UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 82 01.00 10

WARM AIR HEATING SYSTEMS

04/08, CHG 1: 02/20

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USACE / NAVFAC / AFCEC / NASA	**UFGS-23 82 01.00 10 (April 2008)** **Change 1 - 02/20**

Preparing Activity: USACE	**Superseding** **UFGS-23 82 01.00 10 (January 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021

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SECTION 23 82 01.00 10

WARM AIR HEATING SYSTEMS
04/08, CHG 1: 02/20

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NOTE: This guide specification covers the requirements for warm air heating systems used primarily in barracks, offices and other similar applications.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

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NOTE: Equipment listed in this section is not intended for family housing applications. Systems are for use primarily in barracks, offices and other similar applications.

****

1.1 REFERENCES

****

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

this paragraph by organization, designation, date, and title.

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

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.47/CSA 2.3	(2016) Gas-Fired Central Furnaces
ANSI Z21.66/CGA 6.14	(2015; R 2020) Automatic Vent Damper Devices for Use with Gas-Fired Appliances

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

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test

CSA GROUP (CSA)

CSA Directory	(updated continuously online) Product Index

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances
NFPA 701	(2019) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

NAIMA AH116	(2002, 5th Ed) Fibrous Glass Duct Construction Standards

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

SMACNA 1819	(2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition
SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

UNDERWRITERS LABORATORIES (UL)

UL 181	(2013; Reprint Apr 2017) UL Standard for Safety Factory-Made Air Ducts and Air Connectors

UL 296	(2017; Reprint Sep 2020) UL Standard for Safety Oil Burners
UL 441	(2016; Reprint Jul 2016) UL Standard for SafetyGas Vents
UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 641	(2010; Reprint Apr 2018) UL Standard for Safety Type L Low-Temperature Venting Systems
UL 727	(2018) UL Standard for Safety Oil-Fired Central Furnaces
UL 900	(2015) Standard for Air Filter Units
UL 1738	(2010; Reprint Feb 2020) Venting Systems for Gas-Burning Appliances, Categories II, III and IV
UL Bld Mat Dir	(updated continuously online) Building Materials Directory
UL Electrical Construction	(2012) Electrical Construction Equipment Directory
UL Fire Resistance	(2014) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

****

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

****

Provide electrical motor-driven equipment specified complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics and enclosure type shall be as shown. Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Provide motor starters complete with thermal overload protection and other appurtenances necessary. Each motor shall be in accordance with NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 7.45 kW 10 hp or less. Use adjustable frequency drives for larger motors.

1.3 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

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

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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

****

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

SD-02 Shop Drawings

Installation

SD-03 Product Data

Spare Parts
Tests
System Diagrams; G[, [_____]]
Qualifications
Field Training

SD-06 Test Reports

Tests

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals; G[, [_____]]

1.4 QUALITY ASSURANCE

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

1.5 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of detail drawings and not later than [_____] months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 12 months operation, and a list of the parts recommended by the manufacturer to be replaced after [1] [and] [3] year(s) of service.

PART 2 PRODUCTS

****

NOTE: In order to comply with Executive Order 13423 and Public Law 109-58 (Energy Policy Act of 2005), designs must achieve energy consumption levels that are at least 30 percent below the level required by ASHRAE 90.1 - 2004. In accordance with P.L. 109-58 (Energy Policy Act of 2005), Executive Order 13423, and Federal Acquisition Regulation (FAR) 23.203 Energy-efficient Products shall meet or exceed the performance criteria for ENERGY STAR®-qualified or FEMP-designated products as long as these requirements are nonproprietary. The FEMP and ENERGY STAR product requirements are available on the web at www.eere.energy.gov/femp/procurement and www.energystar.gov/products. Where ENERGY STAR or FEMP products are not applicable, energy consuming products and systems shall meet or exceed the requirements of ASHRAE 90.1.

****

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

2.1.2 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. As applicable, affix an ENERGY STAR label to the product.

2.2 SELF-CONTAINED FURNACE

****

NOTE: Indicate on the drawings the unit's thermal output required, the nominal air temperature rise required, the calculated air flow rate, the unit's pressure requirements, the unit's air discharge (i.e. upflow, downflow, or horizontal), etc. These units generally range in size from 11.7 kW 40 MBtuh up to 35.1 kW 120 MBtuh.

Per FEMP/ENERGY STAR: Gas-fired furnaces shall have an Annual Fuel Utilization Efficiency (AFUE) of 90 percent or greater and Oil-fired furnaces shall have an AFUE of 83 percent or greater for units with a heat input rate of less than 66 kW 225,000 Btu/h.

Per ASHRAE 90.1, Table 6.8.1E:
Gas-fired furnaces with a heat input rate of 66 kW 225,000 Btu/h and greater shall have a minimum combustion efficiency (EC) of 80 percent.
Oil-fired furnaces with a heat input rate of 66 kW 225,000 Btu/h and greater shall have a minimum thermal efficiency (ET) of 81 percent.
Gas-fired duct furnaces, gas-fired unit heaters and oil-fired unit heaters shall have a minimum combustion efficiency (EC) of 80 percent.

****

Provide a furnace which is a manufacturer's standard, self-contained, forced circulated air heating type furnace as indicated. Furnace and furnace components shall be completely factory-assembled and wired. Furnace casing shall be factory insulated and be compatible with the operating temperatures. Furnace shall be provided with removable service panels which allow access to all internal components requiring cleaning, servicing, or adjustment.

2.2.1 Gas-Fired Unit

Gas-fired furnace shall be the [conventional][high efficiency, condensing] type in accordance with ANSI Z21.47/CSA 2.3. Furnace design shall be certified by the AMERICAN GAS ASSOCIATION LABORATORIES (AGA). Furnace shall have a minimum certified Annual Fuel Utilization Efficiency (AFUE) [of not less than [90][ ] percent][as indicated on the drawings].

2.2.2 Oil-Fired Unit

Oil-fired furnace shall be in accordance with UL 727 and have a minimum certified Annual Fuel Utilization Efficiency (AFUE) [of [83][ ] percent][as indicated on the drawings].

2.3 FURNACE COMPONENTS

****
NOTE: Delete any of the following paragraphs which are inapplicable to a specific job (i.e. oil-fired components or gas-fired components). For example, oil-fired components are inapplicable to high efficiency furnaces and should be deleted when high efficiency furnaces are specified.
****

2.3.1 Oil-Burning Components

The equipment shall include the oil burner motor, ignition equipment safety devices, and accessories necessary for a full automatic system that conforms to UL 296. Oil-fired units equipped with programming controls shall be furnished with low oil-pressure switches in the fuel supply piping. Oil-fired units not equipped with programming controls shall be equipped with a delayed opening or shutoff valve. The valve shall automatically delay delivery of oil to the burner until such time as the combustion air fan and, when applicable, the induced draft fan are operated at rated speed.

2.3.2 Gas-Burning Components

Gas-burning equipment shall include the gas burners, ignition equipment, gas-control valve, gas piping, gas-pressure regulating valve, when applicable, and accessories necessary for a fully automatic system that is listed in CSA Directory. Gas-fired units equipped with programming controls shall be furnished both with high and with low gas supply pressure switches in the fuel supply piping.

2.3.3 Ignition Systems

2.3.3.1 Gas-Fired Units

Ignition systems shall be of the direct spark, hot surface, or interrupted intermittent type with automatic electric ignition. The pilots shall be of the electrically-ignited proven type. Continuous pilots will not be permitted. Burner shall be designed in accordance with NFPA 54 and located so that parts are protected against overheating. Provisions shall be made in the burner housing for inspection of the pilot flame.

2.3.3.2 Oil-Fired Units

Ignition systems for oil-fired units shall be of the [direct-electrical spark type] [direct-electric spark type or interrupted type] in accordance with UL 296.

2.3.4 Supply Blowers

Blowers shall be centrifugal type. Blowers shall be statically and dynamically balanced. Lubrication points shall be located or extended, as required, to provide ready access for periodic lubrication. The direction of rotation shall be clearly and permanently marked on each blower housing. Blower speeds shall be single, or multispeed, as indicated, to provide the specified range of air temperature rises. Direct-drive blowers may have multiple speed motors to change blower speed. Belt-drive blowers shall be provided with an adjustable base and guard or enclosed in

the unit casing. The belt drive shall be designed in accordance with the applicable Rubber Manufacturer's Association (RMA) power transmission belt specifications, with a service factor of at least 1.2. Shafts shall be supported by a minimum of two self-aligning bearings. Blower speed shall be adjusted by the use of variable pitch drive sheaves.

2.3.5 Vents for Conventional furnaces

****
NOTE: Delete this paragraph if high efficiency furnaces are specified.
****

A 8 mm 0.3125 inch diameter hole shall be provided in the vent stack not greater than 152 mm 6 inches from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack shall be provided complete with bird screen and rain hood.

2.3.5.1 Gas-Fired Units

Vent piping shall be in accordance with UL 441, [Type B] [Type BW]. Vent shall conform to NFPA 211 and NFPA 54. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.3.5.2 Oil-Fired Units

Vent piping shall be in accordance with UL 641, Type L. Vent shall conform to NFPA 211. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.3.6 Vents for High Efficiency Furnaces

****
NOTE: Delete this paragraph if gas-fired high efficiency, condensing type furnaces are not used. Conventional vents are not needed for condensing furnaces due to the low exhaust air temperature. Precautions should be taken due to the acidic condition of the condensate. The location and size of the vents should be shown on the drawings. Consult NFPA 54, UL 1738, and available vendor data to design the vents. The vents can be mounted on the roof or exterior wall with proper separation. The vents should be extended above the typical snow level. Vents should be located in such a manner as to prevent vandalism and to prevent discharge of condensate across walkways.
****

Direct venting shall be used for condensing type furnaces. Both the air intake and exhaust vents shall be sized and located as indicated on the drawings and as recommended by the boiler manufacturer. A separate combustion air intake vent and exhaust shall be provided for each furnace. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.3.6.1 Combustion Air Intake Vent

The combustion air intake piping shall be constructed of Schedule 40 PVC in accordance with ASTM D1784. The vent shall be suitable for the temperature at the furnace combustion air intake connection point. Each intake shall be provided complete with bird screen.

2.3.6.2 Exhaust Vent

The exhaust vent piping shall be constructed of Schedule 40 CPVC or stainless steel in accordance with UL 1738 and the furnace manufacturer's recommendations. The exhaust vent shall be suitable for the maximum anticipated furnace exhaust temperature and shall withstand the corrosive effects of the condensate. A 8 mm 0.3125 inch diameter hole shall be provided in the stack not greater than 152 mm 6 inches from the furnace flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack shall be provided complete with bird screen.

2.4 AIR CONDITIONING EQUIPMENT

Cooling coils, condensers and related equipment shall be as specified in Section [23 81 00 DECENTRALIZED UNITARY HVAC EQUIPMENT][23 82 00.00 20 TERMINAL HEATING AND COOLING UNITS].

2.5 CONTROLS

****

NOTE: Indicate the desired sequence of operation on the drawings. Depending on the fuel type and size, some manufacturers offer single stage, two stage, or variable speed operation. Prior to specifying two stage or variable speed operation, coordinate the selection with furnace manufacturers. Consider the use of programmable thermostats for facilities that will experience load variations due to time of occupancy. For projects that involve only thermostatic furnace controls, consider moving the appropriate portions of specification Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC to this paragraph.

****

Furnace controls shall be provided by the furnace manufacturer as an integral part of the furnace. Electronic controls shall be provided. The controls shall allow for [single stage] [two stage] [variable speed] operation. Controls shall be provided as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

2.6 AUTOMATIC VENT DAMPERS

****

NOTE: Delete this paragraph if high efficiency furnaces are specified.

****

Automatic vent dampers shall be provided in the vents of all gas burning

equipment that uses indoor air for combustion. Vent dampers shall conform to ANSI Z21.66/CGA 6.14.

2.7 HUMIDIFIERS

****

NOTE: Delete inapplicable paragraphs. Verify steam availability if steam humidifiers are specified. Recirculating or reservoir type will not be used without automatic bleed where the supply water has a mineral content greater than 4 grams per liter 0.53 ounces per gallon. Capacity shall be computed as recommended by AHRI 630 assuming average building construction and single glass windows are used in calculations.

****

2.7.1 Steam Spray Type

Steam spray humidifiers shall inject steam directly into the [surrounding air] [or] [air stream] as indicated. [Single grid humidifiers shall consist of a single copper distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condenser traps shall be field-installed.] [Enclosed grid shall be housed in a copper enclosure with a build-in condensate drain connection. Exposed grid shall be wick wrapped.] [Package type steam spray humidifiers shall be equipped to trap out and to re-evaporate condensate and to supply dry steam to a single distribution grid. Grid shall be steam jacketed and condensate drained. Unit shall trap excess condensate to return system. Package type steam spray humidifiers shall have modulating electric, electronic, or pneumatic steam control valve, as indicated.] Steam spray humidifiers shall be rated for humidifying capacity in kg pounds of steam per hour and at steam pressure as indicated.

2.7.2 Steam Diffuser Type

Diffuser units shall be of a design that will separate any condensate from steam supply and provide positive drain of condensate to waste and supply dry steam only to air stream. Humidifiers may be installed on single or multiple units. All materials shall be [noncorrosive materials] [Type 300 stainless steel.]

2.7.3 Operation

Humidifier shall be controlled by a manually adjustable humidistat [located in living spaces] [with sensing bulb in [return] [supply]]. Humidifier shall operate when the furnace operates. Humidistat shall be calibrated in percent relative humidity and shall be furnished by the humidifier manufacturer.

2.8 AIR FILTERS

****

NOTE: Normally, replaceable type filters shall be specified; however, permanent type filters may be included in the project specifications provided maintenance facilities are available for cleaning. References to inapplicable filter types will be deleted.

****

Air Filters shall be listed in accordance with requirements of UL 900.

2.8.1 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) 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. Average efficiency shall be not less than [_____] percent when tested according to ASHRAE 52.2.

2.8.2 Sectional Cleanable Filters

Cleanable filters shall be [25] [50] mm [1] [2] inches thick. Viscous adhesive shall be provided in 20 liter 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than 1 liter 1 quart for each filter section. One washing and charging tank shall be provided foe every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and [single] [double] drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position.

2.9 FUEL-OIL SYSTEMS

Fuel oil systems shall conform to Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.10 FUEL-GAS SUPPLY SYSTEM

Fuel-gas supply system shall be as specified in Section 23 11 20 FACILITY GAS PIPING and Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES.

2.11 DUCTWORK COMPONENTS

****

NOTE: The appropriate pressure classification from SMACNA 1966, including points of changes in pressure classification, will be noted on the drawings.

****

2.11.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA 1966 unless otherwise specified. Elbows shall be radius type with a centerline radius of 1-1/2 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, and 500 Pa 1/2, 1, and 2 inch w.g. ductwork shall meet the requirements of Seal Class C. Class 750 through 2500 Pa 3 through 10 inch 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. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 50 mm 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.

2.11.1.1 Transitions

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

2.11.1.2 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runouts length shall be as shown on the drawings, but shall not exceed 3 m 10 feet. Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

2.11.1.3 General Service Duct Connectors

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

2.11.2 Fibrous Glass Ductwork

****

NOTE: Fibrous glass ducts will not be used in ductwork systems for medical facilities or in clean rooms with requirements equal to or exceeding Class 100. Refer to AFR 88-15 for use on Air Force projects.

****

Fibrous glass ductwork may be provided in lieu of sheet metal ductwork except that fibrous glass ductwork will not be allowed in fan and equipment rooms, where subject to traffic or weather damage, for outside air intakes, for risers of more than two stories, in kitchen or fume exhaust ducts, to convey solids or corrosive gases, in concrete, for burial below grade, as casings or housings, or in systems used for life support systems. Fibrous glass ductwork, including components, shall be fabricated in accordance with NAIMA AH116 where the velocity and the static pressure are within its scope. Where the velocity or static pressure exceeds these limits, the ductwork manufacturer shall certify that the ductwork is intended for the velocities and pressures to be encountered, and that the proposed installation meets all performance criteria specified herein for metal ductwork. Fibrous glass ductwork shall have the thermal equivalent of the insulation specified for metal ductwork in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Field or factory fabricated fibrous glass ductwork shall conform to UL 181, Class 1. Duct wall penetrations, traverse joints and longitudinal seams shall be sealed as instructed by the manufacturer by one of the methods prescribed by NAIMA AH116, where applicable, except that pressure sensitive tape shall not be used as a sealant. All items necessary for a complete installation shall be provided as specified for sheet metal duct systems.

2.11.3 Ductwork Accessories

2.11.3.1 Duct Access Doors

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

****

Access doors shall be provided in ductwork where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA 1966. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 by 450 mm 15 by 18 inches, unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 by 600 mm 24 by 24 inches or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

2.11.3.2 Fire Dampers

****

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

****

Fire dampers shall be 1-1/2 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555.

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 specified application, and shall be installed in accordance with their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire 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. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition of floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA 1819 and in manufacturer's instructions for fire dampers shall be followed.

2.11.3.3 Splitters and Manual Balancing Dampers

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

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portion of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 5 mm 3/16 inch rod brought through the side of the duct with locking setscrew and bushing. Two rods are required on splitters over 200 mm 8 inches. Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm 12 inches. Access doors or panels shall be provided for all concealed damper operators and locking setscrew. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

2.11.3.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors or extractors for branch connections. All air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When

installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein . Fixed air deflectors, also called turning vanes, shall be provided in all 90 degree elbows.

2.11.4 Duct Sleeves, Framed Prepared Openings, Closure Collars

2.11.4.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 375 mm 15 inches in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm 15 inches in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor is responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) 20 gauge galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, ASTM A53/A53M, Schedule 20 shall be used. Sleeve shall provide 25 mm 1 inch clearance between the duct and the sleeve or 25 mm 1 inch clearance between the insulation and the sleeve for insulated ducts.

2.11.4.2 Framed Prepared Opening

Openings shall have 25 mm 1 inch clearance between the duct and the opening or 25 mm 1 inch clearance between the insulation and the opening for insulated ducts.

2.11.4.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm 4 inches wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm 15 inches in diameter or less shall be fabricated from 1.0 mm (20 gauge) 20 gauge galvanized steel. Collars for round duct larger than 375 mm 15 inches and all square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge) 18 gauge galvanized steel. Collars shall be installed with fasteners on maximum 150 mm 6 inch centers, except that not less than 4 fasteners shall be used.

2.11.5 Diffusers, Registers, and Grilles

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NOTE: Refer to UFC 3-450-01, Noise and Vibration Control, for noise criteria. Sound power levels required should be included in the appropriate schedule on the drawings.

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

****

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s 50 fpm 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. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m 7 feet above the floor, they shall be protected by a grille or screen in accordance with NFPA 90A.

2.11.5.1 Diffusers

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

2.11.5.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm 6 inches below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 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.

2.11.6 Louvers

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NOTE: Ensure that louver selection includes consideration of parameters such as pressure drop and water penetration.
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Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in Section 08 91 00 METAL [WALL] [AND] [DOOR] LOUVERS.

2.12 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A123/A123M or ASTM A653/A653M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphated and coated with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. 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 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint in accordance with ASTM D520, Type I.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

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NOTE: Reference NFPA 31 for oil-fired units. Reference NFPA 54 for gas-fired units.
****

The warm air heating installation shall conform to the requirements contained in NFPA 90A or NFPA 90B, as applicable. Combustion air supply and ventilation shall be in accordance with [NFPA 31] or [NFPA 54]. Submit drawings consisting of a complete list of equipment and material including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Show on the drawings complete equipment wiring diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit; proposed layout and anchorage of equipment and appurtenance and equipment relationship to other parts of the work including clearances required for maintenance and operation.

3.2.1 Furnaces

Foundations, settings, or suspensions for mounting equipment and accessories including supports, vibration isolators, stands, guides, anchors, clamps, and brackets shall be provided. Foundations and suspension for equipment shall conform to the recommendations of the manufacturer, unless otherwise indicated on drawings. Anchor bolts and sleeves shall be set accurately using properly constructed templates. Anchor bolts, when embedded in concrete, shall be provided with welded-on plates on the head end and guarded against damage until equipment is installed. Equipment bases shall be leveled, using jacks or steel wedges, and when resting on concrete shall be neatly grouted-in with a nonshrinking type of grout. Equipment shall be located as indicated and in such a manner that working space is available for all necessary servicing, such as shaft removal, replacing, or adjusting drives, motors, or shaft seals, air filters, access to automatic controls, humidifiers, and lubrication. Electrical isolation shall be provided between dissimilar metals for the purpose of minimizing galvanic corrosion. The interior of cabinets or casings shall be cleaned before completion of installation. The furnace shall be connected to the vent or chimney with the specified connectors, draft regulators, draft loads, and induced draft fans, as applicable, in accordance with NFPA 211.

3.2.2 Automatic Vent Dampers

Automatic vent dampers shall be installed in accordance with ANSI Z21.66/CGA 6.14.

3.2.3 Humidifiers

Humidifiers shall be installed in accordance with manufacturer's instructions and in an arrangement that will permit access and ease of maintenance. Piping, draining, manual shut-off valve, and solenoid valves when required for type of humidifier furnished shall be provided. Drain lines shall be provided for humidifiers and shall be piped to drains shown. Humidifiers installed in a bypass arrangement shall be provided with an integral damper that can be conveniently operated to regulate or shut off flow through the humidifier. To permit humidifier operation, a manual ON-OFF switch shall be provided near the humidifier. The ON-OFF switch may be integral with the humidifier. When humidifier is installed in glass fiber ductwork, ductwork shall be adequately reinforced to support the humidifier.

3.2.4 Access Panels

Access panels shall be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels shall be of sufficient size and so located that the concealed items may be serviced and maintained or completely removed for replacement. Access panels shall be as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.2.5 Flexible Connectors

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NOTE: Provide flexible connectors where required to absorb expansion and contraction, isolate vibration, absorb noise, compensate offset motion, absorb continuous flexing, and relieve equipment from piping stresses. Where flexible connectors are

needed to correct lateral, parallel, and angular misalignment, limit their use to maximum offset as recommended, in writing, by the manufacturer.
****

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

3.2.6 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07 84 00 FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07 92 00 JOINT SEALANTS.

3.2.7 Metal Ductwork

Installation shall be in accordance with SMACNA 1966 unless otherwise indicated. Duct supports for sheet metal ductwork shall be in accordance with SMACNA 1966, unless otherwise specified. Friction beam clamps indicated in SMACNA 1966 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 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 form 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. Where threaded rods are used, they not be formed or bent.

3.2.8 Fibrous glass Ductwork

Installation shall be in accordance with the manufacturer's written recommendations unless otherwise required in NAIMA AH116. Duct supports for fibrous glass ductwork shall conform to NAIMA AH116. In those cases not covered in NAIMA AH116, the written recommendation of the fibrous duct manufacturer shall be followed.

3.2.9 Air Filters

Air filters shall be installed [in heater casings] [in return air ducts at furnaces] [in return air grilles]. Fans or blowers shall not be operated until filters are installed. After completion of tests and before the building is accepted by the Government, [furnish a new second set of replaceable filters, where utilized] [clean the permanent type filters].

3.2.10 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.

3.2.11 Insulation

Thickness and application of insulation materials for ductwork and equipment shall be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.12 Duct Test Holes

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NOTE: The location of duct test holes will be shown on the drawings. Locate holes so as to implement the requirements of Section 23 05 93 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.

3.2.13 Fuel-Oil System

Fuel oil systems shall be installed in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.3 FIELD PAINTING

Finish painting of items only primed at the factory or surfaces not specifically noted, otherwise are specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 CLEANING

Ducts, plenums, and casings shall be thoroughly cleaned of all debris and blown free of all small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. All equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.5 FIELD TRAINING

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

****

a. Conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit proposed schedule for field training, at least 2 weeks prior to the start of related

training. Training shall be provided for a period of [_____] hours of normal working time shall start after the system is functionally complete but prior to the performance tests.

b. The field instruction shall cover all of the items contained in the approved operating and maintenance manuals. Submit [6] [_____] manuals listing step-by-step procedures required for system startup, operation, shutdown and routine maintenance, at least 2 weeks prior to field training. Include in the manuals the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

c. Each service organization submitted shall be capable of providing [4] [_____] hour onsite response to a service call on an emergency basis.

3.6 TESTS

Upon completion and prior to acceptance of the installation, furnish all equipment, instruments, materials, labor, and supervision required for the tests as specified. Submit proposed test procedures for ductwork leak and performance tests, at least 2 weeks prior to the start of related testing.

a. Obtain necessary natural gas, water and electricity as specified in the [SPECIAL CONTRACT REQUIREMENTS] [Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS.] Provide necessary quantities of propane gas or No. [_____] fuel oil when propane gas or fuel oil is require for testing.

b. Defects disclosed by the tests shall be rectified. Tests shall be made under the direction and subject to the approval of the Contracting Officer. All indicating instruments shall be read at 1/2-hour intervals unless otherwise directed by the Contracting Officer. Submit proposed System Diagrams, at least 2 weeks prior to start of related testing.

c. System diagrams that show the layout of equipment 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.

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

3.6.1 Ductwork Leak Test

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NOTE: This paragraph may be omitted where all ductwork is constructed to static pressure Class 125, 250, or 500 Pa 1/2, 1 or 2 inch w.g.. Otherwise leakage rate will be derived for each system to be tested based on procedure outlined in

SMACNA 1972 CD 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 the ductwork test, an appropriate allowance will be included in the maximum allowable leakage rate.
****

Ductwork leak test shall be performed for the entire air distribution system, including fans, coils, [filters, etc.] [filters etc. designated as static pressure Class 750 Pa 3 inch w.g. through Class 2500 Pa 10 in w.g.]. Test procedure, apparatus, and report shall conform to SMACNA 1972 CD. 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.

3.6.2 Testing, Adjusting, and Balancing

Testing, adjusting, and balancing shall be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.6.3 Performance Tests

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

-- End of Section --