainless steel screens shall be rated "light". Frames shall be removable type, or stainless steel or extruded aluminum.

### 2.8.11 Radon Exhaust Ductwork

Radon exhaust ductwork installed in or beneath slabs shall be fabricated from Schedule 40 PVC pipe that conforms to ASTM D 1785. Fittings shall conform to ASTM D 2466. Solvent cement used to make joints shall conform to ASTM D 2564. Otherwise radon exhaust ductwork shall be metal as specified herein.

## 2.9 AIR SYSTEMS EQUIPMENT

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NOTE: Items in this paragraph may or may not be required depending on whether field-fabricated air handling units apply or whether equipment external to air handling units are used in the distribution system.  
\*\*\*\*\*

### 2.9.1 Fans

\*\*\*\*\*  
NOTE: Coordinate with paragraph Sound Attenuation Equipment.  
  
Refer to TM 5-805-4, Noise and Vibration Control for Mechanical Equipment, for vibration criteria. Vibration isolation required should be shown and included in the appropriate schedule on the drawings.  
  
The designer will indicate the location of each duct smoke detector in the HVAC system and will indicate the detectors on the schematic and associated ladder diagram. Duct smoke detectors will be provided according to NFPA 90A. Duct detectors are intended to shut associated air distribution fans and smoke dampers, if provided. Duct smoke detectors are not for use inside ducts where ambient temperatures exceed 38 degrees C (100 degrees F).  
  
When the building is equipped with a fire alarm system, the duct smoke detectors will be connected to the fire alarm control panel (FACP) for alarm initiation. The designer will indicate wiring to the FACP. For existing fire alarm systems, the designer will detail the connection to the FACP.  
\*\*\*\*\*

Fans shall be tested and rated according to AMCA 210. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than [150] [140] [120] percent of the connected driving capacity. Motor sheaves shall be variable pitch for 11 kW (15 hp) 15 hp and below and fixed pitch as defined by ARI Guideline D. Variable pitch sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at

the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports or mountings as indicated. Vibration-isolation units shall be standard products with published loading ratings. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated.

#### 2.9.1.1 Centrifugal Fans

Centrifugal fans shall be fully enclosed, single-width single-inlet, or double-width double-inlet, AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Impeller wheels shall be rigidly constructed, accurately balanced both statically and dynamically. [Fan blades may be forward curved or backward-inclined airfoil design in wheel sizes up to 750 mm30 inches. Fan blades for wheels over 750 mm30 inches in diameter shall be backward-inclined airfoil design]. [Booster fans for exhaust dryer systems shall be the open-wheel radial type. These fans shall be suitable for conveying lint and the temperatures encountered. The fan shaft shall be provided with a heat slinger to dissipate heat buildup along the shaft. An access (service) door to facilitate maintenance shall be supplied with these fans.] Fan wheels over 900 mm36 inches in diameter shall have overhung pulleys and a bearing on each side of the wheel. Fan wheels 900 mm36 inches or less in diameter may have one or more extra long bearings between the fan wheel and the drive. Bearings shall be sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Grease fittings shall be connected to tubing and serviceable from a single accessible point. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Fan shafts shall be steel, accurately finished, and shall be provided with key seats and keys for impeller hubs and fan pulleys. Each fan outlet shall be of ample proportions and shall be designed for the attachment of angles and bolts for attaching flexible connections. [[Manually] [Automatically] operated inlet vanes shall be provided on suction inlets. [Manually] [Automatically] operated outlet dampers shall be provided.] Motors, unless otherwise indicated, shall 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-start] type with [general-purpose] [weather-resistant] [watertight] enclosure.] [Remote manual switch with pilot indicating light shall be provided where indicated.]

#### 2.9.1.2 In-Line Centrifugal Fans

In-line fans shall have centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Fans shall be mounted in a welded tubular casing. Air shall enter and leave the fan axially. Inlets shall be streamlined with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated, and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. [Motors shall have [open]

[dripproof] [totally enclosed] [explosion-proof] enclosure.] [Motor starters shall be [manual] [magnetic] across-the-line with [general-purpose] [weather-resistant] [explosion-proof] enclosures.] [Remote manual switch with pilot indicating light shall be provided where indicated.]

#### 2.9.1.3 Axial Flow Fans

Axial flow fans shall be complete with drive components and belt guard, and shall have a steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Fan wheels shall have radially projecting blades of airfoil cross section and shall be dynamically balanced and keyed to the fan shaft. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt, shall be permanently lubricated or with accessible grease fittings, and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Fan inlets shall be provided with an aerodynamically shaped bell and an inlet cone. Diffuser or straightening vanes shall be provided at the fan discharge to minimize turbulence and provide smooth discharge air flow. Fan unit shall be provided with [inlet and outlet flanges,] [inlet screen,] [duct equalizer section,] and [manual] [automatic] operation adjustable inlet vanes. Unless otherwise indicated, motors shall not exceed 1800 rpm and shall have [open] [dripproof] [totally enclosed] [explosion-proof] enclosure. [Motor starters shall be [manual] [magnetic] across-the-line with [general-purpose] [weather-resistant] [explosion-proof] enclosure.] [Remote manual switch with pilot indicating light shall be provided where indicated.]

#### 2.9.1.4 Panel Type Power Wall Ventilators

Fans shall be propeller type, assembled on a reinforced metal panel with venturi opening spun into panel. Fans with wheels less than 600 mm24 inches in diameter shall be direct or V-belt driven and fans with wheels 600 mm24 inches diameter and larger shall be V-belt drive type. Fans shall be furnished with wall mounting collar. Lubricated bearings shall be provided. Fans shall be fitted with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Motor enclosure shall be [dripproof] [totally enclosed fan cooled] [explosion-proof] type. [Gravity] [Motor operated] backdraft dampers shall be provided where indicated.

#### 2.9.1.5 Centrifugal Type Power Wall Ventilators

Fans shall be [direct] [or] [V-belt] driven centrifugal type with backward inclined, non-overloading wheel. Motor housing shall be removable and weatherproof. Unit housing shall be designed for sealing to building surface and for discharge and condensate drippage away from building surface. Housing shall be constructed of heavy gauge aluminum. Unit shall be fitted with an [aluminum or plated steel wire discharge bird screen,] [[anodized aluminum] [stainless steel] wall grille,] [manufacturer's standard [gravity] [motor-operated] damper,] an airtight and liquid-tight metallic wall sleeve. Motor enclosure shall be [totally enclosed fan cooled] [dripproof] [explosion-proof] type. Lubricated bearings shall be provided.

#### 2.9.1.6 Centrifugal Type Power Roof Ventilators

\*\*\*\*\*  
**NOTE: Delete kitchen exhaust fan when not required.**  
\*\*\*\*\*

Fans shall be [direct] [or] [V-belt] driven with backward inclined, non-overloading wheel. Motor compartment housing shall be hinged or removable and weatherproof, constructed of heavy gauge aluminum. Fans shall be provided with [birdscreen,] [disconnect switch,] [[gravity] [motorized] dampers,] [sound curb,] [roof curb,] and [extended base]. Motors enclosure shall be [dripproof] [explosion-proof] type. Grease-laden kitchen exhaust fans shall be centrifugal type according to UL 705 and fitted with V-belt drive, round hood, and windband upblast discharge configuration, integral residue trough and collection device, motor and power transmission components located in outside positively air ventilated compartment. Lubricated bearings shall be provided.

#### 2.9.1.7 Propeller Type Power Roof Ventilators

Fans shall be [direct] [or] [V-belt] driven. Fan housing shall be hinged or removable weathertight, fitted with framed rectangular base constructed of aluminum or galvanized steel. Motors shall be [totally enclosed fan cooled] [explosion-proof] type. Motors shall be provided with nonfusible, horsepower rated, manual disconnect mount on unit. Fans shall be provided with [gravity] [motor operated] dampers, [birdscreen] [sound curb] [roof curb]. Lubricated bearings shall be provided.

#### 2.9.1.8 Air-Curtain Fans

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**NOTE: Air curtains designed as fly fans will be provided on all exterior entranceways to food preparation areas, except they will not be required if the entranceway is to be used only as an emergency exit. Air curtains for service windows and service entries will be installed whenever feasible on the exterior of the entranceway. When air curtains are mounted in locations significantly above normal door heights, curtain air velocities and noise levels should be verified by the designer.**  
\*\*\*\*\*

Air curtains shall be provided with a weatherproof housing constructed of high impact plastic or minimum 1.3 mm (18 gauge) 18 gauge rigid welded steel. Fan wheels shall be backward curved, non-overloading, centrifugal type and accurately balanced statically and dynamically. Motors shall have totally enclosed fan cooled enclosures. Motor starters shall be remote manual type with weather-resistant enclosure actuated when the doorway served is open. The air curtains shall attain the air velocities specified within 2 seconds following activation. Air intake and discharge openings shall be protected by bird screens. Air curtain unit or a multiple unit installation shall be at least as wide as the opening to be protected. The air discharge openings shall be so designed and equipped as to permit outward adjustment of the discharge air. Adjustment and installation placement shall be according to the manufacturer's written recommendation. Directional controls on air curtains for service windows shall be designed to be easily cleanable or readily removable. Air curtains shall be designed to prevent the adjustment of the air velocities specified. The

interior surfaces of the air curtain units shall be accessible for cleaning. Certified test data indicating that the fan will provide the air velocities required when fan is mounted as indicated shall be furnished. Air curtains designed as fly fans shall be provided where indicated. [Air curtains designed for use in service entranceways shall develop an air curtain not less than 75 mm3 inches thick at the discharge nozzle. The air velocity shall be not less than 8 m/s1600 fpm across the entire entryway when measured 900 mm3 feet above the floor.] [Air curtains designed for use on customer entranceways shall develop an air curtain not less than 200 mm8 inches thick at the discharge opening. The velocity shall be not less than 3 m/s600 fpm across the entire entryway when measured 900 mm3 feet above the floor. Recirculating type air curtains shall be equipped with readily removable filters, or the filters shall be designed for in-position cleaning. The air capture compartment shall be readily accessible and easily cleanable or designed for in-position cleaning.] [Air curtains designed for use on service windows shall develop an air curtain not less than 200 mm8 inches thick at the discharge opening. The air velocity shall be not less than 3 m/s600 fpm across the entire opening of the service window measured 900 mm3 feet below the air discharge opening.]

#### 2.9.1.9 Ceiling Exhaust Fans

Suspended cabinet-type ceiling exhaust fans shall be centrifugal type, direct-driven. Fans shall have acoustically insulated housing. Integral backdraft damper shall be chatter-proof. The integral face grille shall be of egg-crate design or louver design. Fan motors shall be mounted on vibration isolators. Unit shall be provided with mounting flange for hanging unit from above. Fans shall be U.L. listed.

#### 2.9.2 Coils

\*\*\*\*\*

NOTE: The designer will research local conditions to determine the effect of corrosive atmosphere on dissimilar metals. Where condenser or evaporator coils are to be installed in corrosive atmospheres, the specification for coils and fins will be rewritten for these specific conditions. Consideration should be given to the following coil and fin combinations based on past experience with the suitability of these materials in dealing with the local conditions.

- a. Copper coil and aluminum fins, coated.
- b. Copper coil and copper fins, coated.
- c. Aluminum coil and aluminum fins, coated.
- d. Aluminum coil and aluminum fins, uncoated.
- e. Copper coil and copper fins, uncoated.

Coating may be either phenolic or vinyl. For coils with relatively close fin spacing such as those found in most unitary equipment, the phenolic coating is preferred. Phenolic has less tendency to bridge across the fins than vinyl, has better thermal conductivity than vinyl and in many

conditions weathers better than vinyl.

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Coils shall be fin-and-tube type constructed of seamless [copper] [red brass] tubes and [aluminum] [or] [copper] fins mechanically bonded or soldered to the tubes. [Copper tube wall thickness shall be a minimum of [0.406] [0.508] [0.6096] mm[0.016] [0.020] [0.024] inches]. [Red brass tube wall thickness shall be a minimum of [0.89] [1.24] mm[0.035] [0.049] inches]. [Aluminum fins shall be [0.14] [0.19] mm[0.0055] [0.0075] inch minimum thickness.] [Copper fins shall be 0.114 mm0.0045 inch minimum thickness.] Casing and tube support sheets shall be not lighter than 1.6 mm (16 gauge) 16 gauge galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Each coil shall be tested at the factory under water at not less than 2.76 MPa400 psi air pressure and shall be suitable for 1.38 MPa200 psi working pressure. Coils shall be mounted for counterflow service. Coils shall be rated and certified according to ARI 410.

#### 2.9.2.1 Direct-Expansion Coils

Direct-expansion coils shall be suitable for the refrigerant involved. Suction headers shall be seamless copper tubing or seamless or resistance welded steel tube with copper connections. Supply headers shall consist of a distributor which shall distribute the refrigerant through seamless copper tubing equally to all circuits in the coil. Tubes shall be circuited to ensure minimum pressure drop and maximum heat transfer. Circuiting shall permit refrigerant flow from inlet to suction outlet without causing oil slugging or restricting refrigerant flow in coil. Each coil to be field installed shall be completely dehydrated and sealed at the factory upon completion of pressure tests.

#### 2.9.2.2 Water Coils

Water coils shall be installed with a pitch of not less than 10 mm per meter 1/8 inch per foot of the tube length toward the drain end. Headers shall be constructed of cast iron, welded steel or copper. Each coil shall be provided with a plugged vent and drain connection extending through the unit casing.

#### 2.9.2.3 Steam Heating Coils

Steam coils shall be constructed of cast semisteel, welded steel or copper headers, and [red brass] [copper] tubes. Headers shall be constructed of cast iron, welded steel or copper. Fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Each coil shall be provided with a field or factory installed vacuum breaker. Coils shall be single-tube type with tubes not less than 12 mm1/2 inch outside diameter, except for steam preheat coils. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coils shall be factory tested to ensure that, when supplied with a uniform face velocity, temperature across the leaving side will be uniform with a maximum variation of no more than 5 percent.

#### 2.9.2.4 Steam Preheat (Nonfreeze) Coils

Steam (nonfreeze) coils shall be steam-distribution-tube type with condensing tubes not less than 25 mm1 inch outside diameter for tube lengths 1.5 m60 inches and over and 12 mm1/2 inch outside diameter for tube

lengths under 1.5 m60 inches. Headers shall be constructed of cast iron, welded steel, or copper. Distribution tubes shall be not less than 15 mm 5/8 inch outside diameter for tube lengths 1.5 m60 inches and over and 10 mm 3/8 inch outside diameter for tube lengths under 1.5 m60 inches with orifices to discharge steam to condensing tubes. Distribution tubes shall be installed concentric inside of condensing tubes and shall be held securely in alignment. Maximum length of a single coil shall be limited to 3.66 m144 inches. Coils shall be factory tested to ensure that, when supplied with a uniform face velocity, temperature across the leaving side will be uniform with a maximum variation of no more than 5 percent.

### 2.9.3 Air Filters

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NOTE: Filters should be selected based on the functional needs of the area served, including indoor air quality. The combination of the extended surface pleated panel filters and the extended surface nonsupported pocket filters or the cartridge filter of the same efficiency are intended to fulfill the filtration requirements in TM 5-810-1, Heating, Ventilating, and Air-Conditioning for areas where indoor air quality is of primary concern.

In the event the retention of efficiency values in the specification becomes cumbersome, the requirements may be revised by referring to the efficiencies indicated on the drawings, to show for each air handling unit or system the efficiency of the air filters required, and the maximum initial resistance.

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Air filters shall be listed according to requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method shall be as listed under the Label Service and shall meet the requirements of UL 586.

#### 2.9.3.1 Extended Surface Pleated Panel Filters

Filters shall be 50 mm2 inch depth, sectional, disposable type of the size indicated and shall have an average efficiency of 25 to 30 percent when tested according to ASHRAE 52.2. Initial resistance at 2.54 m/s500 feet per minute shall not exceed 9 mm0.36 inches water gauge. Filters shall be UL Class 2. Media shall be nonwoven cotton and synthetic fiber mat. A wire support grid bonded to the media shall be attached to a moisture resistant fiberboard frame. All four edges of the filter media shall be bonded to the inside of the frame to prevent air bypass and increase rigidity.

#### 2.9.3.2 Extended Surface Nonsupported Pocket Filters

Filters shall be [750] [\_\_\_\_\_] mm[30] [\_\_\_\_\_] inch depth, sectional, replaceable dry media type of the size indicated and shall have an average efficiency of 80 to 85 percent when tested according to ASHRAE 52.2. Initial resistance at [2.54] [\_\_\_\_\_] m/s[500] [\_\_\_\_\_] feet per minute shall not exceed [11] [\_\_\_\_\_] mm[0.45] [\_\_\_\_\_] inches water gauge. Filters shall be UL Class 1. Media shall be fibrous glass, supported in the air stream by a wire or non-woven synthetic backing and secured to a galvanized steel



metal header. Pockets shall not sag or flap at anticipated air flows. Each filter shall be installed [with an extended surface pleated panel filter as a prefilter] in a factory preassembled, side access housing or a factory-made sectional frame bank, as indicated.

#### 2.9.3.3 Cartridge Type Filters

Filters shall be 305 mm12 inch depth, sectional, replaceable dry media type of the size indicated and shall have an average efficiency of 80 to 85 percent when tested according to ASHRAE 52.2. Initial resistance at [2.54] [\_\_\_\_\_] m/s[500] [\_\_\_\_\_] feet per minute shall not exceed [14] [\_\_\_\_\_] mm [0.56] [\_\_\_\_\_] inches, water gauge. Filters shall be UL class 1. Media shall be pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow will have no effect on filter integrity or performance. Each filter shall be installed [with an extended surface pleated media panel filter as a prefilter] in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

#### 2.9.3.4 Sectional Cleanable Filters

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**NOTE: Delete washing and charging racks when not required.**  
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Cleanable filters shall conform to [\_\_\_\_\_] , and shall be [25] [50] mm[1] [2] inches thick. Viscous adhesive shall be provided in 20 liter5 gallon containers in sufficient quantity for 12 cleaning operations and not less than one literone quart for each filter section. One washing and charging tank shall be provided for every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and [single] [double] drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position.

#### 2.9.3.5 Replaceable Media Filters

Replaceable media filters shall be the [dry-media] [viscous adhesive] type, of the size required to suit the application. Filtering media shall be not less than 50 mm2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge)16 gauge galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding [1.5] [\_\_\_\_\_] m/s, [300] [\_\_\_\_\_] feet per minute, with initial resistance of [32] [\_\_\_\_\_] Pa[0.13] [\_\_\_\_\_] inches water gauge. Average efficiency shall be not less than [\_\_\_\_\_] percent when tested according to ASHRAE 52.2.

#### 2.9.3.6 Automatic Renewable Media Filters

Automatic, renewable media filters shall consist of a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass supplied in convenient roll form. Operation and maintenance requirements of the filter shall not require water supply, sewer connections, adhesive reservoir, or sprinkler equipment. Basic frame shall be fabricated of not less than 2 mm (14 gauge)14 gauge galvanized steel. Filters shall be

sectional design with each section of each filter fully factory assembled, requiring no field assembly other than setting in place next to any adjacent sections and the installation of media in roll form. Each filter shall be complete with initial loading of filter media drive motor adequate to handle the number of sections involved, and [painted steel] [stainless steel] control box containing a warning light to indicate media runout, a runout switch, and a Hand-Off-Auto selector switch. Media feed across the filter face shall be in [full-face increments] [increments] automatically controlled as determined by [filter pressure differential] [time interval control] [time interval control with pressure override] [photo electric control] to provide substantially constant operating resistance to airflow and varying not more than plus or minus 10 percent. Media shall be rolled or enclosed in such a way that collected particulates will not re-entrain. Rolls of clean media, no less than 19.8 m65 feet long, shall be rerolled on disposable spools in the rewind section of the filter after the media has accumulated its design dirt load. Rewind section shall be equipped with a compression panel to tightly rewind used media for ease of handling. Media shall be of continuous, bonded fibrous glass material, shall be UL Class 2, and shall not compress more than 6 mm1/4 inch when subjected to air flow at 2.54 m/s500 fpm. Media shall be factory charged with an odorless and flame retardant adhesive which shall not flow while in storage nor when subjected to temperatures up to 79.4 degrees C175 degrees F. Media shall be supported on both the leaving and entering air faces. The initial resistance of the clean media shall not exceed 45 Pa (0.18 inch water gauge) 0.18 inch water gauge at its rated velocity of 2.54 m/s500 fpm. Control shall be set so that the resistance to air flow is between 100 and 125 Pa 0.40-and 0.50 inch water gauge unless otherwise indicated. Dust holding capacity under these operating conditions, when operating at a steady state with an upper operating resistance of 125 Pa (0.50 inch water gauge), 0.50 inch water gauge, shall be at least 592 (55) grams of ASHRAE Standard Test Dust per square meter (foot) of media area, when tested according to the dynamic testing provisions of ASHRAE 52.2. Average arrestance under these conditions shall be 80 percent. When used in conjunction with factory fabricated air handling units, the horizontal type automatic renewable media filters shall be dimensionally compatible with the connecting air handling units. Horizontal type filter housings shall have all exposed surfaces factory insulated internally with 25 mm,1 inch, 24 kg per cubic meter (1-1/2 pound)1-1/2 pound density neoprene coated fibrous glass with thermal conductivity not greater than 0.04 W/m-K (0.27 Btu/hour/degree F/square foot/inch0.27 Btu/hour/degree F/square foot/inch of thickness. Access doors for horizontal filters shall be of double wall construction as specified for plenums and casings for field-fabricated units in paragraph DUCTWORK COMPONENTS.

#### 2.9.3.7 Electrostatic Filters

Electrostatic filters shall be the combination dry agglomerator/extended surface nonsupported pocket filter or the combination dry agglomerator/automatic renewable media (roll) type, as indicated (except as modified). Each dry agglomerator electrostatic air filter shall be supplied with the correct quantity of fully housed power packs and equipped with silicon rectifiers, manual reset circuit breakers, low voltage safety cutout, relays for field wiring to remote indication of primary and secondary voltages, and lamps mounted in the cover to indicate these functions locally. Power pack enclosure shall be equipped with external mounting brackets, and low and high voltage terminals shall be fully exposed with access cover removed for ease of installation. Interlock safety switches shall be furnished for each access door and access panel which permits access to either side of the filter, so that the filter will

be de-energized in the event that a door or panel is opened. Ozone generation within the filter shall not exceed five parts per one hundred million parts of air. High voltage insulators shall be located outside the moving air stream or on the clean air side of the unit and shall be serviceable. Ionizer wire supports shall be fully exposed and ionizer wires shall be furnished pre-cut to size and with formed loops at each end to facilitate ionizer wire replacement. Agglomerator cell plates shall allow proper air stream entrainment of agglomerates and prevent excessive residual dust build-up. Cells shall be open at the top and bottom to prevent accumulation of agglomerates which settle by gravity. Where the dry agglomerator electrostatic filter is indicated to be the automatic renewable media type, the storage section shall utilize a horizontal or vertical travelling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service and supplied in 19.8 m65 foot lengths in convenient roll form. Storage section construction and roll media characteristics shall otherwise be as specified for automatic renewable media filters. Initial air flow resistance of the dry agglomerator/renewable media combination, after installation of clean media, shall not exceed 62.3 Pa (0.25 inch water gauge)0.25 inch water gauge at 2.54 m/s500 fpm face velocity. Minimum atmospheric air dust spot efficiency of the combination shall be not less than 90 percent when tested according to ASHRAE 52.2 at an average operating resistance of 125 Pa (0.50 inch water gauge)0.50 inch water gauge. Where the dry agglomerator electrostatic filter is indicated to be of the extended surface nonsupported pocket filter type, the storage section shall be as specified for extended surface non-supported pocket filters, with sectional holding frames or side access housings as indicated. Initial air flow resistance of the dry agglomerator/extended surface nonsupported pocket filter section combination, after installation of clean filters, shall not exceed 162 Pa (0.65 inch water gauge)0.65 inch water gauge at 2.54 m/s500 fpm face velocity. Minimum atmospheric air dust spot efficiency of the combination shall be not less than 95 percent when tested according to ASHRAE 52.2. Front access filters shall be furnished with full height air distribution baffles and upper and lower mounting tracks to permit the baffles to be moved for agglomerator cell inspection and service. When used in conjunction with factory fabricated air handling units, side access housings shall be supplied which have dimensional compatibility.

#### 2.9.3.8 High-Efficiency Particulate Air (HEPA) Filters

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**NOTE: High-efficiency particulate air filters will be used in CLEAN ROOMS (White Rooms or Dust Controlled Facilities), clean work stations, and for critical areas of hospitals. The efficiency of the prefilter will be indicated on the drawings to suit the anticipated contamination load and the degree of prefiltration efficiency required. ASME AG-1 may be referenced either all or in part when extreme temperature or humidity requirements exist. Designer should ensure that requirements added to text from ASME AG-1 are essential to customer's needs, as this standard is not intended for routine commercial applications, and may add unnecessary expense to project. When used, ASME AG-1 should be added to paragraph REFERENCES.**

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HEPA filters shall meet the requirements of IEST RP-CC-001.3 and shall be

individually tested and certified to have an efficiency of not less than [95] [99.97] percent. Initial resistance at [\_\_\_\_\_] m/s[\_\_\_\_\_] feet per minute shall not exceed [\_\_\_\_\_] Pa[\_\_\_\_\_] inches water gauge. Filters shall be constructed by pleating a continuous sheet of filter medium into closely spaced pleats separated by corrugated aluminum or mineral-fiber inserts, strips of filter medium, or by honeycomb construction of the pleated filter medium. Interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer shall be cemented to the perimeter of the [upstream] [downstream] face of the filter cell sides. Adhesive sealer shall be of self-extinguishing rubber-base type or other materials conforming to fire hazard classification specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Filter cell sides shall be [18 mm3/4 inch thick exterior grade fire-retardant plywood] [cadmium plated steel] [galvanized steel] assembled in a rigid manner. Overall cell side dimensions shall be correct to 2.0 mm,1/16 inch, and squareness shall be maintained to within 3.2 mm1/8 inch. Each holding frame shall use spring loaded fasteners or other devices to seal the filter tightly within it and to prevent any bypass leakage around the filter during its installed life. Air capacity and the nominal depth of the filter shall be as indicated. Each filter shall be installed in a factory preassembled side access housing or a factory-made sectional supporting frame as indicated. Prefilters of the type, construction and efficiency indicated, shall be provided.

#### 2.9.3.9 Range and Griddle Hood Service

Filter shall be sectional, permanent, washable, all metallic media type, nominal 50 mm2 inches thick, with suitable metal frames, designed for extraction of grease from grease-laden air. Clean filter static pressure drop shall not exceed [\_\_\_\_\_] Pa[\_\_\_\_\_] inch water gauge when handling [\_\_\_\_\_] L/s[\_\_\_\_\_] cfm air.

#### 2.9.3.10 Holding Frames

Frames shall be fabricated from not lighter than 1.6 mm (16 gauge)16 gauge sheet steel with rust-inhibitor coating. Each holding frame shall be equipped with suitable filter holding devices. Holding frame seats shall be gasketed. All joints shall be airtight.

#### 2.9.3.11 Filter Gauges

Filter gauges shall be dial type, diaphragm actuated draft and shall be provided for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Gauges shall be at least 98 mm3-7/8 inches in diameter, shall have white dials with black figures, and [graduations] [shall be graduated in 0.0025 kPa mm (0.01 inch of water),0.01 inch,] and shall have a minimum range of 0.25 kPa (1 inch of water)1 inch beyond the specified final resistance for the filter bank on which each gauge is applied. Each gauge shall incorporate a screw operated zero adjustment and shall be furnished complete with two static pressure tips with integral compression fittings, two molded plastic vent valves, two 1.5 m5 foot minimum lengths of 6.35 mm 1/4 inch diameter [aluminum] [vinyl] tubing, and all hardware and accessories for gauge mounting.

#### 2.10 AIR HANDLING UNITS

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**NOTE: To prevent condensate overflow, calculate the**

size of condensate drain pans for air handling units where abnormally high latent loads will be encountered such as high humidity locations or units operating with 100 percent outside air. Where the potential exists for a manufacturer's standard condensate pan to be smaller than the size calculated, include the size required in the equipment schedule on the drawings.

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#### 2.10.1 Field-Fabricated Air Handling Units

Built-up units shall be as specified in paragraph DUCTWORK COMPONENTS. Fans, coils spray-coil dehumidifiers, and air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

#### 2.10.2 Factory-Fabricated Air Handling Units

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**NOTE: Coordinate with paragraph Fans and paragraph Coils.**

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Units shall be [single-zone draw-through type] [or] [single-zone blow-through type] [or] [multizone blow-through type] [blow-through double-deck type] [blow-through triple deck type] as indicated. Units shall include fans, coils, airtight insulated casing, [prefilters,] [secondary filter sections,] [and] [diffuser sections where indicated,] [air blender] adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, [mixing box] [combination sectional filter-mixing box,] [[pan] [drysteam] [spray type] humidifier,] vibration-isolators, and appurtenances required for specified operation. Vibration isolators shall be as indicated. Each air handling unit shall have physical dimensions suitable to fit space allotted to the unit and shall have the capacity indicated. Air handling unit shall have published ratings based on tests performed according to ARI 430.

##### 2.10.2.1 Casings

Casing sections shall be [[single] [50 mm2 inch double] wall type] [as indicated,] constructed of a minimum 1.3 mm18 gauge galvanized steel, or 1.3 mm18 gauge steel outer casing protected with a corrosion resistant paint finish according to paragraph FACTORY PAINTING. [Inner casing of double-wall units shall be minimum 1.0 mm (20 gauge)20 gauge solid galvanized steel.] Casing shall be designed and constructed with an integral insulated structural steel frame such that exterior panels are non-load bearing. Exterior panels shall be individually removable. Removal shall not affect the structural integrity of the unit. Casings shall be provided with inspection doors, access sections, and access doors as indicated. Inspection and access doors shall be insulated, fully gasketed, double-wall type, of a minimum 1.3 mm (18 gauge)18 gauge outer and 1.0 mm (20 gauge)20 gauge inner panels. Doors shall be rigid and provided with heavy duty hinges and latches. Inspection doors shall be a minimum 300 mm12 inches wide by 300 mm12 inches high. Access doors shall be minimum 600 mm 24 inches wide and shall be the full height of the unit casing or a minimum of 1800 mm,6 foot, whichever is less. [A minimum 200 by 200 mm8 by 8 inches sealed glass window suitable for the intended application shall be installed in all access doors.] Access Sections shall be according to paragraph AIR HANDLING UNITS. Drain pan shall be

double-wall insulated type constructed of 1.4 mm16 gauge [galvanized steel] [stainless steel], pitched to the drain connection. Drain pans shall be constructed water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils shall not flow across the face of lower coils. Intermediate drain pans or condensate collection channels and downspouts shall be provided, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Drain pan shall be constructed so that the pan may be visually inspected easily including underneath the coil without removal of the coil and so that the pan may be physically cleaned completely and easily underneath the coil without removal of the coil. Casing insulation shall conform to NFPA 90A Single-wall casing sections handling conditioned air shall be insulated with not less than 25 mm1 inch thick, 24 kg per cubic meter1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.033 W/m-K0.23 Btu/hr-sf-F. Double-wall casing sections handling conditioned air shall be insulated with not less than 50 mm2 inches of the same insulation specified for single-wall casings. Foil-faced insulation shall not be an acceptable substitute for use with double wall casing. Double wall insulation must be completely sealed by inner and outer panels. Factory applied fibrous glass insulation shall conform to ASTM C 1071, except that the minimum thickness and density requirements do not apply, and shall meet the requirements of NFPA 90A. Air handling unit casing insulation shall be uniform over the entire casing. Foil-faced insulation shall not be an acceptable substitute for use on double-wall access doors and inspections doors [and casing sections]. Duct liner material, coating, and adhesive shall conform to fire-hazard requirements specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Exposed insulation edges and joints where insulation panels are butted together shall be protected with a metal nosing strip or shall be coated to conform to meet erosion resistance requirements of ASTM C 1071. A latched and hinged inspection door, shall be provided in the fan and coil sections. Additional inspection doors, access doors and access sections shall be provided [\_\_\_\_\_] [where indicated].

#### 2.10.2.2 Heating and Cooling Coils

Coils shall be provided as specified in paragraph AIR SYSTEMS EQUIPMENT, for types indicated.

#### 2.10.2.3 Cooling Coils, Spray Type

Cooling coils shall be of the copper finned [direct expansion] [water] type as specified in paragraph AIR SYSTEMS EQUIPMENT furnished complete with water sprays. All horizontal units and vertical units with coil face velocities of 2.5 m per second (550 fpm)550 fpm or above, shall be provided with moisture eliminators. Sprays shall have all bronze, brass, or stainless steel centrifugal type nozzles, with removable caps designed and arranged for uniform wetting of the entire coil face area. Nozzles shall be supplied by standard weight galvanized steel piping and a centrifugal type circulating pump furnished as an integral part of the unit. Eliminators shall be not lighter than 0.7 mm (24 gauge)24 gauge corrosion-resistant steel, removable for maintenance and coil inspection. No water shall carry over into the fan section or supply ducts from the air handling unit provided with or without eliminators.

#### 2.10.2.4 Air Filters

Air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for

types and thickness indicated.

#### 2.10.2.5 Fans

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**NOTE: Coordinate with paragraph Sound Attenuation Equipment.**

**Refer to TM 5-805-4, Noise and Vibration Control for Mechanical Equipment, for vibration criteria.  
Vibration isolation required should be shown and included in the appropriate schedule on the drawings.**

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Fans shall be double-inlet, centrifugal type with each fan in a separate scroll. Fans and shafts shall be dynamically balanced prior to installation into air handling unit, then the entire fan assembly shall be statically and dynamically balanced at the factory after it has been installed in the air handling unit. Fans shall be mounted on steel shafts accurately ground and finished. Fan bearings shall be sealed against dust and dirt and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Bearings shall be permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit.

Bearings shall be supported by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing.

Bearings may not be fastened directly to the unit sheet metal casing.

Fans and scrolls shall be furnished with coating indicated. Fans shall be driven by a unit-mounted or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Belt guards shall be the three sided enclosed type with solid or expanded metal face. Belt drives shall be designed for not less than a 1.3 service factor based on motor nameplate rating. [Motor sheaves shall be variable pitch for 20 kW25 hp and below and fixed pitch above 20 kW25 hp as defined by ARI Guideline D.] Where fixed sheaves are required, variable pitch sheaves may be used during air balance, but shall be replaced with an appropriate fixed sheave after air balance is completed. Variable pitch sheaves shall be selected to drive the fan at a speed that will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Motors for V-belt drives shall be provided with adjustable bases. Fan motors shall have [open] [splashproof] [totally enclosed] enclosures. Motor starters shall be [manual] [magnetic] [across-the-line] [reduced-voltage-start] type with [general-purpose] [weather-resistant] [watertight] enclosure. Unit fan or fans shall be selected to produce the required capacity at the fan static pressure. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300, ASHRAE 68, or ARI 260.

#### 2.10.2.6 Access Sections and Filter/Mixing Boxes

Access sections shall be provided where indicated and shall be furnished with access doors as shown. Access sections and filter/mixing boxes shall be constructed in a manner identical to the remainder of the unit casing and shall be equipped with access doors. Mixing boxes shall be designed to minimize air stratification and to promote thorough mixing of the air streams.

#### 2.10.2.7 Diffuser Sections

Diffuser sections shall be furnished between the discharge of all housed supply fans [and cooling coils of blow-through single zone units] [and] [filter sections of those units with high efficiency filters located immediately downstream of the air handling unit fan section]. Diffuser sections shall be fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, shall be designed to be airtight under positive static pressures up to [2] [\_\_\_\_\_] kPa[8] [\_\_\_\_\_] inches water gauge and shall have an access door on each side for inspection purposes. Diffuser section shall contain a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for corrosion with manufacturer's standard corrosion-resisting finish. The diffusion plate shall be designed to accomplish uniform air flow across the down-stream [coil] [filters] while reducing the higher fan outlet velocity to within plus or minus 5 percent of the required face velocity of the downstream component.

#### 2.10.2.8 Dampers

Dampers shall be as specified in paragraph CONTROLS.

### 2.11 TERMINAL UNITS

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**NOTE: Coordinate with paragraph Sound Attenuation Equipment.**  
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#### 2.11.1 Room Fan-Coil Units

Base units shall include galvanized coil casing, coil assembly drain pan [valve and piping package,] [outside air damper,] [wall intake box,] air filter, fans, motor, fan drive, and motor switch, plus an enclosure for cabinet models and casing for concealed models. Leveling devices integral with the unit shall be provided for vertical type units. Sound power levels shall be as indicated. Sound power level data or values for these units shall be obtained according to test procedures based on ARI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models will be acceptable for concealed models without separate test provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Automatic valves and controls shall be provided as specified in paragraph CONTROLS. Each unit shall be fastened securely to the building structure. Capacity of the units shall be as indicated. Room fan-coil units shall be certified as complying with ARI 440, and shall meet the requirements of UL 1995.

##### 2.11.1.1 Enclosures

Enclosures shall be fabricated of not lighter than 1.3 mm18 gauge steel, reinforced and braced. Front panels of enclosures shall be removable and provided with 7 mm1/4 inch closed cell insulation or 13 mm1/2 inch thick dual density foil faced fibrous glass insulation. The exposed side shall be high density, erosion-proof material suitable for use in air streams with velocities up to 23 m/s4,500 fpm. Discharge grille shall be [adjustable] [fixed] and shall be of such design as to properly distribute air throughout the conditioned space. Plastic discharge and return grilles are acceptable provided the plastic material is certified by the



manufacturer to be classified as flame resistant according to UL 94 and the material shall comply with the heat deflection criteria specified in UL 1995.

Ferrous metal surfaces shall be galvanized or factory finished with corrosion resistant enamel. Access doors or removable panels shall be provided for piping and control compartments. Duct discharge collar shall be provided for concealed models. Enclosures shall have easy access for filter replacement.

#### 2.11.1.2 Fans

Fans shall be galvanized steel or aluminum, multiblade, centrifugal type. In lieu of metal, fans and scrolls may be non-metallic materials of suitably reinforced compounds. Fans shall be dynamically and statically balanced. Surfaces shall be smooth. Assemblies shall be accessible for maintenance. Disassembly and re-assembly shall be by means of mechanical fastening devices and not by epoxies or cements.

#### 2.11.1.3 Coils

Coils shall be constructed of not less than 10 mm<sup>3</sup>/8 inch outside diameter seamless copper tubing, with copper or aluminum fins mechanically bonded or soldered to the tubes. Coils shall be provided with not less than 12 mm<sup>1</sup>/2 inch outside diameter flare or sweat connectors, accessory piping package with thermal connections suitable for connection to the type of control valve supplied, and manual air vent. Coils shall be tested hydrostatically at 2000 kPa300 psi or under water at 1700 kPa250 psi air pressure and suitable for 1400 kPa200 psi working pressure. Provisions shall be made for coil removal.

#### 2.11.1.4 Drain Pans

Drain and drip pans shall be sized and located to collect all water condensed on and dripping from any item within the unit enclosure or casing. Condensate drain pans shall be designed for self-drainage to preclude the buildup of microbial slime and shall be thermally insulated to prevent condensation and constructed of not lighter than 0.9 mm<sup>21</sup> gauge type 304 stainless steel or noncorrosive ABS plastic. Insulation shall have a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and shall be of a waterproof type or coated with a waterproofing material. Drain pans shall be pitched to drain and shall be designed so as to allow no standing water. Minimum 20 mm<sup>3</sup>/4 inch NPT or 15 mm<sup>5</sup>/8 inch OD drain connection shall be provided in drain pan. Auxiliary drain pans to catch drips from control and piping packages, eliminating insulation of the packages, may be plastic; if metal, the auxiliary pans shall comply with the requirements specified above. Insulation at control and piping connections thereto shall extend 25 mm<sup>1</sup> inch minimum over the auxiliary drain pan.

#### 2.11.1.5 Manually Operated Outside Air Dampers

Manually operated outside air dampers shall be provided according to the arrangement indicated. Dampers shall be parallel airfoil type and of galvanized construction. Blades shall rotate on stainless steel or nylon sleeve bearings.

#### 2.11.1.6 Filters

Filters shall be of the fiberglass disposable type, 25 mm<sup>1</sup> inch thick,

conforming to ASHRAE 52.2. Filters in each unit shall be removable without the use of tools.

#### 2.11.1.7 Motors

\*\*\*\*\*  
**NOTE: Statements should be deleted depending on  
whether the units are freestanding, built-in or both  
Values for high static motors cover 115V, 230V, and  
277V.**  
\*\*\*\*\*

Motors shall be of the permanent split-capacitor type with built-in thermal overload protection, directly connected to unit fans. Motor switch shall be two or three speeds and off, manually operated, and shall be mounted on an identified plate [inside the unit below or behind an access door] [or] [adjacent to the room thermostat] [as indicated]. In lieu of the above fan speed control, a solid-state variable-speed controller having a minimum speed reduction of 50 percent may be provided. Motors shall have permanently-lubricated or oilable sleeve-type or combination ball and sleeve-type bearings with vibration isolating mountings suitable for continuous duty. Motor power consumption, shown in watts, at the fan operating speed selected to meet the specified capacity shall not exceed the following values:

##### Free Discharge Motors

| Unit Capacity (L/S) | Maximum Power Consumption (Watts) |      |      |
|---------------------|-----------------------------------|------|------|
|                     | 115V                              | 230V | 277V |
| 94                  | 70                                | 110  | 90   |
| 142                 | 100                               | 110  | 110  |
| 189                 | 170                               | 150  | 150  |
| 283                 | 180                               | 210  | 220  |
| 378                 | 240                               | 240  | 230  |
| 472                 | 310                               | 250  | 270  |
| 566                 | 440                               | 400  | 440  |

##### Free Discharge Motors

| Unit Capacity (cfm) | Maximum Power Consumption (Watts) |      |      |
|---------------------|-----------------------------------|------|------|
|                     | 115V                              | 230V | 277V |
| 200                 | 70                                | 110  | 90   |
| 300                 | 100                               | 110  | 110  |
| 400                 | 170                               | 150  | 150  |
| 600                 | 180                               | 210  | 220  |
| 800                 | 240                               | 240  | 230  |
| 1000                | 310                               | 250  | 270  |
| 1200                | 440                               | 400  | 440  |

##### High Static Motors

| Unit Capacity (L/S) | Maximum Power Consumption (Watts) |
|---------------------|-----------------------------------|
| 94                  | 145                               |
| 142                 | 145                               |
| 189                 | 210                               |
| 283                 | 320                               |
| 378                 | 320                               |
| 472                 | 530                               |
| 566                 | 530                               |

## High Static Motors

| Unit Capacity (cfm) | Maximum Power Consumption (Watts) |
|---------------------|-----------------------------------|
| 200                 | 145                               |
| 300                 | 145                               |
| 400                 | 210                               |
| 600                 | 320                               |
| 800                 | 320                               |
| 1000                | 530                               |
| 1200                | 530                               |

### 2.11.2 Coil Induction Units

Base unit shall include air plenums, air-discharge nozzles, air discharge grilles, recirculation grilles, water coil assembly, valve and piping package, condensate drain pan, and adjustable air-balancing dampers, plus an enclosure for cabinet models and casing for concealed models. Each unit shall be selected to produce not less than the capacity indicated without exceeding the indicated static pressure. The sound power level shall be as indicated. Sound power level data or values for these units shall be based on tests conducted according to ANSI S12.32. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. The values obtained for the standard cabinet models will be acceptable for concealed models without separate tests, provided there is no variation between models as to coil configuration, air discharge nozzles, air balancing dampers, or relative arrangement of parts. Automatic valves and controls shall be provided as specified in paragraph CONTROLS. Each unit shall be secured to the building structure. Capacity of the units shall be as indicated. The induction units shall conform to the provisions of [\_\_\_\_\_].

#### 2.11.2.1 Enclosures

Enclosures shall be fabricated of not lighter than 1.2 mm (18 gauge) 18 gauge steel, reinforced and braced. Front panel of enclosure shall be removable and insulated when required acoustically and to prevent condensation. Discharge grilles shall be [adjustable] [integrally stamped] and shall properly distribute air throughout the conditioned space. Plastic discharge and return grilles are not acceptable. Access doors shall be provided for all piping and control compartments.

#### 2.11.2.2 Air Plenums

Plenums shall be fabricated of galvanized steel with interior acoustically baffled and lined with sound absorbing material that will attenuate the sound power from the primary air supply to the room. Heat-resistant nozzles shall be integral with or attached airtight to the plenum. Where coil induction units are supplied with vertical runouts, a streamlined, vaned, mitered elbow transition piece shall be provided for connection between the unit and ductwork. An adjustable air-balancing damper shall be provided in each unit.

#### 2.11.2.3 Coils

Coils shall be constructed of not less than 10 mm 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins, mechanically bonded or soldered to the tubes. Coil connections shall be provided with not less than 13 mm 1/2 inch outside diameter flare or sweat connectors, accessory

pipng package with terminal connections suitable for connection to the type of control valve supplied, and manual air vent. Coils shall be tested hydrostatically at 2000 kPa300 psi or under water at 1700 kPa250 psi air pressure and shall be suitable for 1400 kPa (200 psi) (200 psi) working pressure.

#### 2.11.2.4 Screens

Lint screens or throwaway filters shall be provided for each unit and shall be easily accessible.

#### 2.11.2.5 Drain Pan

Drain and drip pans shall be sized and located to collect condensed water dripping from any item within the unit enclosure. Drain pans shall be constructed of not lighter than 0.9 mm (21 gauge)21 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Insulation shall have a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and be of a waterproof type or coated with a waterproofing material. In lieu of the above, drain pans may be constructed of die-formed 0.8 mm (22 gauge)22 gauge steel, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 0.9 mm (21 gauge)21 gauge steel material or of die-formed 0.9 mm (21 gauge)21 gauge type 304 stainless steel insulated as specified above. Drain pans shall be pitched to drain. Drain connection shall be provided when a condensate drain system is indicated. Connection shall be minimum 20 mm3/4 inch NPT or 15 mm 5/8 inch OD.

#### 2.11.3 Variable Air Volume (VAV) and Dual Duct Terminal Units

\*\*\*\*\*  
**NOTE: Delete reheat coils when not required.**  
\*\*\*\*\*

VAV and dual duct terminal units shall be the type, size, and capacity shown and shall be mounted in the ceiling or wall cavity and shall be suitable for single or dual duct system applications. Actuators and controls shall be as specified in paragraph CONTROLS. Unit enclosures shall be constructed of galvanized steel not lighter than 0.85 mm (22 gauge) 22 gauge or aluminum sheet not lighter than 1.3 mm (18 gauge)18 gauge. Single or multiple discharge outlets shall be provided as required. Units with flow limiters are not acceptable. Unit air volume shall be factory preset and readily field adjustable without special tools. Reheat coils shall be provided as indicated. A flow chart shall be attached to each unit. Acoustic performance of the terminal units shall be based upon units tested according to ARI 880. Sound power level shall be as indicated. Discharge sound power shall be shown for minimum and [375] [\_\_\_\_\_] Pa [1-1/2] [\_\_\_\_\_] inches water gauge inlet static pressure. Acoustical lining shall be according to NFPA 90A.

##### 2.11.3.1 Constant Volume, Single Duct

Constant volume, single duct, terminal units shall contain within the casing, a mechanical or pneumatic constant volume regulator. Volume regulators shall control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 200 to 1500 Pa3/4 to 6 inch water gauge.

#### 2.11.3.2 Variable Volume, Single Duct

Variable volume, single duct, terminal units shall be provided with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Units shall control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 200 to 1500 Pa<sup>3/4</sup> to 6 inch water gauge.

Internal resistance of units shall not exceed 100 Pa (0.4 inch water gauge) 0.4 inch water gauge at maximum flow range. External differential pressure taps separate from the control pressure taps shall be provided for air flow measurement with a 0 to 250 Pa<sup>0</sup> to 1 inch water gauge range. Unit volume controller shall be normally [open] [closed] upon loss of pneumatic pressure.

#### 2.11.3.3 Variable Volume, Single Duct, Fan-Powered

Variable volume, single duct, fan-powered terminal units shall be provided with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Units shall control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 200 to 1500 Pa<sup>3/4</sup> to 6 inch water gauge. Unit fan shall be centrifugal, direct-driven, double-inlet type with forward curved blades. Fan motor shall be either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type. Fan/motor assembly shall be isolated from the casing to minimize vibration transmission. Fan control shall be factory furnished and wired into the unit control system. A factory-mounted pressure switch shall be furnished to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

#### 2.11.3.4 Dual Duct Terminal Units

Dual duct terminal units shall be provided with hot and cold inlet valve or dampers. Dampers shall be controlled in unison by single or dual actuators. Actuator shall be as specified in paragraph CONTROLS. Unit shall control delivered air volumes within plus or minus 5 percent with inlet air variations from 250 to 2000 Pa<sup>1</sup> to 8 inch water gauge in either duct. Mixing baffles shall be included with the unit casing. Cabinet and closed duct leakage shall not exceed 2 percent of maximum rated air volume.

Internal resistance of units shall not exceed [\_\_\_\_\_] Pa<sup>inch</sup> water gauge at maximum flow range.

#### 2.11.3.5 Ceiling Induction Unit

Ceiling induction unit shall be provided with a calibrated primary air volume sensing device, primary air valve, induced air damper, and insulated induction tube. Unit shall be arranged to induce air from the ceiling plenum to maintain a maximum total flow circulated to the conditioned space. Primary air shall be varied upon demand of the room thermostat. Upon a demand for maximum cooling, the unit shall deliver 100 percent primary air and, at minimum cooling, shall deliver [50] [25] percent primary air. Terminal unit shall be capable of closing to full shut off without additional actuators or linkage changes. Terminals shall reset primary air volume within plus or minus 5 percent determined by the thermostat regardless of upstream changes in the static pressure. Minimum inlet static pressure shall not exceed 250 Pa (1 inch water gauge), 1 inch water gauge, including a maximum of 75 Pa (0.3 inch water gauge) 0.3 inch water gauge downstream static pressure. External differential pressure

taps separate from control pressure taps shall be provided for primary air flow measurement with 0 to 250 Pa0 to 1 inch water gauge range. Each unit shall be normally [open] [closed] upon loss of pneumatic pressure. Actuator and accuracy controls shall be completely factory piped requiring only field installation of 138 kPa20 psi pneumatic main air and room thermostat.

#### 2.11.3.6 Reheat Units

a. Hot Water Coils: Hot-water coils shall be fin-and-tube type constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Headers shall be constructed of cast iron, welded steel or copper. Casing and tube support sheets shall be 1.6 mm (16 gauge), 16 gauge, galvanized steel, formed to provide structural strength. Tubes shall be correctly circuited for proper water velocity without excessive pressure drop and they shall be drainable where required or indicated. At the factory, each coil shall be tested at not less than 1700 kPa250 psi air pressure and shall be suitable for 1400 kPa (200 psi)200 psi working pressure. Drainable coils shall be installed in the air handling units with a pitch of not less than 10 mm per m1/8 inch per foot of tube length toward the drain end. Coils shall conform to the provisions of ARI 410.

b. Steam Coils: Steam coils shall be constructed of cast semisteel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered to the tubes. Tubes shall be rolled and bushed, brazed or welded into headers. Coil casings and tube support sheets, with collars of ample width, shall be not lighter than 1.6 mm (16 gauge)16 gauge galvanized steel formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. The fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Coils shall be factory pressure tested and capable of withstanding 1700 kPa (250 psi)250 psi hydrostatic test pressure or 1400 kPa (250 psi)250 psi air pressure, and shall be for [700] [1400] kPa [100] [200] psi steam working pressure. Preheat coils shall be steam-distribution tube type with condensing tubes having not less than 15 mm5/8 inch outside diameters. Distribution tubes shall have not less than 10 m 3/8 inch outside diameter, with orifices to discharge steam to condensing tubes. Distribution tubes shall be installed concentric inside of condensing tubes and shall be held securely in alignment. The maximum length of a single coil shall be limited to 120 times the diameter of the outside tube. Other heating coils shall be single tube type with not less than 12 mm 1/2 inch outside diameter. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coils shall conform to the provisions of ARI 410.

c. Electric Resistance Heaters: Electric resistance heaters shall be of the duct-mounting type consisting of a nickel-chromium resistor mounted on refractory material and a steel or aluminum frame for attachment to ductwork. Electric duct heater shall meet the requirement of Underwriters Laboratories and NFPA 70 and shall be provided with a built-in or surface-mounted high-limit thermostat. Electric duct heaters shall be interlocked electrically so that heaters cannot be energized unless the fan is

running.

#### 2.11.4 Unit Ventilators

Unit ventilators shall include an enclosure, [galvanized casing,] [cold-rolled steel casing with corrosion resistant coating,] coil assembly, [resistance heating coil assembly,] [valve and piping package,] drain pan, air filters, fan assembly, fan drive, motor, motor controller, dampers, and damper operators. Sound power level shall be as indicated. Sound power level data or values for these units shall be obtained according to test procedures based on ARI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles, when handling standard flow for which the unit air capacity is rated. Each unit shall be secured to the building structure. Capacity of the unit ventilators shall be as indicated. Unit ventilators shall be of the year-round classroom type with automatic controls arranged to properly heat, cool, and ventilate the room. Automatic valves and controls shall be provided as specified in paragraph CONTROLS. Sequence of control shall be any one of the standard ANSI cycles specified in paragraph CONTROLS.

##### 2.11.4.1 Enclosures

Enclosures shall be fabricated of not lighter than 1.6 mm (16 gauge) 16 gauge galvanized steel, reinforced and braced, or all welded framework with panels to provide equivalent strength. The casing shall be acoustically and thermally insulated internally with not less than 13 mm 1/2 inch thick dual density fibrous glass insulation. The exposed side shall be high density, erosion-proof material suitable for use in air streams with velocities up to 246 m/s 4500 fpm. The insulation shall be fastened with waterproof, fire-resistant adhesive. Front panel shall be designed for easy removal by one person. [Discharge grilles shall have adjustable grilles or grilles with adjustable vanes and] [Discharge grilles] shall properly distribute air throughout the conditioned space. Return grilles shall be removable where front panel does not provide access to interior components. Plastic discharge or return grilles are not acceptable. Removable panels or access doors shall be provided for all piping and control compartments. Fan switch shall be key operated or accessible through a locked access panel. Gaskets shall be provided at the back and bottom of the unit for effective air seal, as required.

##### 2.11.4.2 Electric Resistance Heating Elements

Electric resistance heating elements shall be of the sheathed, finned, tubular type, or of the open resistance type designed for direct exposure to the air stream. Heating element electrical characteristics shall be as indicated. Where fan motor or control voltage is lower than required for the electric resistance heating element, a fused factory mounted and wired transformer shall be provided.

##### 2.11.4.3 Fans

Fans shall be of the galvanized steel or aluminum, multiblade, centrifugal type, dynamically and statically balanced. Fan housings shall be provided with resilient mounted, self-aligning permanently lubricated ball bearings, sleeve bearings, or combination ball and sleeve bearings, capable of not less than 2000 hours of operation on one oiling. Fans shall be direct-connected.

#### 2.11.4.4 Coils

Coils shall be circuited for a maximum water velocity of 2.4 m/s8 fps without excessive pressure drop and shall otherwise be as specified for hot water coils in paragraph TERMINAL UNITS.

#### 2.11.4.5 Drain Pans

Drain and drip pans shall be sized and located to collect all condensed water dripping from any item within the unit enclosure. Drain pans shall be constructed of not lighter than 1.2 mm (18 gauge)18 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Insulation shall be coated with a fire-resistant waterproofing material. In lieu of the above, drain pans may be constructed of die-formed 1.0 mm (20 gauge)20 gauge steel, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 1.3 mm (18 gauge)18 gauge steel material, or of die-formed 1.3 mm (18 gauge)18 gauge type 304 stainless steel insulated as specified above. Drain pans shall be pitched to drain. Drain connection shall be provided when a condensate drain system is indicated. Connection shall be minimum 20 mm3/4 inch NDT or 18 mm5/8 inch OD.

#### 2.11.4.6 Filters

Fiberglass disposable type, 25 mm1 inch thick, conforming to ASHRAE 52.2, installed upstream of coil.

#### 2.11.4.7 Dampers

An outside air proportioning damper shall be provided on each unit. In addition, a vane shall be provided to prevent excessive outside air from entering unit and to prevent blow-through of outside air through the return air grille under high wind pressures. Where outside air and recirculated air proportioning dampers are provided on the unit, an additional vane will not be required. Face and bypass dampers shall be provided for each unit to ensure constant air volume at all positions of the dampers. Each unit shall be provided with a factory installed control cam assembly, pneumatic motor, or electric motor to operate the face and bypass dampers and outside air damper or outside air and recirculated air dampers in the sequence as specified in paragraph CONTROLS.

#### 2.11.4.8 Motors

\*\*\*\*\*  
**NOTE: Statements should be deleted depending on  
whether the units are freestanding, built-in, or  
both.**  
\*\*\*\*\*

Motors shall be of the permanent split-capacitor type with built-in thermal overload protection and automatic reset. Motor shall be mounted on a resilient mounting, isolated from the casing and shall be suitable for operation on electric service available. A manually operated motor switch shall provide for 2 or 3 speeds and off and shall be mounted on an identified plate [inside the unit below or behind an access door] [or] [adjacent to the room thermostat] [as indicated]. In lieu of speed control, a solid state variable speed controller having minimum speed reduction of 50 percent may be provided.



#### 2.11.4.9 Outside Air Intakes

Outside air intakes shall be the manufacturer's standard design and provided with 13 mm1/2 inch mesh bird screen or louvers on 13 mm1/2 inch centers.

### 2.12 ENERGY RECOVERY DEVICES

#### 2.12.1 Rotary Wheel

\*\*\*\*\*

NOTE: Energy recovery device supply/exhaust filters, preheat coils, backdraft dampers, exhaust dampers, recirculation dampers, face and bypass dampers, drainage provisions, controls and like ancillaries will be shown on the drawings and supplemented by the specifications as necessary. Select minimum acceptable energy transfer effectiveness and maximum acceptable cross-contamination.

Delete moisture resistance and chain drive if not required.

\*\*\*\*\*

Unit shall be a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream. Device performance shall be according to ASHRAE 84. Device shall deliver an energy transfer effectiveness of not less than [70] [85] [\_\_\_\_\_] percent with cross-contamination not in excess of [0.1] [1.0] [\_\_\_\_\_] percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel. Exchange media shall be chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Exhaust and supply streams shall be isolated by seals which are static, field adjustable, and replaceable. Chain drive mechanisms shall be fitted with ratcheting torque limiter or slip-clutch protective device. Enclosure shall be fabricated from galvanized steel and shall include maintenance access provisions. Recovery control and rotation failure provisions shall be as indicated.

#### 2.12.2 Run-Around-Coil

\*\*\*\*\*

NOTE: Delete "factory fabricated and tested" if not required.

Coordinate with paragraph Glycol.

\*\*\*\*\*

Assembly shall be factory fabricated and tested air-to-liquid-to-air energy recovery system for transfer of sensible heat from exhaust air to supply air stream. System shall deliver an energy transfer effectiveness not less than that indicated without cross-contamination with maximum energy recovery at minimum life cycle cost. Components shall be computer optimized for capacity, effectiveness, number of coil fins per inch, number of coil rows, flow rate, heat transfer rate of [\_\_\_\_\_] percent by volume of [ethylene] [propylene] glycol solution, and frost control. Coils shall conform to paragraph AIR HANDLING UNITS. Related pumps, and piping specialties shall conform to requirements of [Section 15652A COLD STORAGE

### 2.12.3 Heat Pipe

\*\*\*\*\*

**NOTE: Schedule should include face air velocity,  
static pressure drop, temperature requirements for  
entering and leaving air or exhaust streams.**

**Delete flexible connectors if not required.**

\*\*\*\*\*

Device shall be a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams. Device shall deliver an energy transfer effectiveness not less than that indicated without cross-contamination. Heat exchanger tube core shall be [15] [18] [25] mm [1/2] [5/8] [1] inch nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Maximum fins per unit length and number of tube rows shall be as indicated. Tubes shall be fitted with internal capillary wick, filled with an ASHRAE 15, Group 1 refrigerant working fluid, selected for system design temperature range, and hermetically sealed. Heat exchanger frame shall be constructed of not less than 1.6 mm (16 gauge) 16 gauge galvanized steel and fitted with intermediate tube supports, and flange connections. Tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio shall be provided. [A drain pan constructed of welded Type 300 series stainless steel shall be provided.] Heat recovery regulation shall be provided by [system face and bypass dampers and related control system as indicated] [interfacing with manufacturer's standard tilt-control mechanism for summer/winter operation, regulating the supply air temperature and frost prevention on weather face of exhaust side at temperature indicated]. Coil shall be fitted with pleated flexible connectors.

### 2.13 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A 123/A 123M or ASTM A 924/A 924M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatized and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654, and ASTM D 3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 3 mm 1/8 inch. Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to ASTM D 520 Type I.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

### 3.1.1 Piping

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers. Changes in direction shall be made with fittings, except that bending of pipe 100 mm4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Horizontal supply mains shall pitch down in the direction of flow as indicated. The grade shall be not less than 2 mm in 1 ml inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the system. Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 65 mm2-1/2 inches or less in diameter, and with flanges for pipe 80 mm3 inches and larger. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric unions or flanges. All piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded.

#### 3.1.1.1 Joints

a. Threaded Joints: Threaded joints shall be made with tapered threads and made tight with a stiff mixture of graphite and oil or polytetrafluoroethylene tape or equivalent thread joint compound or material, applied to the male threads only.

b. Soldered Joints: Joints in copper tubing shall be cut square with ends reamed, and all filings and dust wiped from interior of pipe. Joints shall be soldered with 95/5 solder or brazed with silver solder applied and drawn through the full fitting length. Care shall be taken to prevent annealing of tube or fittings when making connections. Joints 65 mm2-1/2 inches and larger shall be made with heat uniformly around the entire circumference of the joint with a multi-flame torch. Connections in floor slabs shall be brazed. Excess solder shall be wiped from joint before solder hardens. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

c. Welded Joints : [Welding shall be according to qualified procedures using qualified welders and welding operators. Procedures and welders shall be qualified according to ASME BPVC IX. Welding procedures qualified by others and welders and welding operators qualified by another operator may be permitted by ASME B31.1. Structural members shall be welded according to Section 05090A WELDING, STRUCTURAL. All welds shall be permanently identified by imprinting the welder's or welding operator's assigned symbol adjacent to the weld.] [Welding and

nondestructive testing procedures are specified in Section 05093 WELDING PRESSURE PIPING.] Welded joints shall be fusion welded unless otherwise required. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. Electrodes shall be stored and dried according to AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

#### 3.1.1.2 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

#### 3.1.1.3 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items.

### 3.1.2 Supports

#### 3.1.2.1 General

Hangers used to support piping 50 mm2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

#### 3.1.2.2 Seismic Requirements (Pipe Supports and Structural Bracing)

\*\*\*\*\*

**NOTE: Provide seismic requirements, if a Government designer (either Corps office or A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase if seismic details are**

**not provided. Sections 13080 and 15070, properly  
edited, must be enclosed in the contract documents.**

\*\*\*\*\*

Piping and attached valves shall be supported and braced to resist seismic loads as specified under Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 15070A SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT [as shown on the drawings]. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for support shall be as specified under Section 05210A STEEL JOISTS.

#### 3.1.2.3 Pipe Hangers, Inserts and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Types 5, 12, and 26 shall not be used.

- a. Hangers: Type 3 shall not be used on insulated piping.
- b. Inserts: Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.
- c. C-Clamps: Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.
- d. Angle Attachments: Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.
- e. Hangers: Type 24 may be used only on trapeze hanger systems or on fabricated frames.
- f. Type 39 saddles shall be used on all insulated pipe 100 mm4 inches and larger when the temperature of the medium is above 15.5 degrees C60 degrees F. Type 39 saddles shall be welded to the pipe.
- g. Type 40 shields shall:
  - (1) be used on all insulated pipes less than 100 mm4 inches.
  - (2) be used on all insulated pipes 100 mm4 inches and larger when the temperature of the medium is 15.5 degrees C60 degrees F or less.
  - (3) have a high density insert for pipe 50 mm2 inches and larger, and for smaller pipe when the insulation shows signs of being visibly compressed, or when the insulation or jacket shows visible signs of distortion at or near the type 40 shield. High density inserts shall have a density of 144 kg/cubic meter (9 pcf) 9 pcf or greater.
- h. Horizontal Pipe Supports: Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm1 foot from the pipe fitting joint at each change

in direction of the piping. Pipe supports shall be spaced not over 15 feet apart at valves. [Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 220 N (50 pounds) shall have the excess hanger loads suspended from panel points.]

i. Vertical Pipe Supports: Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

j. Pipe Guides: Type 35 guides using steel reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

k. Steel Slides: Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger with medium 15.5 degrees C (60 degrees F) or greater, a Type 39 saddle may be welded to the pipe and freely rest on a steel plate. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

l. High Temperature Guides with Cradles: Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches), or by an amount adequate for the insulation, whichever is greater.

m. Insulated Pipe: Insulation on horizontal pipe shall be continuous through hangers for hot and cold piping. Other requirements on insulated pipe are specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

### 3.1.3 Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

### 3.1.4 Penetrations

#### 3.1.4.1 Pipe Sleeves

\*\*\*\*\*  
**NOTE: Detail type of pipe sleeves on the drawings, illustrating method of sealing annular space between pipe and sleeve. Coordinate requirements for clearance around sleeves with Section 15070A SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT.**

\*\*\*\*\*

Sleeves shall not be installed in structural members except where indicated or approved. Sleeves shall be of sufficient length to pass through entire thickness of walls and partitions and shall be cut flush with each surface.

Pipes passing through concrete or masonry wall shall be provided with pipe sleeves fitted into place at the time of construction. Unless otherwise indicated, sleeves shall provide a minimum of [6] [19] mm[1/4] [3/4] inch all-around clearance between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in bearing walls and wet areas shall be steel pipe or cast iron pipe. Sleeves in non-bearing walls or ceilings may be steel pipe, cast iron pipe, galvanized sheet metal with lock-type longitudinal seam and of the metal thickness indicated, or moisture resistant fiber or plastic. Install sleeves through below-grade walls in contact with earth so that sleeves are recessed 13 mm1/2 inch from wall surfaces on both sides. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve, in non-fire rated walls, shall be sealed as indicated and specified in Section 07920 JOINT SEALANTS. Pipes passing through wall waterproofing membrane shall be sleeved as specified above, and a waterproofing clamping flange shall be installed as indicated. Provide flashing in accordance with Section 07600 FLASHING AND SHEET METAL where pipes pass through outside walls. Sleeve requirements for insulated pipes shall be in accordance with Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

#### 3.1.4.2 Roof and Floor Sleeves

Pipes passing through roof or floor waterproofing membrane shall be installed through a 17-ounce copper sleeve or a 0.8 mm0.032 inch thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm8 inches from the pipe and shall be set over the roof or floor membrane in a troweled coating of bituminous cement. Unless otherwise shown, the flashing sleeve shall extend up the pipe a minimum of 50 mm2 inches above highest floor level or a minimum of 250 mm10 inches above the roof. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 250 mm10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess. In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. Sleeves are not required for supply, drainage, waste and vent piping passing through concrete slab on grade, except where penetrating a membrane waterproof floor. Pipe sleeves passing through floors in wet areas shall extend at least 100 mm4 inches above the finished floor; otherwise extend sleeves in floor slabs 50 mm2 inches above the finished

floor. Provide flashing in accordance with Section 07600 FLASHING AND SHEET METAL where pipes pass through building roofs. Sleeve requirements for insulated pipes shall be in accordance with Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

#### 3.1.4.3 Ducts

\*\*\*\*\*  
**NOTE: Where sleeves are installed in the bearing walls, the designer must provide design details in drawings of the structural steel sleeves after consulting with structural engineers for the design details.**  
\*\*\*\*\*

Provide sleeves and prepared openings for duct mains, branches, and other item penetrations, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface; sleeves for round duct shall be 380 mm15 inches and smaller; provide framed prepared openings for round duct larger than 380 mm 15 inches and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide 25 mm1 inch clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming to ASTM C 553, Type 1, Class B-2.

a. Sleeve Fabrication: Fabricate sleeves, except as otherwise specified or indicated, from 20 gauge 1 mm0.0396 inch thick minimum galvanized steel sheet. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming to ASTM A 53/A 53M, Schedule 40.

b. Framed Prepared Openings: Fabricate framed prepared openings from 20 gauge 1 mm 0.0396 inch minimum galvanized steel sheet, unless otherwise indicated. Reinforce all around openings with 25 x 25 x 3 mm 1 x 1 x 0.125 inch galvanized steel angles, tack welded to wall side of openings; angle leg shall be flush with ends of opening.

c. Closure Collars: Provide closure collars of a minimum 100 mm4 inches width, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 380 mm15 inches in diameter or less from 20 gauge, 1 mm0.0396 inch minimum galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with a minimum dimension over 380 mm15 inches from 18 gauge 1.4 mm 0.0516 inch galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 380 mm15 inches or less from 20 gauge 1 mm0.0396 inch galvanized steel. Install collars with fasteners a maximum of 150 mm6 inches on centers; attach to collars a minimum of 4 fasteners where opening is 300 mm12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 500 mm20 inches in diameter or less.

#### 3.1.4.4 Packing and Sealant

Pack the space between the pipe or tubing and the sleeve firmly with



mineral wool insulation. Except as otherwise specified, the annular space at both ends of the sleeve shall be sealed as indicated with sealants conforming to ASTM C 920 and with primer, backstop material and surface preparation as specified in Section 07920 JOINT SEALANTS. The annular space shall not be sealed for interior walls and chase walls that are not designated as fire rated or requiring acoustical attenuation. In waterproofed construction, caulk both ends of the sleeve with plastic waterproof cement that will dry to a firm but pliable mass. In lieu of plastic waterproof cement and mineral wool insulation, a mechanically adjustable, segmented, elastomeric seal may be used; if used, seal segments shall be interlocking and shaped to continuously fill the annular space between the pipe and sleeve to provide a watertight seal when expanded by tightening fasteners. Fasteners shall be galvanized. Where sleeves are installed in below-grade walls in contact with earth, fill the annular space between pipe and sleeve with backing material and sealants in the joint between the pipe and concrete or masonry. Sealant selected for the earth side of the wall shall be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Where pipes pass through fire-rated walls, fire-partitions, fire-rated chase walls or floors above grade, the penetration shall be sealed with firestopping materials as specified in Section 07840 FIRESTOPPING.

#### 3.1.4.5 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07840 FIRESTOPPING.

#### 3.1.4.6 Escutcheons

Escutcheons shall be provided at finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheons shall be secured to pipe or pipe covering. Escutcheons shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

#### 3.1.4.7 Electrical Penetrations

Seal openings around electrical penetrations through fire-rated walls, partitions, floors, or ceilings in accordance with Section 07840 FIRESTOPPING. Provide flanges where busways make penetrations through walls and floors, and seal to maintain smoke and fire ratings. Where conductors run through smoke and fire partitions, install in 103 mm4 inch rigid steel conduits with grounding bushings, extending 305 mm12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions.

#### 3.1.5 Condensate Drain Lines

Water seals shall be provided in the condensate drain from all [units.] [units except room [fan-coil units] [and] [coil-induction units]]. The depth of each seal shall be 50 mm2 inches plus 0.1 mm for each Pa, the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Water seals shall be constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Pipe cap or plug cleanouts shall be provided where indicated. Drains indicated to connect to the sanitary waste system shall be

connected by an indirect waste fitting. Air conditioner drain lines shall be insulated as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

#### 3.1.6 Pipe-Alignment Guides

Pipe-alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m5 feet on each side of each expansion joint, and in lines 100 mm4 inches or smaller not more than 600 mm2 feet on each side of the joint.

#### 3.1.7 Air Vents and Drains

##### 3.1.7.1 Vents

Air vents shall be provided at high points, on water coils, and where indicated to ensure adequate venting of the piping system.

##### 3.1.7.2 Drains

Drains shall be provided at low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

#### 3.1.8 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment such as pumps, heaters, heating or cooling coils, and other similar items, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purposes. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

#### 3.1.9 Equipment and Installation

Frames and supports shall be provided for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Air handling units shall be floor mounted or ceiling hung, as indicated. The method of anchoring and fastening shall be as detailed. Floor-mounted equipment, unless otherwise indicated, shall be set on not less than 150 mm6 inch concrete pads or curbs doweled in place. Concrete foundations for circulating pumps shall be heavy enough to minimize the intensity of the vibrations transmitted to the piping and the surrounding structure, as recommended in writing by the pump manufacturer. In lieu of a concrete pad foundation, a concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. The concrete foundation or concrete pedestal block shall be of a mass not less than three times the weight of the components to be supported. Lines connected to the pump mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300A CAST-IN-PLACE STRUCTURAL CONCRETE.

### 3.1.10 Access Panels

Access panels shall be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500A MISCELLANEOUS METALS.

### 3.1.11 Flexible Connectors

\*\*\*\*\*  
**NOTE: Flexible connectors will be provided where required to absorb expansion and contraction, isolate vibration, absorb noise, compensate offset motion, absorb continuous flexing, and relieve equipment from piping stresses. Where flexible connectors are needed to correct lateral, parallel, and angular misalignment, their use will be limited to maximum offset as recommended, in writing, by the manufacturer.**  
\*\*\*\*\*

Pre-insulated flexible connectors and flexible duct shall be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the connector or duct manufacturer and shall be provided at the intervals recommended.

### 3.1.12 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07840 FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07920 JOINT SEALANTS.

### 3.1.13 Metal Ductwork

Installation shall be according to SMACNA HVAC Duct Const Stds unless otherwise indicated. Duct supports for sheet metal ductwork shall be according to SMACNA HVAC Duct Const Stds, unless otherwise specified. Friction beam clamps indicated in SMACNA HVAC Duct Const Stds shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion. Supports on the risers shall allow free vertical movement of the duct. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided.

#### 3.1.13.1 Underground Ductwork

\*\*\*\*\*  
**NOTE: Due to potential contaminants of air-stream, such as pesticides and corrosion, underground ductwork should be used only for exhaust air.**  
\*\*\*\*\*

Underground ductwork shall be PVC plastisol coated galvanized steel with coating on interior and exterior surfaces and watertight joints. Ductwork shall be installed as indicated, according to ACCA Manual 4 and manufacturer's instructions. Maximum burial depth shall be 2 m6 feet.

#### 3.1.13.2 Radon Exhaust Ductwork

\*\*\*\*\*  
NOTE: Subslab ventilation for radon mitigation will  
be designed as prescribed in TM 5-810-1.  
\*\*\*\*\*

Subslab suction piping shall be perforated where indicated. PVC joints shall be installed as specified in ASTM D 2855.

#### 3.1.13.3 Light Duty Corrosive Exhaust Ductwork

Light duty corrosive exhaust ductwork shall be PVC plastisol coated galvanized steel with PVC coating on interior [surfaces.] [and exterior surfaces] [and epoxy wash primer coating on exterior surfaces].

#### 3.1.14 Fibrous Glass Ductwork

Installation shall be according to the manufacturer's written recommendations unless otherwise required in NAIMA AH115. Duct supports for fibrous glass ductwork shall conform to NAIMA AH115. In those cases not covered in NAIMA AH115, the written recommendation of the fibrous duct manufacturer shall be followed.

#### 3.1.15 FRP Ductwork

\*\*\*\*\*  
NOTE: Study characteristics of exhaust stream  
constituents and contaminant materials to determine  
service life and safety controlling parameters.  
Consider that constituents concentrate upon  
evaporation of carrier. Some concentrates detonate  
upon impact. Design to preclude concentrate  
high-out water washing may be necessary. Review  
fire protection provisions, and the need for fire  
stops. The manufacturer cannot be held responsible  
for performance of his product, unless the  
specification delineates product exposure. Modify  
or supplement specification criteria as necessary.  
\*\*\*\*\*

Fibrous glass reinforced plastic ducting and related structures shall conform to SMACNA Industry Practice. Flanged joints shall be provided where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 10 degrees C, 50 degrees F, joints shall be heat cured by exothermic reaction heat packs.

#### 3.1.16 Kitchen Exhaust Ductwork

\*\*\*\*\*  
NOTE: The requirements in NFPA 96 pertaining to  
enclosures around kitchen exhaust ducts shall be  
shown on the drawings.

The referenced SMACNA HVAC Duct Construction Manual does not cover negative pressures in excess of 3 inches water gauge. If the static pressure within the duct will exceed 3 inches negative, then the spacing and duct thickness must be indicated on the drawings and the paragraph accordingly.

\*\*\*\*\*

#### 3.1.16.1 Ducts Conveying Smoke and Grease Laden Vapors

Ducts conveying smoke and grease laden vapors shall conform to requirements of NFPA 96. Seams, joints, penetrations, and duct-to-hood collar connections shall have a liquid tight continuous external weld. Duct material shall be [minimum 1.3 mm (18 gauge), 18 gauge, Type 304L or 316L, stainless steel] [minimum 1.6 mm (16 gauge), 16 gauge carbon steel]. [Duct construction shall include external perimeter angle sized in accordance with SMACNA HVAC Duct Const Stds, except welded joint reinforcement shall be on maximum of 600 mm 24 inch centers; continuously welded companion angle bolted flanged joints with flexible ceramic cloth gaskets where indicated; pitched to drain at low points; welded pipe coupling-plug drains at low points; welded fire protection and detergent cleaning penetration; steel framed, stud bolted, and flexible ceramic cloth gasketed cleaning access provisions where indicated. Angles, pipe couplings, frames, bolts, etc., shall be same material as that specified for the duct unless indicated otherwise.]

#### 3.1.16.2 Exposed Ductwork

Exposed ductwork shall be fabricated from minimum 1.3 mm (18 gauge), 18 gauge, Type 304L or 316L, stainless steel with continuously welded joints and seams. Ducts shall be pitched to drain at hoods and low points indicated. Surface finish shall match hoods.

#### 3.1.16.3 Concealed Ducts Conveying Moisture Laden Air

Concealed ducts conveying moisture laden air shall be fabricated from minimum [1.3 mm (18 gauge), 18 gauge, Type 300 series, stainless steel] [1.6 mm (16 gauge), 16 gauge, galvanized steel] [0.55 mm, 16 ounce, tempered copper sheet]. Joints shall be continuously welded, brazed, or soldered to be liquid tight. Duct shall be pitched to drain at points indicated. Transitions to other metals shall be liquid tight, companion angle bolted and gasketed.

#### 3.1.17 Acoustical Duct Lining

Lining shall be applied in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C 916, Type I, NFPA 90A, UL 723, and ASTM E 84. Top and bottom pieces shall lap the side pieces and shall be secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA HVAC Duct Const Stds. Welded pins, cup-head pins, or adhered clips shall not distort the duct, burn through, nor mar the finish or the surface of the duct. Pins and washers shall be flush with the surfaces of the duct liner and all breaks and punctures of the duct liner coating shall be sealed with the nonflammable, fire resistant adhesive. Exposed edges of the liner at the duct ends and at other joints where the lining will be subject to erosion shall be coated with a heavy brush coat of the nonflammable, fire resistant adhesive, to

prevent delamination of glass fibers. Duct liner may be applied to flat sheet metal prior to forming duct through the sheet metal brake. Lining at the top and bottom surfaces of the duct shall be additionally secured by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA HVAC Duct Const Stds to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, will be acceptable.

#### 3.1.18 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection shall be provided. The distribution system (supply and return) shall be protected with temporary seal-offs at all inlets and outlets at the end of each day's work. Temporary protection shall remain in place until system is ready for startup.

#### 3.1.19 Insulation

Thickness and application of insulation materials for ductwork, piping, and equipment shall be according to Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Outdoor air intake ducts and plenums shall be externally insulated [up to the point where the outdoor air reaches the conditioning unit] [or] [up to the point where the outdoor air mixes with the outside air stream].

#### 3.1.20 Duct Test Holes

\*\*\*\*\*  
**NOTE: The location of duct test holes will be shown  
on the drawings. Holes should be located so as to  
implement the requirements of Section 15990A  
TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.**  
\*\*\*\*\*

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

#### 3.1.21 Power Roof Ventilator Mounting

Foamed 13 mm1/2 inch thick, closed-cell, flexible elastomer insulation shall cover width of roof curb mounting flange. Where wood nailers are used, holes shall be pre-drilled for fasteners.

#### 3.1.22 Power Transmission Components Adjustment

V-belts and sheaves shall be tested for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct driven couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

### 3.2 FIELD PAINTING AND IDENTIFICATION SYSTEMS

\*\*\*\*\*  
**NOTE: There is a similar requirement for  
identification in Section 15400A, PLUMBING, GENERAL**

**PURPOSE. The designer will ensure that color coding for all mechanical systems is coordinated.**

\*\*\*\*\*

### 3.2.1 Identification Tags

\*\*\*\*\*

**NOTE: Delete when identification tags are not considered necessary on small projects.**

\*\*\*\*\*

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number shall be installed on all valves and dampers. Tags shall be 35 mm1-3/8 inch minimum diameter and marking shall be stamped or engraved. Indentations shall be black for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

### 3.2.2 Finish Painting and Pipe Color Code Marking

\*\*\*\*\*

**NOTE: Designer will coordinate color code marking with Section 09900. Color code marking for piping not listed in Table 1 of Section 09900 will be added to the table.**

\*\*\*\*\*

Finish painting of items only primed at the factory, surfaces not specifically noted otherwise, and color code marking for piping shall be as specified in Section 09900 PAINTS AND COATINGS.

### 3.2.3 Color Coding Scheme for Locating Hidden Utility Components

\*\*\*\*\*

**NOTE: The Color Code Table will be coordinated with the installation. Identification plate specified in Section 09900 PAINTS AND COATINGS will be deleted if color coding scheme is specified.**

\*\*\*\*\*

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 12 mm3/8 inch diameter and secured to removable ceiling panels with fasteners. Each fastener shall be inserted into the ceiling panel so as to be concealed from view. The fasteners shall be manually removable without the use of tools and shall not separate from the ceiling panels when the panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall be approximately 1 m3 foot wide, 750 mm30 inches high, and 12 mm1/2 inches thick. The board shall be made of wood fiberboard and framed under glass or 1.6 mm1/16 inch transparent plastic cover. The color code symbols shall be approximately 20 mm3/4 inch in diameter and the related lettering in 12 mm1/2 inch high capital letters. The color code board shall be mounted [where indicated] [in the mechanical or equipment room]. The color code system shall be as indicated below:

|         |         |         |          |
|---------|---------|---------|----------|
| Color   | System  | Item    | Location |
| [_____] | [_____] | [_____] | [_____]  |

### 3.3 PIPING HYDROSTATIC TEST

After cleaning, water piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Leaks shall be repaired and piping retested until test is successful. No loss of pressure will be allowed. Leaks shall be repaired by re-welding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before covering or concealing.

### 3.4 DUCTWORK LEAK TEST

\*\*\*\*\*

NOTE: This paragraph may be omitted where all ductwork is constructed to static pressure Class 125, 250, or 500 Pa (1/2, 1, or 2 inch W.G.). Otherwise, leakage rate will be derived for each system to be tested based on procedure outlined in SMACNA Leakage Test Mnl for Seal Class A. If round/oval metal ductwork only is specified, C sub L = 3 will be used, otherwise C sub L = 6 may be used.

The value of P used will be equal to the highest duct static pressure class; i.e., 3, 4, 6, or 10, for the ductwork to be tested. Where major components such as fans, coils, filters, etc. will be included in ductwork test, an appropriate allowance will be included in the maximum allowable leakage rate.

When ductwork leakage testing is deleted, the designer must also appropriately edit out the references to ductwork leakage testing under SD-06 in the Submittals paragraph and in paragraph DUCTWORK LEAK TESTING of UFGS-15990A when included in the project.

\*\*\*\*\*

Ductwork leak test shall be performed for the entire air distribution and exhaust system, including fans, coils, [filters, etc.] [filters, etc. designated as static pressure Class 750 Pa3 inch water gauge through Class 2500 Pa10 inch water gauge.] Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. The maximum allowable leakage rate is [\_\_\_\_\_] L/s[\_\_\_\_\_] cfm. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

### 3.5 DAMPER ACCEPTANCE TEST

All fire dampers and smoke dampers shall be operated under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Fire dampers equipped with fusible links shall be tested by having the fusible link cut in place. Dynamic fire dampers shall be tested with the air handling and distribution system running. All fire dampers shall be reset with the fusible links replaced after acceptance



testing. To ensure optimum operation and performance, the damper must be installed so it is square and free from racking.

### 3.6 TESTING, ADJUSTING, AND BALANCING

Testing, adjusting, and balancing shall be as specified in Section 15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

### 3.7 PERFORMANCE TESTS

After testing, adjusting, and balancing has been completed as specified, each system shall be tested as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be made as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Tests shall cover a period of not less than [\_\_\_\_\_] days for each system and shall demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings shall be made at points indicated on the drawings for the duration of the time period and shall record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

### 3.8 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of foreign matter. A temporary bypass shall be provided for water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Inside of [room fan-coil units] [coil-induction units,] [air terminal units,] [unit ventilators,] ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

### 3.9 FIELD TRAINING

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**NOTE: The number of hours of instruction should be determined based of the number and complexity of the systems specified.**  
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The Contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of [\_\_\_\_\_] hours of normal working time and shall start after the system is functionally complete but prior to the performance tests. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions.

-- End of Section --