****
USACE / NAVFAC / AFCESA / NASA **UFGS-23 00 00 (April 2008)**

Preparing Activity: USACE **Superseding UFGS-23 00 00 (January 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated March 2008
****

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 00 00

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS

04/08

2.4.5 Diffusers, Registers, and Grilles
2.4.5.1 Diffusers
2.4.5.2 Perforated Plate Diffusers
2.4.5.3 Linear Diffusers
2.4.5.4 Security Ceiling Diffusers
2.4.5.5 Registers and Grilles
2.4.5.6 Registers
2.4.5.7 Security Supply Air Registers Except in Cells
2.4.5.8 Security Return and Other Air Registers Except in Cells
2.4.5.9 Security Supply Air Registers in Cells
2.4.5.10 Security Return and Other Type Air Registers in Cells
2.4.6 Louvers
2.4.7 Air Vents, Penthouses, and Goosenecks
2.4.8 Bird Screens and Frames
2.4.9 Radon Exhaust Ductwork
2.5 AIR SYSTEMS EQUIPMENT
2.5.1 Fans
2.5.1.1 Centrifugal Fans
2.5.1.2 In-Line Centrifugal Fans
2.5.1.3 Axial Flow Fans
2.5.1.4 Panel Type Power Wall Ventilators
2.5.1.5 Centrifugal Type Power Wall Ventilators
2.5.1.6 Centrifugal Type Power Roof Ventilators
2.5.1.7 Propeller Type Power Roof Ventilators
2.5.1.8 Air-Curtain Fans
2.5.1.9 Ceiling Exhaust Fans
2.5.2 Coils
2.5.2.1 Direct-Expansion Coils
2.5.2.2 Water Coils
2.5.2.3 Steam Heating Coils
2.5.2.4 Steam Preheat (Nonfreeze) Coils
2.5.2.5 Electric Heating Coil
2.5.2.6 Eliminators
2.5.2.7 Sprayed Coil Dehumidifiers
2.5.2.8 Corrosion Protection for Coastal Installations
2.5.3 Air Filters
2.5.3.1 Extended Surface Pleated Panel Filters
2.5.3.2 Extended Surface Nonsupported Pocket Filters
2.5.3.3 Cartridge Type Filters
2.5.3.4 Sectional Cleanable Filters
2.5.3.5 Replaceable Media Filters
2.5.3.6 Automatic Renewable Media Filters
2.5.3.7 Electrostatic Filters
2.5.3.8 High-Efficiency Particulate Air (HEPA) Filters
2.5.3.9 Holding Frames
2.5.3.10 Filter Gauges
2.6 AIR HANDLING UNITS
2.6.1 Field-Fabricated Air Handling Units
2.6.2 Factory-Fabricated Air Handling Units
2.6.2.1 Casings
2.6.2.2 Heating and Cooling Coils
2.6.2.3 Air Filters
2.6.2.4 Fans
2.6.2.5 Access Sections and Filter/Mixing Boxes
2.6.2.6 Diffuser Sections
2.6.2.7 Dampers
2.7 TERMINAL UNITS
2.7.1 Room Fan-Coil Units
2.7.1.1 Enclosures

-- End of Section Table of Contents --

****
USACE / NAVFAC / AFCESA / NASA | **UFGS-23 00 00 (April 2008)**

Preparing Activity: USACE | **Superseding UFGS-23 00 00 (January 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated March 2008
****

SECTION 23 00 00

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS
04/08

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

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

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

Comments 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).
****

PART 1 GENERAL

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

1.1 JOB REQUIREMENTS

a. Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation and to eliminate interference with other construction.

b. Asbestos and asbestos-containing products are not allowed.

1.2 REFERENCES

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

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

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

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

AIR 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 201	(2002) Fans and Systems
AMCA 210	(1999; 2001a) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 220	(2005) Test Methods for Air Curtain Units
AMCA 300	(2005) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2005) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(1998) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 260	(2001; Addendum 2002) Sound Rating of Ducted Air Moving and Conditioning Equipment
ARI 350	(2000) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment

ARI 410	(2001; 2002a) Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 430	(1999) Standard for Central-Station Air-Handling Units
ARI 440	(2005) Standard for Room Fan-Coils and Unit Ventilators
ARI 880	(1998; 2002a) Standard for Air Terminals
ARI 885	(1998; 2002a) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
ARI DCAACP	(Online) Directory of Certified Applied Air-Conditioning Products
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 SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(2007; Errata 2007) Safety Code for Refrigeration
ASHRAE 52.2	(2007; Interpertation 1: 2007) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2007; Interpertation 1: 2007) Ventilation for Acceptable Indoor Air Quality
ASHRAE 68	(1997) Laboratory Method of Testing to Determine the Sound Power In a Duct
ASHRAE 70	(2006) Method of Testing for Rating the Performance of Air Outlets and Inlets
ASHRAE 84	(1991) Method of Testing Air-to-Air Heat Exchangers
ASHRAE 90.1 - IP	(2004; Addendas a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,r,s,t,u,v,x,ak 2006; Supp to Addendas 2006; Errata 2007; Interpretations 8 - 15:2007) Energy

	Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition
ASHRAE 90.1 - SI	(2004; Addendas a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,r,s,t,u,v,x,ak 2006; Supp to Addendas 2006; Errata 2007; Interpretations 8 - 15:2007) Energy Standard for Buildings Except Low-Rise Residential Buildings, SI Edition

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 167	(1999; R 2004) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 53/A 53M	(2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 924/A 924M	(2007) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 117	(2007) Standing Practice for Operating Salt Spray (Fog) Apparatus
ASTM B 152/B 152M	(2006a) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B 209	(2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 209M	(2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B 280	(2003) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM C 1071	(2005) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C 553	(2002) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 916	(1985; R 2007) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM D 1654	(2005) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D 1785	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2466	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2564	(2004e1) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D 2855	(1996; R 2002) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D 3359	(2002) Measuring Adhesion by Tape Test
ASTM D 520	(2000; R 2005) Zinc Dust Pigment
ASTM E 2016	(2006) Standard Specification for Industrial Woven Wire Cloth
ASTM E 84	(2007b) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F 1040	(1987; R 2007) Standard Specification for Filter Units, Air Conditioning, Viscous - Impingement and Dry Types, Replaceable

Acoustical Society of America (ASA)

ASA S12.51	(2002) Acoustics Determination of Sound Power Levels of Noise Sources using Sound Pressure Precision Method for Reverberation Rooms

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2006) Standard for Industrial Controls and Systems Enclosures
NEMA MG 1	(2007) Standard for Motors and Generators
NEMA MG 10	(2001; R 2007) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2007) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007) National Electrical Code - 2008 Edition
NFPA 701	(2004) Fire Tests for Flame Propagation of Textiles and Films
NFPA 90A	(2002; Errata 2003; Errata 2005) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 96	(2007) Ventilation Control and Fire Protection of Commercial Cooking Operations

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

SMACNA FGDCS	(2003, 7th Ed) Fibrous Glass Duct Construction Standards
SMACNA HVAC Duct Const Stds	(1995; Addendum 1997, 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	(2005) Standard for Factory-Made Air Ducts and Air Connectors
UL 1995	(2005) Standard for Heating and Cooling Equipment
UL 555	(2006) Standard for Fire Dampers
UL 555S	(1999; Rev thru Jul 2006) Smoke Dampers
UL 586	(1996; Rev thru Aug 2004) Standard for High-Efficiency Particulate, Air Filter Units
UL 705	(2004; Rev thru Mar 2006) Standard for Power Ventilators
UL 723	(2003; Rev thru May 2005) Standard for Test for Surface Burning Characteristics of Building Materials
UL 900	(2004; Rev thru Nov 2007) Standard for Air Filter Units

UL 94	(1996; Rev thru Jun 2006) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL Bld Mat Dir	(2007) Building Materials Directory
UL Electrical Constructn	(2007) Electrical Construction Equipment Directory
UL Fire Resistance	(2007) Fire Resistance Directory

1.3 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

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

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

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

For Navy projects, delete the following submittal items and associated bracketed information: Drawings, Test Procedures, Diagrams, and Bolts.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

[SD-02 Shop Drawings]

[Drawings[; 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. Include any information required to demonstrate that the system has been coordinated and will properly function as a unit on the drawings 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. Highlight the data to show model, size, options, etc., that are intended for consideration. Provide adequate data to demonstrate compliance with contract requirements for the following:

Metallic Flexible Duct
Insulated Nonmetallic Flexible Duct Runouts
Duct Connectors
Duct Access Doors
Fire Dampers
Manual Balancing Dampers
Automatic Smoke-Fire Dampers
Automatic Smoke Dampers
Sound Attenuation Equipment
Acoustical Duct Liner
Diffusers
Registers and Grilles
Louvers
Air Vents, Penthouses, and Goosenecks
Centrifugal Fans
In-Line Centrifugal Fans
Axial Flow Fans
Panel Type Power Wall Ventilators
Centrifugal Type Power Wall Ventilators
Centrifugal Type Power Roof Ventilators
Propeller Type Power Roof Ventilators
Air-Curtain Fans
Ceiling Exhaust Fans
Air Handling Units[; G][; G, [_____]]
Room Fan-Coil Units[; G][; G, [_____]]
Coil Induction Units[; G][; G, [_____]]
Constant Volume, Single Duct Terminal Units[; G][; G, [_____]]
Variable Volume, Single Duct Terminal Units[; G][; G, [_____]]
Variable Volume, Single Duct, Fan-Powered Terminal Units[; G][; G, [_____]]
Dual Duct Terminal Units[; G][; G, [_____]]
Ceiling Induction Terminal Units[; G][; G, [_____]]
Reheat Units[; G][; G, [_____]]
Unit Ventilators
Energy Recovery Devices[; G][; G, [_____]]]

[Test Procedures]

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

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.]

Operation and Maintenance Training

Proposed On-site Training schedule, submitted concurrently with the Operation and Maintenance Manuals.

SD-06 Test Reports

Performance Tests[; G][; G, [_____]]

Test reports for the [ductwork leak test, and] performance tests in booklet form, upon completion of testing. Document phases of tests performed including initial test summary, repairs/adjustments made, and final test results in the reports.

Damper Acceptance Test[; G][; G, [_____]]

Proposed schedule, at least 2 weeks prior to the start of test.

[SD-07 Certificates]

[Bolts]

[Written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. Include illustrations of product markings, and the number of each type of bolt to be furnished in the certification.]

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions
Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

[Six] [_____] manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the following:

Fire Dampers[; G][; G, [_____]]
Manual Balancing Dampers[; G][; G, [_____]]
Automatic Smoke-Fire Dampers[; G][; G, [_____]]
Automatic Smoke Dampers[; G][; G, [_____]]
Centrifugal Fans[; G][; G, [_____]]
In-Line Centrifugal Fans[; G][; G, [_____]]
Axial Flow Fans[; G][; G, [_____]]
Panel Type Power Wall Ventilators[; G][; G, [_____]]
Centrifugal Type Power Wall Ventilators[; G][; G, [_____]]
Centrifugal Type Power Roof Ventilators[; G][; G, [_____]]
Propeller Type Power Roof Ventilators[; G][; G, [_____]]
Air-Curtain Fans[; G][; G, [_____]]
Ceiling Exhaust Fans[; G][; G, [_____]]
Air Handling Units[; G][; G, [_____]]
Room Fan-Coil Units[; G][; G, [_____]]
Coil Induction Units[; G][; G, [_____]]
Constant Volume, Single Duct Terminal Units[; G][; G, [_____]]
Variable Volume, Single Duct Terminal Units[; G][; G, [_____]]
Variable Volume, Single Duct, Fan-Powered Terminal Units[; G][; G, [_____]]
Dual Duct Terminal Units[; G][; G, [_____]]
Ceiling Induction Terminal Units[; G][; G, [_____]]
Reheat Units[; G][; G, [_____]]
Unit Ventilators[; G][; G, [_____]]
Energy Recovery Devices[; G][; G, [_____]]

1.4 DELIVERY, STORAGE, AND HANDLING

Store equipment at the jobsite so that it is protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

a. Provide Components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being 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 that is sold 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. Where applicable, provide equipment that is an ENERGY STAR Qualified product or a Federal Energy Management Program (FEMP) designated product.

b. Nameplates. All equipment shall have a nameplate, installed by the manufacturer, that identifies the manufacturer's name, address, type or style, and model or serial number.

****
NOTE: Catwalks, ladders, and guardrails may be

required. If so, select the applicable item and indicate on drawings. If not applicable, delete the entire last sentence.

****

c. 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. The requirements for [catwalks,] [operating platforms,] [ladders,] [and] [guardrails] are specified in Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

2.2 ELECTRICAL WORK

****

NOTE: Show the electrical characteristics, motor starter type(s), enclosure type, and maximum rpm on the drawings in the equipment schedules.

Where reduced-voltage motor starters are recommended by the manufacturer or required otherwise, specify and coordinate the type(s) required in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Reduced-voltage starting is required when full voltage starting will interfere with other electrical equipment and circuits and when recommended by the manufacturer. Where adjustable speed drives (SD) are specified, reference Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS. The methods for calculating the economy of using an adjustable speed drive is described in UFC 3-520-01 INTERIOR ELECTRICAL SYSTEMS.

****

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system , and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size

to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

e. [Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW 10 hp or less and adjustable frequency drives for larger motors.] [Provide variable frequency drives for motors as specified in Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS.]

2.3 INDOOR AIR QUALITY

All equipment and components furnished as part of this Section shall comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.4 DUCT SYSTEMS

****

NOTE: Identify all pressure classification for all ductwork in accordance with SMACNA HVAC Duct Const Stds, including points of changes in pressure classification, on the drawings. Indicate pitch of ductwork, low spots in ductwork, and means of disposing of condensate, where required. Size outdoor air intakes so that rain and snow are not drawn into the ductwork. Slope watertight intakes to a drain line and provide means 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.

Limit the use of flexible duct (due to the inordinate pressure drop and corresponding fan energy consumption that it causes). Show the extent of flexible duct on the drawings. 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. Show the extent of non-metallic duct on the drawings when these standards limit its use.

The minimum duct seal level shall conform to ASHRAE 90.1 including: Outdoor supply ducts and return

ducts shall meet seal level A. Outdoor exhaust ducts shall meet a seal level C. Unconditioned space supply ducts with 50 mm (2 inches) w.c. or less shall meet seal level B and greater than 50 mm (2 inches) w.c. shall meet seal level A. Unconditioned space exhaust duct shall meet seal level C and return duct shall meet seal level B. Conditioned space supply ducts with 50 mm (2 inches) w.c. or less shall meet seal level C and greater than 50 mm (2 inches) w.c. shall meet seal level B. Conditioned space exhaust duct shall meet seal level B and return duct shall meet seal level C.

For Navy projects all ductwork must meet the requirements of Seal Class A.

****

2.4.1 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. Ductwork shall meet the requirements of Seal Class [A][C]. 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 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and shall be suitable for the range of air distribution and ambient temperatures that it will be exposed to. Do not use pressure sensitive tape 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. Apply the sealant 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. Apply one brush coat of the sealant over the outside of the joint to at least 50 mm 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.4.1.1 Metallic Flexible Duct

a. Duct shall conform to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Fire hazard rating of duct assembly shall not exceed 25 for flame spread and 50 for smoke developed. Proved ducts designed for working pressures of 497 Pa two inches water gauge positive and 373 Pa 1.5 inches water gauge positive. Flexible round duct length shall not exceed 1525 mm five feet. Secure connections by applying adhesive for 51 mm two inches over rigid duct, apply flexible duct 51 mm two inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

b. Inner duct core: Flexible core shall be interlocking spiral or helically corrugated and constructed of zinc-coated steel, aluminum, or stainless steel; or shall be constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant,

flexible vapor barrier film, inner duct core.

c. Insulation: Inner duct core shall be insulated with mineral fiber blanket type flexible insulation, minimum of 25 mm one inch thick. Insulation shall be covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.4.1.2 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length shall be as shown on the drawings, but shall in no case exceed 1.5 m 5 feet. Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Provide either field or factory applied vapor barrier. Provide not less than 0.60 L 20 ounce glass fabric duct connectors coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece 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 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

2.4.1.3 General Service Duct Connectors

Provide a flexible duct connector approximately 150 mm 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. The composite connector system shall comply with NFPA 701 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

2.4.1.4 High Temperature Service Duct Connections

Material shall be approximately 2.38 mm 3/32 inch thick, 1.2 to 1.36 kg per square meter 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 C 1200 degrees F.

2.4.1.5 Aluminum Ducts

ASTM B 209M ASTM B 209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.4.1.6 Copper Sheets

ASTM B 152/B 152M, light cold rolled temper.

2.4.1.7 Corrosion Resisting (Stainless) Steel Sheets

ASTM A 167

2.4.2 Ductwork Accessories

2.4.2.1 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.
****

Provide hinged access doors conforming to SMACNA HVAC Duct Const Stds 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. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 by 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. Equip doors 600 by 600 mm 24 x 24 inches or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.4.2.2 Fire Dampers

****
NOTE: Indicate the location of each fire damper and details of the damper installations according to NFPA 90A. Three-hour rated fire dampers must be specifically identified on the drawings. Pressure relief damper upstream of the fire damper will be used for Army and Air Force projects only.
****

Use 1.5 hour rated fire dampers unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. Perform the fire damper test as outlined in NFPA 90A. Provide a pressure relief damper 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. Equip sleeves or frames with perimeter mounting angles attached on both sides of the wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies in conformance with UL Fire Resistance. 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. Install dampers 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, comply with the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers. Perform acceptance testing of fire dampers per paragraph Fire Damper Acceptance Test and NFPA 90A.

2.4.2.3 Manual Balancing Dampers

****
NOTE: Show all volume dampers on the drawings. Do not rely upon diffuser and register volume dampers for balancing.
****

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers 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 mm 12 inches. Provide access doors or panels 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.

2.4.2.4 Automatic Smoke-Fire Dampers

****
NOTE: Use this paragraph for Navy projects only. When this paragraph is not used, delete "Automatic Smoke-Fire Dampers" from the submittal list.

For smoke-fire dampers, use UL 555S Class III, unless the particular building and application such as hospital dictates the use of UL 555S Class II instead.
****

Multiple blade type, 82 degrees C 180 degrees F fusible fire damper link; smoke damper assembly to include pneumatically powered operator. UL 555 as a 1.5 hour rated fire damper; further qualified under UL 555S as a leakage rated damper. Leakage rating under UL 555S shall be no higher than Class [II] [or] [III] at an elevated temperature Category B (121 degrees C 250 degrees F for 30 minutes). Pressure drop in the damper open position shall not exceed 25 Pa 0.1 inch water gauge with average duct velocities of 13 m/second 2500 fpm.

2.4.2.5 Automatic Smoke Dampers

****
NOTE: Use this paragraph for Navy projects only. When this paragraph is not used, delete "Automatic Smoke Dampers" from the submittal list.

For smoke-fire dampers, use UL 555S Class III, unless the particular building and application such as hospital dictates the use of UL 555S Class II instead.
****

UL listed multiple blade type, supplied by smoke damper manufacturer, with

pneumatic damper operator as part of assembly. Qualified under UL 555S with a leakage rating no higher than class [II] [or] [III] at an elevated temperature Category B (121 degrees C 250 degrees F for 30 minutes). Pressure drop in the damper open position shall not exceed 25 Pa 0.1 inch water gauge with average duct velocities of 13 m/second 2500 fpm.

2.4.2.6 Air Deflectors and Branch Connections

****
NOTE: Air deflectors are for Army and Air Force projects only.
****

Provide air deflectors at all 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 for branch connections. Furnish all air deflectors, except those installed in 90 degree elbows, 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. 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.

2.4.2.7 Dampers

Where outdoor air supply and exhaust air dampers are required they shall have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - SIASHRAE 90.1 - IP, including: Maximum Damper Leakage for: 1) Climate Zones 1,2,6,7,8 the maximum damper leakage at 250 Pa1.0 inch w.g. for motorized dampers is 20 L/s per Square M4 cfm per SQFT of damper area and non-motorized dampers are not allowed. 2) All other Climate Zones the maximum damper leakage at 250 Pa1.0 inch w.g. is 50 L/s per square M10 cfm per SQFT and for non-motorized dampers is 100 L/s per square M20 cfm per SQFT of damper area.
Dampers smaller than 600 mm24 inches in either direction may have leakage of 200 L/s per square M40 cfm per SQFT.

2.4.3 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.
****

2.4.3.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA HVAC Duct Const Stds, as applicable. Construct system casing of not less than 1.6 mm 16 gauge galvanized sheet steel. Furnish cooling coil drain pans with 25 mm 1 inch threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 1.6 mm 16 gauge steel, galvanized after fabrication or of 1.3 mm 18 gauge corrosion-resisting sheet steel conforming to ASTM A 167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Insulation shall be coated with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 500 Pa 2 inch water gauge greater than the maximum negative pressure in the coil space.

2.4.3.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA HVAC Duct Const Stds.

2.4.3.3 Access Doors

****
NOTE: Determine whether an electrical push-button to stop the fan by a person inside the casing is required. If required, check the drawings to ensure that the item is shown, and properly coordinated with electrical drawings. Push-button station will be used for Army and Air Force projects only.
****

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, doors shall be 900 x 450 mm 36 x 18 inches located 450 mm 18 inches above the floor. Where the space available will not accommodate doors of this size, use doors as large as the space will accommodate. Doors shall swing so that fan suction or pressure holds door in closed position, and shall be airtight. Provide a push-button station, located inside the casing, to stop the supply.

2.4.3.4 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 one mm 20 gauge galvanized sheet steel and shall be assembled with fasteners treated against corrosion. Standard length panels shall deflect not more than 13 mm 1/2 inch under operation. Details of construction, including joint sealing, not specifically covered shall be as indicated in SMACNA HVAC Duct Const Stds. Construct the plenums and casings to withstand the specified internal pressure of the air systems.

2.4.3.5 Duct Liner

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

2.4.4 Sound Attenuation Equipment

****

NOTE: Use sound attenuators or acoustical duct liner only where acoustical treatment is required and there are no other suitable alternatives. Do not use acoustical duct liner in medical facilities.

Refer to UFC 3-450-02, Noise and Vibration, for noise criteria. Sound power levels required should be included in the appropriate schedule on the drawings.

****

a. For systems with total pressure above 1 kPa 4 Inches Water Gauge: Provide sound attenuators on the discharge duct of each fan operating at a total pressure above 1 kPa 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. Construct traps 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. 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 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. For connection to ductwork, provide a duct transition section. 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. Construct the double-walled duct and fittings from 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. Provide a sufficient length of run to obtain the noise reduction coefficient specified. 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 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 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. For system with total pressure of 1 kPa 4 Inch Water Gauge and Lower: Use sound attenuators only where indicated. Factory fabricated sound attenuators shall be constructed of galvanized steel sheets. Outer casing shall be not less than 0.85 mm 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. Construct sound attenuators 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.

c. For acoustical duct liner: Use fibrous glass designed exclusively for lining ductwork and conforming 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 23 07 00 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.]

2.4.5 Diffusers, Registers, and Grilles

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

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

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 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. Provide linear slot diffusers 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.

2.4.5.1 Diffusers

Diffuser types shall be as indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Electrical Constructn for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets 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.

2.4.5.2 Perforated Plate Diffusers

****
NOTE: Use this paragraph for Navy projects only.
****

Provide adjustable [one-way,] [two-way,] [three-way,] [or] [four-way] air pattern controls as indicated. Diffuser faceplates shall not sag or deflect when operating under design conditions.

2.4.5.3 Linear Diffusers

****
NOTE: Use this paragraph for Navy projects only.
****

Joints between diffuser sections shall appear as hairline cracks. Provide alignment slots for insertion of key strips or other concealed means to align exposed butt edges of diffusers. [Equip with plaster frames when mounted in plaster ceiling.] Do not use screws and bolts in exposed face of frames or flanges. Frames and flanges exposed below ceiling shall be metal-filled and ground smooth. Furnish separate pivoted or hinged adjustable air-volume-damper and separate air-deflection blades.

2.4.5.4 Security Ceiling Diffusers

****
NOTE: Use this paragraph for brig facilities only.
****

Diffusers shall be steel with faceplate, fixed diffusion louvers, flat surface margin, and an opposed blade damper. Faceplate shall be 1.9 mm 14 gage minimum with 13 by 13 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.4.5.5 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. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install wall supply registers at least 150 mm 6 inches below the ceiling unless otherwise indicated. Locate return and exhaust registers 150 mm 6 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.

2.4.5.6 Registers

****
NOTE: Use this paragraph for Navy projects only. Delete paragraph, "Registers and Grilles," when this paragraph is used.
****

Double-deflection supply registers. [Provide manufacturer-furnished volume dampers. Volume dampers shall be of the group-operated, opposed-blade type and key adjustable by inserting key through face of register. Operating mechanism shall not project through any part of the register face. Automatic volume control devices will be acceptable.] [Provide exhaust and return registers as specified for supply registers, except that exhaust and return registers shall have a single set of nondirectional face bars or vanes having the same appearance as the supply registers.] [Set face bars or vanes at [____] degrees.]

2.4.5.7 Security Supply Air Registers Except in Cells

****
NOTE: Use this paragraph for brig facilities only.
****

Supply air registers, except in prisoner cells and prisoner holding cells, shall be steel with individually adjustable horizontal and vertical vanes, perforated faceplate, flat surface margin and opposed blade damper. Vertical vanes shall be in front; vane spacing shall be 19 mm 3/4 inch o.c. Perforated faceplate shall be 1.9 mm 14 gage (minimum) with 13 by 13 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.4.5.8 Security Return and Other Air Registers Except in Cells

****
NOTE: Use this paragraph for brig facilities only.
****

Return, exhaust, transfer and relief air registers, except in prisoner cells and prisoner holding cells shall be steel with perforated faceplate, flat surface margin, opposed blade damper, and duct mounting sleeve. Faceplate shall be 14 gage (minimum) with 13 by 13 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.4.5.9 Security Supply Air Registers in Cells

****
NOTE: Use this paragraph for brig facilities only.
****

Supply air registers in prisoner cells and prisoner holding cells shall be steel with perforated faceplate, flat surface margin, extension sleeve, opposed blade damper, and back mounting flanges. Faceplate shall be 1.9 mm 14 gage (minimum) with 13 by 13 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Wall sleeve shall be 14 gage (minimum).

2.4.5.10 Security Return and Other Type Air Registers in Cells

****
NOTE: Use this paragraph for brig facilities only.
****

Return, exhaust, transfer and relief air registers in prisoner cells and prisoner holding cells shall be steel with perforated faceplate, flat surface margin, wall sleeve, opposed blade damper, and back mounting flanges. Faceplate shall be 1.9 mm 14 gage (minimum) with 13 by 13 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Wall sleeve shall be 14 gage (minimum).

2.4.6 Louvers

****
NOTE: Ensure that louver selection includes consideration of parameters such as pressure drop and water penetration.
****

Louvers for installation in exterior walls that are associated with the air supply and distribution system shall be as specified in Section [07 57 13 FLASHING AND SHEET METAL] [08 91 00 METAL [WALL] [AND] [DOOR] LOUVERS]

2.4.7 Air Vents, Penthouses, and Goosenecks

Fabricate Air vents, penthouses, and goosenecks 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. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.4.8 Bird Screens and Frames

Bird screens shall conform to ASTM E 2016, 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, and fabricated from either stainless steel or extruded aluminum.

2.4.9 Radon Exhaust Ductwork

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

2.5 AIR SYSTEMS EQUIPMENT

****
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.
****

2.5.1 Fans

****
NOTE: Coordinate with paragraph Sound Attenuation Equipment. Include any applicable noise criteria in appropriate equipment schedule on the drawings.

Refer to UFC 3-450-02, Design: Noise and Vibration Control, for vibration criteria. Detail vibration isolation required on the drawings and include it in the appropriate schedule.

Design and detail ductwork near air moving devices to minimize system effect on the fans in accordance with AMCA 201. Add system effect to the duct friction loss and indicate fan static pressure on drawings for the designed ductwork configuration.

Indicate the location of each duct smoke detector in the HVAC system and include the detectors on the schematic and associated ladder diagram. Provide duct smoke detectors 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 exceeds 38 degrees C (100 degrees F).

When the building is equipped with a fire alarm system, connect the duct smoke detectors to the fire alarm control panel (FACP) for alarm initiation. Show wiring to the FACP for either new or existing fire alarm systems.

In order to comply with the Energy Policy Act of 2005 energy consumption levels must be at least 30 percent below the level required by ASHRAE 90.1-2004. Ensure that the efficiency specified shall permit unlimited competition among at least three manufacturers.

Fans with motors greater than 0.5 kW (3/4 hp) shall have automatic controls capable of shutting off fans when not required.

HVAC systems having a total fan system power exceeding 3.7 kW (5 hp) shall meet the provisions of ASHRAE 90.1. These include ASHRAE 90.1, Table 6.5.3.1, Fan Power Limitation:

For supply air volumes less than 9,400 L/s (20,000 cfm) the allowable nameplate motor power for a constant volume fan is 1.9 kW/1000 L/s (1.2 hp/1000 cfm) and for a variable volume fan is 2.7 kW/1000 L/s (1.7 hp/1000 cfm).

For supply air volumes of 9,400 L/s (20,000 cfm) and greater the allowable nameplate motor power for a constant volume fan is 1.7 kW/1000 L/s(1.1 hp/1000 cfm and for a variable volume fan is 2.4 kW/1000 L/s (1.5 hp/1000 cfm).

****

Fans shall be tested and rated according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans shall not exceed 85 dBA when tested per AMCA 300 and rated per AMCA 301. All fans shall have an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives 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 and below and fixed pitch as defined by ARI Guideline D. Select variable pitch sheaves 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, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans 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. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. Obtain the sound power level values according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated. Power ventilators shall conform to UL 705 and shall have a UL label.

2.5.1.1 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 mm 30 inches. Fan blades for wheels over 750 mm 30 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. Equip the fan shaft with a heat slinger to dissipate heat buildup along the shaft. Install an access (service) door to facilitate maintenance to these fans.] Fan wheels over 900 mm 36 inches in diameter shall have overhung pulleys and a bearing on each side of the wheel. Fan wheels 900 mm 36 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] [dripproof] [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.] [Provide remote manual switch with pilot indicating light where indicated.]

2.5.1.2 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. Mount fans in a welded tubular casing. Air shall enter and leave the fan axially. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts 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.] [Provide remote manual switch with pilot indicating light where indicated.]

2.5.1.3 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. Enclose and isolate fan bearings and drive shafts 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. Provide fan inlets with an aerodynamically shaped bell and an inlet cone. Install diffuser or straightening vanes at the fan discharge to minimize turbulence and provide smooth discharge air flow. Furnish fan unit 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.] [Provide remote manual switch with pilot indicating light where indicated.]

2.5.1.4 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 mm 24 inches in diameter shall be direct or V-belt driven and fans with wheels 600 mm 24 inches diameter and larger shall be V-belt drive type. Provide fans with wall mounting collar. Lubricated bearings shall be provided. Equip fans 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. Install [gravity] [motor operated] backdraft dampers where indicated.

2.5.1.5 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. Construct housing of heavy gauge aluminum. Equip unit with an [aluminum or plated steel wire discharge bird screen,] [disconnect switch,] [[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. Use only lubricated bearings.

2.5.1.6 Centrifugal Type Power Roof Ventilators

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

Fans shall be [direct] [or] [V-belt] driven centrifugal type with backward inclined, non-overloading wheel. Motor compartment housing shall be hinged or removable and weatherproof, constructed of heavy gauge aluminum. Provide fans with [birdscreen,] [disconnect switch,] [[gravity] [motorized] dampers,] [sound curb,] [roof curb,] and [extended base]. Motors enclosure shall be [dripproof] [explosion-proof] type. 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. Use only lubricated bearings.

2.5.1.7 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. Furnish motors with nonfusible, horsepower rated, manual disconnect mount on unit. Furnish fans with [gravity] [motor operated] dampers, [birdscreen] [sound curb] [roof curb]. Use only lubricated bearings.

2.5.1.8 Air-Curtain Fans

****
NOTE: Provide air curtains designed as fly fans on all exterior entranceways to food preparation areas, except where the entranceway is to be used only as

an emergency exit. Include air curtains for service windows and service entries whenever feasible on the exterior of the entranceway. When air curtains are mounted in locations significantly above normal door heights, verify curtain air velocities and noise levels.

****

Fans shall conform to AMCA 220 with AMCA seal. Furnish air curtains with a weatherproof housing constructed of high impact plastic or minimum 1.3 mm 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. Provide bird screens at air intake and discharge openings. Air curtain unit or a multiple unit installation shall be at least as wide as the opening to be protected. Provide the air discharge openings to permit outward adjustment of the discharge air. Adjustment and installation placement shall be according to the manufacturer's written recommendation. Furnish directional controls on air curtains for service windows for easy clean or convenient removal. 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. Provide certified test data indicating that the fan will provide the air velocities required when fan is mounted as indicated. Provide air curtains designed as fly fans unless otherwise indicated. [Air curtains designed for use in service entranceways shall develop an air curtain not less than 75 mm 3 inches thick at the discharge nozzle. The air velocity shall be not less than 8 m/s 1600 fpm across the entire entryway when measured 900 mm 3 feet above the floor.] [Air curtains designed for use on customer entranceways shall develop an air curtain not less than 200 mm 8 inches thick at the discharge opening. The velocity shall be not less than 3 m/s 600 fpm across the entire entryway when measured 900 mm 3 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 mm 8 inches thick at the discharge opening. The air velocity shall be not less than 3 m/s 600 fpm across the entire opening of the service window measured 900 mm 3 feet below the air discharge opening.]

2.5.1.9 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. Mount fan motors on vibration isolators. Furnish unit with mounting flange for hanging unit from above. Fans shall be U.L. listed.

2.5.2 Coils

****

NOTE: 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, rewrite the specification for coils and fins for these specific conditions. Consider 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, vinyl or epoxy[slsh]electrodeposition. For coils with relatively close fin spacing such as those found in most unitary equipment, the phenolic or epoxy[slsh]electrodeposition coating is preferred, as these have less tendency to bridge across the fins than vinyl, better thermal conductivity than vinyl and in many conditions weathers better than vinyl.

****

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 mm 0.0045 inch minimum thickness.] Casing and tube support sheets shall be not lighter than 1.6 mm 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 MPa 400 psi air pressure and shall be suitable for 1.38 MPa 200 psi working pressure and 149 degrees C 300 degrees F operating temperature unless otherwise stated. Mount coils for counterflow service. Coils shall be rated and certified and meet the requirements of ARI 410.

2.5.2.1 Direct-Expansion Coils

****
NOTE: Use this paragraph for Army and Air Force projects only.
****

Direct-expansion coils shall be suitable for the refrigerant involved. Refrigerant piping shall conform to ASTM B 280 and shall be cleaned, dehydrated and sealed. Suction headers shall be seamless copper tubing or seamless or resistance welded steel tube with copper connections. Supply headers shall consist of a distributor that 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.

2.5.2.2 Water Coils

Install water coils with a pitch of not less than 10 mm/m 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Water coils shall be removable and have drain pans.

2.5.2.3 Steam Heating Coils

Construct steam coils from cast semisteel, welded steel or copper headers, and [red brass] [copper] tubes. Construct headers from 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. Provide each coil with a field or factory installed vacuum breaker. Coils shall be single-tube type with tubes not less than 13 mm 1/2 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.

2.5.2.4 Steam Preheat (Nonfreeze) Coils

Steam (nonfreeze) coils shall be steam-distribution-tube type with condensing tubes not less than 25 mm 1 inch outside diameter for tube lengths 1.5 m 60 inches and over and 13 mm 1/2 inch outside diameter for tube lengths under 1.5 m 60 inches. Construct headers from 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 m 60 inches and over and 10 mm 3/8 inch outside diameter for tube lengths under 1.5 m 60 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 m 144 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.

2.5.2.5 Electric Heating Coil

****

NOTE: Use this paragraph for Navy projects only. Choose the second set of brackets if an air-conditioning unit for EDP is specified.

****

Coil shall be an electric duct heater in accordance with UL 1995 and NFPA 70. Coil shall be duct- or unit-mounted. Coil shall be of the [nickel chromium resistor, single stage, strip] [nickel chromium resistor, single stage, strip or stainless steel, fin tubular] type. Coil shall be provided with a built-in or surface-mounted high-limit thermostat interlocked electrically so that the coil cannot be energized unless the fan is energized. Coil casing and support brackets shall be of galvanized steel or aluminum. Coil shall be mounted to eliminate noise from expansion and contraction and be completely accessible for service.

2.5.2.6 Eliminators

****
NOTE: Use this paragraph for Navy projects only.
****

Equip each cooling coil having an air velocity of over 2 m/s 400 fpm through the net face area with moisture eliminators, unless the coil manufacturer guarantees, over the signature of a responsible company official, that no moisture will be carried beyond the drip pans under actual conditions of operation. Construct of minimum 24 gage [zinc-coated steel] [copper] [copper nickel] [or] [stainless steel], removable through the nearest access door in the casing or ductwork. Eliminators shall have not less than two bends at 45 degrees and shall be spaced not more than 63 mm 2-1/2 inches center-to-center on face. Each bend shall have an integrally formed hook as indicated in the SMACNA FGDCS.

2.5.2.7 Sprayed Coil Dehumidifiers

****
NOTE: Use this paragraph for Navy projects only.
****

Provide assembly with reinforced, braced, and externally insulated galvanized steel casing, vertical in-line spray pump, bronze self-cleaning spray nozzles, galvanized steel pipe spray headers, adjustable float valve with replaceable neoprene seat, manufacturer's standard cooling coil, and welded black steel drain tank. Provide overflow drain, make-up, and bleed connection.

2.5.2.8 Corrosion Protection for Coastal Installations

****
NOTE: Use this paragraph for Navy projects only.

Specify corrosion protection for exterior HVAC equipment, including air handling units, heat exchanger coil surfaces, equipment casings, air-cooled water chiller coils, heat pumps, and air conditioning units, that is exposed to the weather within 8 km (5 miles) of a sea (salt) water coast.

At these coastal locations, this corrosion protection is also required on HVAC equipment within buildings that are subject to the outside weather conditions. Specifically, equipment requiring protection is defined as the first HVAC equipment (excluding louvers) met by the outside air in the supply air ductwork system.

Specifier shall survey the HVAC equipment market place, find and specify the manufacturer's standard off-the-shelve anti-corrosion options for "coastal" or "sea coast" installations. Specify the various systems (utilizing the word "or") offered by three competitive equipment selections. This approach is by far less costly than specifying custom corrosion protection.

Manufacturer's standard off-the-shelve anti-corrosion options for "coastal" or "sea coast" installations also vary with type and size of HVAC equipment.

After thorough investigation of the commercial market, determines manufacturer's standard off-the-shelve anti-corrosion options are not available for the selected equipment, contact the Mechanical Design Branch, NAVFACENGCOM for consultation if the need for this protection is considered mandatory by the station.

For installations at MCAS Cherry Point and MCB Camp LeJeune, including New River, and installations at NAS Oceana including Dam Neck, specify corrosion protection for all outside, and specific inside HVAC equipment exposed to the weather. Follow the guidance specified in the criteria NOTE above.

****

[_____]

2.5.3 Air Filters

****

NOTE: Select filters 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 UFC 3-410-01, Design: Heating, Ventilating, and Air-Conditioning for areas where indoor air quality is of primary concern. Consider limiting the variety of filter sizes required to minimize inventory requirements for system maintenance.

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.

****

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.

2.5.3.1 Extended Surface Pleated Panel Filters

Filters shall be 50 mm 2 inch depth, sectional, disposable type of the size indicated and shall have a MERV of 8 when tested according to ASHRAE 52.2. Initial resistance at 2.54 m/s 500 fpm shall not exceed 0.09 kPa 0.36

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.

2.5.3.2 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 a MERV of 13 when tested according to ASHRAE 52.2. Initial resistance at [2.54] [_____] m/s [500] [_____] fpm shall not exceed [0.1125] [_____] kPa [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.

2.5.3.3 Cartridge Type Filters

Filters shall be 305 mm 12 inch depth, sectional, replaceable dry media type of the size indicated and shall have a MERV of 13 when tested according to ASHRAE 52.2. Initial resistance at [2.54] [_____] m/s [500] [_____] fpm shall not exceed [0.14] [_____] kPa [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.

2.5.3.4 Sectional Cleanable Filters

****
NOTE: Delete washing and charging racks when not required.
****

Cleanable filters shall be [25] [50] mm [1] [2] inches thick. Viscous adhesive shall be provided in 20 L 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than one L one 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.

2.5.3.5 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 mm 2 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 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] [_____] fpm, with initial resistance of [32] [_____] Pa [0.13] [_____] inches water gauge. The MERV shall be not less than [_____] when tested according to ASHRAE 52.2.

2.5.3.6 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 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 m 65 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 mm 1/4 inch when subjected to air flow at 2.54 m/s 500 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 C 175 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 at its rated velocity of 2.54 m/s 500 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, 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/cubic meter 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/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 DUCT SYSTEMS.

2.5.3.7 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. Furnish interlock safety switches for each access door and access panel that 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 precut 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 traveling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service and supplied in 19.8 m 65 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 at 2.54 m/s 500 fpm face velocity. The MERV of the combination shall be not less than 15 when tested according to ASHRAE 52.2 at an average operating resistance of 125 Pa 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 at 2.54 m/s 500 fpm face velocity. The MERV of the combination shall be not less than 16 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.

2.5.3.8 High-Efficiency Particulate Air (HEPA) Filters

****

NOTE: Use high-efficiency particulate air filters in CLEAN ROOMS (White Rooms or Dust Controlled Facilities), clean work stations, and for critical areas of hospitals. Show the efficiency of the prefilter on the drawings. The efficiency will be sufficient for the anticipated contamination load and the degree of prefiltration required. ASME AG-1 may be referenced either all or in part when extreme temperature or humidity requirements exist. 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 the project. When used, ASME AG-1 should be added to paragraph REFERENCES.

****

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 fpm 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 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Filter cell sides shall be [19 mm 3/4 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 mm 1/16 inch, and squareness shall be maintained to within 3.2 mm 1/8 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. Provide prefilters of the type, construction and efficiency indicated.

2.5.3.9 Holding Frames

Fabricate frames from not lighter than 1.6 mm 16 gauge sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Holding frame seats shall be gasketed. All joints shall be airtight.

2.5.3.10 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 mm 3-7/8 inches in diameter, shall have white dials with black figures, and [graduations] [shall be graduated in 0.0025 kPa 0.01 inch of water,] and shall have a minimum range of 0.25 kPa 1 inch of water 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 m 5 foot minimum lengths of 6.35 mm 1/4 inch diameter [aluminum] [vinyl] tubing, and all hardware and accessories for gauge mounting.

2.6 AIR HANDLING UNITS

****

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.

For AHU's intended for outdoor installation, note on equipment schedule that AHU roof (used for Army projects only) must slope a minimum of 6 mm/300 mm (1/4 in per ft) and the roof shall overhang wall panels by a minimum of 50 mm (2 inches).

****

2.6.1 Field-Fabricated Air Handling Units

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

2.6.2 Factory-Fabricated Air Handling Units

****

NOTE: Coordinate with paragraph Fans and paragraph Coils.

****

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 be rated in accordance with ARI 430 and ARI certified for cooling.

2.6.2.1 Casings

Casing sections shall be [[single] [50 mm 2 inch double] wall type] [as indicated,] constructed of a minimum 1.3 mm 18 gauge galvanized steel, or 1.3 mm 18 gauge corrosion-resisting sheet steel conforming to ASTM A 167, Type 304. [Inner casing of double-wall units shall be minimum one mm 20 gauge solid galvanized steel or corrosion-resisting sheet steel conforming to ASTM A 167, Type 304.] Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing. Exterior panels shall be individually removable with standard tools. Removal shall not affect the structural integrity of the unit. Furnish casings with inspection doors, access sections, and access doors, all capable of opening a minimum of 90 degrees, as indicated. Inspection and access doors shall be insulated, fully gasketed, double-wall type, of a minimum 1.3 mm 18 gauge outer and one mm 20 gauge inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A 167, Type 304. Doors shall be rigid and provided with

heavy duty hinges and latches. Inspection doors shall be a minimum 300 mm 12 inches wide by 300 mm 12 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 mm 8 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 (thickness equal to exterior casing) constructed of 1.4 mm 16 gauge [galvanized steel] [corrosion resisting sheet steel conforming to ASTM A 167, Type 304], conforming to ASHRAE 62.1. Construct drain pans 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. Provide intermediate drain pans or condensate collection channels and downspouts, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan 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. Coils shall be individually removable from the casing. Casing insulation shall conform to NFPA 90A. Single-wall casing sections handling conditioned air shall be insulated with not less than 25 mm 1 inch thick, 24 kg/cubic meter 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.033 W/m-K 0.23 Btu/hr-sf-F. Double-wall casing sections handling conditioned air shall be insulated with not less than 50 mm 2 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 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or shall be coated to conform to meet erosion resistance requirements of ASTM C 1071. Provide a latched and hinged inspection door, in the fan and coil sections. Provide additional inspection doors, access doors and access sections [_____] [where indicated].

2.6.2.2 Heating and Cooling Coils

Coils shall be provided as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.6.2.3 Air Filters

Air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.6.2.4 Fans

****

NOTE: Coordinate with paragraph Sound Attenuation Equipment.

Refer to UFC 3-450-02, Design: Noise and Vibration

Control, for vibration criteria. Detail vibration isolation required and include it in the appropriate schedule on the drawings.

****

Provide fans that meet the requirements of ASHRAE 90.1 - SIASHRAE 90.1 - IP as specified in paragraph AIR SYSTEMS EQUIPMENT. 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. Mount fans 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. Furnish fans and scrolls 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 kW 25 hp and below and fixed pitch above 20 kW 25 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. Select variable pitch sheaves to drive the fan at a speed that will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Furnish motors for V-belt drives 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.

2.6.2.5 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.6.2.6 Diffuser Sections

Furnish diffuser sections 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, designed to be airtight under positive static pressures up to [2] [_____] kPa [8] [_____] inches water gauge and with 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.

2.6.2.7 Dampers

Dampers shall be as specified in paragraphs CONTROLS and DUCT ACCESSORIES.

2.7 TERMINAL UNITS

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

2.7.1 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. Obtain sound power level data or values for these units 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. Provide automatic valves and controls as specified in paragraph CONTROLS. Fasten each unit 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.

2.7.1.1 Enclosures

Fabricate enclosures from not lighter than 1.3 mm 18 gauge steel, reinforced and braced. Front panels of enclosures shall be removable and provided with 7 mm 1/4 inch closed cell insulation or 13 mm 1/2 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/s 4,500 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. Provide access doors or removable panels for piping and control compartments. Provide duct discharge collar for concealed models. Enclosures shall have easy access for filter replacement.

2.7.1.2 Fans

Provide fans that meet the requirements of ASHRAE 90.1 - SIASHRAE 90.1 - IP as specified in paragraph AIR SYSTEMS EQUIPMENT. 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.

2.7.1.3 Coils

Fabricate coils from 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. Provide coils with not less than 13 mm 1/2 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. Test coils hydrostatically at 2000 kPa 300 psi or under water at 1700 kPa 250 psi air pressure. Coils shall be suitable for 1400 kPa 200 psi working pressure. Make provisions for coil removal.

2.7.1.4 Drain Pans

Size and locate drain and drip pans 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 21 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. Design drain pans so as to allow no standing water and pitch to drain. Provide minimum 19 mm 3/4 inch NPT or 15 mm 5/8 inch OD drain connection 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 1 inch minimum over the auxiliary drain pan.

2.7.1.5 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.

2.7.1.6 Filters

Filters shall be of the fiberglass disposable type, 25 mm 1 inch thick, conforming to ASTM F 1040. Filters in each unit shall be removable without the use of tools.

2.7.1.7 Motors

****
NOTE: Edit 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. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. 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

2.7.2 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 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 ASA S12.51. 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. Provide automatic valves and controls as specified in paragraph CONTROLS. Secure each unit to the building structure. Capacity of the units shall be as indicated.

2.7.2.1 Enclosures

Fabricate enclosures from not lighter than 1.2 mm 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. Provide access doors for all piping and control compartments.

2.7.2.2 Air Plenums

Fabricate plenums from 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. Provide an adjustable air-balancing damper in each unit.

2.7.2.3 Coils

Fabricate coils from 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. Furnish coil connections with not less than 13 mm 1/2 inch outside diameter flare or sweat connectors, accessory piping 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 kPa 300 psi or under water at 1700 kPa 250 psi air pressure and shall be suitable for 1400 kPa 200 psi working pressure.

2.7.2.4 Screens

Provide easily accessible lint screens or throwaway filters for each unit.

2.7.2.5 Drain Pan

Size and locate drain and drip pans 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 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 steel, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 0.9 mm 21 gauge steel material or of die-formed 0.9 mm 21 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Provide drain connection when a condensate drain system is indicated. Connection shall be minimum 19 mm 3/4 inch NPT or 15 mm 5/8 inch OD.

2.7.3 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 or aluminum sheet not lighter than 1.3 mm 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. Provide reheat coils as indicated. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to ARI 880 with the calculations prepared in accordance with ARI 885. 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.

2.7.3.1 Constant Volume, Single Duct Terminal Units

Constant volume, single duct, terminal units shall contain within the casing, a 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 Pa 3/4 to 6 inch water gauge.

2.7.3.2 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units 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 3/4 to 6 inch water gauge. Internal resistance of units shall not exceed 100 Pa 0.4 inch water gauge at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 250 Pa 0 to 1 inch water gauge range.

2.7.3.3 Variable Volume, Single Duct, Fan-Powered Terminal Units

Provide variable volume, single duct, fan-powered terminal units 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 3/4 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. Isolate fan/motor assembly from the casing to minimize vibration transmission. Fan control shall be factory furnished and wired into the unit control system. Provide a factory-mounted pressure switch to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

2.7.3.4 Dual Duct Terminal Units

Provide dual duct terminal units 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 1 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 inch water gauge at maximum flow range.

2.7.3.5 Ceiling Induction Terminal Units

****
NOTE: Do not use ceiling induction units on NAVFAC projects.
****

Provide ceiling induction unit with a calibrated primary air volume sensing device, primary air valve, induced air damper, and insulated induction tube. Arrange unit 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, including a maximum of 75 Pa 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 Pa 0 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 kPa 20 psi pneumatic main air and room thermostat.

2.7.3.6 Series Fan Powered Variable Air Volume (VAV) Terminals

****
NOTE: For evaporator variable airflow applications such as VAV or multizone, provisions for capacity control and minimum capacity must be indicated. Capacity control may be compressor unloading or multiple compressors. For minimum capacity control, these applications should be provided with factory installed hot-gas bypass.
****

Provide units factory assembled, designed, tested, and rated in accordance with ARI 880. Units shall be ARI certified and listed in the ARI DCAACP. Units shall provide a supply air discharge mix by modulation of conditioned primary air and recirculating of return air. Units shall include casing, centrifugal fan and motor, primary VAV damper or valve, electronic volume regulator, discharge air damper, primary air inlet cone with high and low pressure flow sensors, recirculating air filter frames, filter, and electrical disconnect. [Provide hot water heating coils integral to the terminal, or provide insulated hot water coil section attached to the discharge of the terminal.]

a. Casing: Provide removable full bottom access panels for servicing internal components without disturbing duct connections. Insulate inside of casing with manufacturer's standard insulation. Units shall have recirculating air inlet equipped with filter frame, round primary damper or valve, and unit mounting brackets.

b. Fans and motors: Provide centrifugal, forward curved, multiblade, fan wheels with direct-drive motors. Motors shall be premium efficiency in accordance with NEMA MG 1, permanent-split capacitor type with thermal overload protection and permanently lubricated bearings. Motors shall have three speeds or be equipped with solid state speed controllers. Provide isolation between fan motor assembly and unit casing. Fan and motor shall be removable through casing access panel.

c. Flow sensor: Sensor shall be ring or cross type with minimum of two pickup points which average the velocity across the inlet. Flow measurement shall be within plus or minus 5 percent of rated airflow with 1.5 diameters of straight duct upstream of unit and inlet static variation of 124 to 1240 Pa 0.5 to 5.0 inches water gauge. Flow measuring taps and calibration flowchart shall be supplied with each unit for field balancing airflows.

d. Primary VAV damper or valve: Galvanized steel damper blade shall close against gasket inside unit. Connect damper to operating shaft with a positive mechanical connection. Provide nylon bearing for damper shaft. Cylindrical die cast aluminum valve inlet tapered to fit round flexible ducts with integral flow diffuser and beveled self-centering disc. Damper or valve leakage at shutoff shall not exceed 2 percent of capacity at 250 Pa 1 inch water gauge pressure.

e. Regulator: Volume regulator shall be electronic. Electronic controls contained in NEMA ICS 6, Type 1 enclosure sealed from airflow. Controls shall be mounted on side of unit or on air valve. System powered regulators shall not be permitted. Volume regulator shall reset primary air volume as determined by thermostat, within upstream static pressure variation noted in paragraph entitled "Flow Sensor." Volume regulators shall be field adjustable and factory set and calibrated to indicated maximum and minimum primary airflows. Volume regulators shall be direct acting and normally [open] [closed] upon loss of pneumatic pressure.

f. Electrical: Unit shall incorporate single point electrical connection with electrical disconnect. Electrical components shall be UL or ETL listed and installed in accordance with NFPA 70. Electrical components shall be mounted in control box. Units UL or ETL listed as an assembly do not require airflow switch interlock with electric heating coil when factory assembled.

g. Filters: Provide UL listed throwaway 25 mm one inch thick fiberglass filters, standard dust-holding capacity.

2.7.3.7 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, 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 kPa 250 psi air pressure and shall be suitable for 1400 kPa 200 psi working pressure. Install drainable coils in the air handling units with a pitch of not less than 10 mm per m 1/8 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 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 hydrostatic test pressure or 1400 kPa 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 mm 5/8 inch outside diameters. Distribution tubes shall have not less than 10 mm 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 13 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. Interlock electric duct heaters electrically so that they cannot be energized unless the fan is running.

2.7.4 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. Obtain sound power level data or values for these units 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. Secure each unit 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.

2.7.4.1 Enclosures

Fabricate enclosures from not lighter than 1.6 mm 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. Fasten the insulation with waterproof, fire-resistant adhesive. Design front panel 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. Furnish removable panels or access doors for all piping and control compartments. Fan switch shall be key operated or accessible through a locked access panel. Install gaskets at the back and bottom of the unit for effective air seal, as required.

2.7.4.2 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, provide a fused factory mounted and wired transformer.

2.7.4.3 Fans

Provide fans that meet the requirements of ASHRAE 90.1 - SIASHRAE 90.1 - IP as specified in paragraph AIR SYSTEMS EQUIPMENT. Fans shall be of the galvanized steel or aluminum, multiblade, centrifugal type, dynamically and statically balanced. Equip fan housings 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.

2.7.4.4 Coils

Coils shall be circuited for a maximum water velocity of 2.4 m/s 8 fps

without excessive pressure drop and shall otherwise be as specified for hot water coils in paragraph TERMINAL UNITS.

2.7.4.5 Drain Pans

Size and locate drain and drip pans 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 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 steel, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 1.3 mm 18 gauge steel material, or of die-formed 1.3 mm 18 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Furnish drain connection unless otherwise indicated. Connection shall be minimum 19 mm 3/4 inch NDT or 18 mm 5/8 inch OD.

2.7.4.6 Filters

Fiberglass disposable type, 25 mm 1 inch thick, rated in accordance with ASTM F 1040, installed upstream of coil.

2.7.4.7 Dampers

Provide an outside air proportioning damper on each unit. In addition, provide a vane 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. Provide face and bypass dampers for each unit to ensure constant air volume at all positions of the dampers. Furnish each unit 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.

2.7.4.8 Motors

****
NOTE: Edit based 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. Mount motor on a resilient mounting, isolated from the casing and 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. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

2.7.4.9 Outside Air Intakes

Outside air intakes shall be the manufacturer's standard design and provided with 13 mm 1/2 inch mesh bird screen or louvers on 13 mm 1/2 inch centers.

2.8 ENERGY RECOVERY DEVICES

****
NOTE: All energy recovery devices shall meet the requirements of ASHRAE 90.1. Individual fan systems that have both a design supply air capacity of 2360 L/s (5,000 cfm) or greater and have a minimum outdoor air supply of 70 percent or greater of the design supply air quantity shall have an energy recovery system with at least 50 percent recovery effectiveness in accordance with ASHRAE 90.1.
****

2.8.1 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. Equip chain drive mechanisms with ratcheting torque limiter or slip-clutch protective device. Fabricate enclosure from galvanized steel and include provisions for maintenance access. Recovery control and rotation failure provisions shall be as indicated.

2.8.2 Run-Around-Coil

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

Coordinate with paragraph Glycol Solution in Section 23 64 26 CHILLED AND CONDENSER WATER PIPING AND ACCESSORIES. Glycol is considered a hazardous waste. If the base does not have a used glycol waste program, using glycol can be an expensive maintenance item..
****

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 23 63 00.00 10 COLD STORAGE REFRIGERATION SYSTEMS] [Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS] [23 69 00.00 20 REFRIGERATION EQUIPMENT FOR COLD STORAGE] [_____].

2.8.3 Heat Pipe

****

NOTE: Include face air velocity, static pressure drop, temperature requirements for entering and leaving air or exhaust streams on the equipment schedule for heat pipes.

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 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.

2.8.4 Dessicant Wheel

Supply and regeneration airstreams shall be counterflow. The dehumidifier shall be a rotary type designed for continuous operation. The wheel structure shall be of the extended surface type in the axial flow direction and the geometry shall provide for laminar flow over the operating range for minimum air pressure differentials. The dehumidifier shall be complete with a drive system utilizing a fractional-horsepower electric motor and speed reducer assembly driving the rotor. A slack-side tensioner shall be included for automatic take-up for belt-driven wheels. The desiccant

material shall be an adsorbing type. The desiccant material shall be applied to the wheel such that the entire surface is active as a desiccant and the desiccant material does not degrade or detach from the surface of the wheel. The wheel shall be fitted with full-face, low-friction contact seals on both sides to prevent cross leakage. The rotary structure shall have underheat, overheat and rotation fault circuitry. The wheel assembly shall be warranted for a minimum of five years.

2.8.5 Plate Heat Exchanger

Energy recovery ventilator unit shall be factory-fabricated for indoor installation, consisting of a flat plate cross-flow heat exchanger, cooling coil, supply air fan and motor and exhaust air fan and motor. Casing shall be 1 mm 20 gauge G90, galvanized steel, double wall construction with 25 mm one inch insulation. Heat exchanger core shall be fibrous desiccant cross-flow type capable of easy removal from the unit.

2.9 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 that 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.

2.10 FIELD PAINTING

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 50 degrees C 120 degrees F shall be cleaned to bare metal. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures less than 50 degrees C 120 degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 50 degrees C 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.0076 mm 0.3 mil, one coat of primer applied to a minimum dry film thickness of 0.0255 mm one mil; and two coats of enamel applied to a minimum dry film thickness of 0.0255 mm one mil per coat.

b. Temperatures between 50 and 205 degrees C 120 and 400 degrees F: Metal surfaces subject to temperatures between 50 and 205 degrees C 120 and 400 degrees F shall receive two coats of 205 degrees C 400 degrees F heat-resisting enamel applied to a total minimum thickness of 0.05 mm two mils.

c. Temperatures greater than 205 degrees C 400 degrees F: Metal surfaces subject to temperatures greater than 205 degrees C 400 degrees F shall receive two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 0.05 mm two mils.

2.11 SUPPLEMENTAL COMPONENTS/SERVICES

2.11.1 Chilled, Condenser, or Dual Service Water Piping and Accessories

The requirements for chilled, condenser, or dual service water piping and accessories are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

2.11.2 Refrigerant Piping

The requirements for refrigerant piping are specified in Section 23 23 00 REFRIGERANT PIPING.

2.11.3 Water or Steam Heating System Accessories

The requirements for water or steam heating accessories such as expansion tanks and steam traps are specified in Section [23 52 00 HEATING BOILERS][23 21 13.00 20 LOW TEMPERATURE WATER [LTW] HEATING SYSTEM][23 22 26.00 20 STEAM SYSTEM AND TERMINAL UNITS].

2.11.4 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section [22 00 00 PLUMBING, GENERAL PURPOSE][23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS] except as modified herein.

2.11.5 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.11.6 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.11.7 Controls

The requirements for controls are specified in [Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS][and][Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS] [Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS][and][23 09 23.13 20 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC].

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

Installation shall be as shown and according to the manufacturer's diagrams, recommendations and manufacturer's installation instructions.

3.2.1 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 mm 2 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 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. The method of anchoring and fastening shall be as detailed. Set floor-mounted equipment on not less than 150 mm 6 inch concrete pads or curbs doweled in place unless otherwise indicated. 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. Furnish foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section [03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE] [03 30 00 CAST-IN-PLACE CONCRETE].

3.2.3 Access Panels

Install access panels 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 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

3.2.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the duct, shall be of the type recommended by the duct manufacturer and shall be provided at the intervals recommended.

3.2.5 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.

3.2.5.1 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 m 6 feet.

3.2.5.2 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.

3.2.5.3 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].

3.2.6 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.

3.2.7 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.
****

3.2.7.1 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, Type 304L or 316L, stainless steel] [minimum 1.6 mm 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.]

3.2.7.2 Exposed Ductwork

Exposed ductwork shall be fabricated from minimum 1.3 mm 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.

3.2.7.3 Concealed Ducts Conveying Moisture Laden Air

Concealed ducts conveying moisture laden air shall be fabricated from minimum [1.3 mm 18 gauge, Type 300 series, stainless steel] [1.6 mm 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.

3.2.8 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.

3.2.9 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.

3.2.10 Insulation

Thickness and application of insulation materials for ductwork, piping, and equipment shall be according to Section 23 07 00 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].

3.2.11 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 23 05 93.00 10 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.

3.2.12 Power Roof Ventilator Mounting

Foamed 13 mm 1/2 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.

3.2.13 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.

3.3 PENETRATIONS

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

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Provide sleeves for round duct 380 mm 15 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 mm one 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 with ASTM C 553, Type 1, Class B-2.

a. Sleeves: Fabricate sleeves, except as otherwise specified or indicated, from 1 mm 20 gauge thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A 53/A 53M, Schedule 20.

b. Framed Prepared Openings: Fabricate framed prepared openings from 1 mm 20 gauge galvanized steel, unless otherwise indicated.

c. Insulation: Provide duct insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS continuous through sleeves and prepared openings except firewall penetrations. Terminate duct insulation at fire dampers and flexible connections. For duct handling air at or below 16 degrees C 60 degrees F, provide insulation continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air.

d. Closure Collars: Provide closure collars of a minimum 100 mm 4 inches wide, 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 mm 15 inches in diameter or less from 1 mm 20 gauge galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 380 mm 15 inches from 1.40 mm 18 gauge galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 380 mm 15 inches or less from 1 mm 20 gauge galvanized steel. Install collars with fasteners a maximum of 150 mm 6 inches on center. Attach to collars a minimum of 4 fasteners where the opening is 300 mm 12 inches in diameter or less, and a minimum of 8 fasteners

where the opening is 500 mm 20 inches in diameter or less.

e. Firestopping: Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.4 FIELD PAINTING AND IDENTIFICATION SYSTEMS

****
NOTE: There is a similar requirement for identification in Section 22 00 00 PLUMBING, GENERAL PURPOSE. The designer will ensure that color coding for all mechanical systems is coordinated.
****

3.4.1 Identification Tags

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

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Tags shall be 35 mm 1-3/8 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.

3.4.2 Finish Painting

****
NOTE: Designer will coordinate color code marking with Section 09 90 00.
****

The requirements for finish painting of items only primed at the factory, and surfaces not specifically noted otherwise, are specified in Section 09 90 00 PAINTS AND COATINGS.

3.4.3 Color Coding Scheme for Locating Hidden Utility Components

****
NOTE: Coordinate the Color Code Table with the installation. Delete identification plate specified in Section 09 90 00 PAINTS AND COATINGS if color coding scheme is specified.
****

Use scheme 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 13 mm 3/8 inch diameter and secured to removable ceiling panels with fasteners. Insert each fastener 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 m 3 foot wide, 750 mm 30 inches high, and 13 mm 1/2 inches thick. The board shall be made of wood fiberboard and framed under glass or 1.6 mm 1/16 inch transparent plastic cover. The color code symbols shall be approximately 19 mm 3/4 inch in diameter and the related lettering in 13 mm 1/2 inch high capital letters. Mount the color code board [where indicated] [in the mechanical or equipment room]. The color code system shall be as indicated below:

Color	System	Item	Location
[_____]	[_____]	[_____]	[_____]

3.5 DUCTWORK LEAK TEST

****

NOTE: Omit this paragraph for Navy projects. Delete the bracketed portion of "Test Procedures" in SD-03, and "Performance Tests" in SD-06 of this Section.

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.). Delete the corresponding requirements in SD-06 of this Section and corresponding paragraph in Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS when this paragraph is deleted.

Otherwise, derive the leakage rate for each system 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.

The maximum allowable duct leakage shall meet the requirements of AHSRAE 90.1.

****

Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils, [filters, etc.][filters, etc. designated as static pressure Class 750 Pa 3 inch water gauge through Class 2500 Pa 10 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.

3.6 DAMPER ACCEPTANCE TEST

Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by

having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.7 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section [23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS][23 08 00.00 20 HVAC TESTING/ADJUSTING/BALANCING]. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.8 PERFORMANCE TESTS

After testing, adjusting, and balancing is complete as specified, test each system 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. Make corrections and adjustments 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. Make coincidental chart recordings at points indicated on the drawings for the duration of the time period and 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.

3.9 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. 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. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. 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. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions.

3.10 OPERATION AND MAINTENANCE TRAINING

****
NOTE: Determine the number of hours of instruction based on the number and complexity of the systems specified.
****

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. The training period shall consist

of a total of [_____] hours of normal working time and shall start after all work specified herein is functionally completed and the Performance Tests have been approved. The field instruction shall cover all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Notify the Contracting Officer at least 14 days prior to the date of proposed conduct of the training course.

-- End of Section --