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USACE / NAVFAC / AFCEA UFGS-15532N (September 1999)  
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Preparing Activity: NAVFAC Replacing without revision  
NFGS of same number and date

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 22 December 2004

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09/99

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### SECTION 15532N

#### WARM AIR HEATING SYSTEMS 09/99

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NOTE: This guide specification covers the requirements for warm air heating systems within a building.

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

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

Use of electronic communication is encouraged.

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

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## PART 1 GENERAL

### 1.1 REFERENCES

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

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

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

ARI 610 (1996) Central Systems Humidifiers for Residential Applications

ARI Guideline F (1997) Selection, Installation, and  
Servicing of Residential Humidifiers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.4 (1983; R 2001) Sound Level Meters (ASA 47)

ANSI Z21.66 (1996) Automatic Vent Damper Devices for  
Use with Gas-Fired Appliances

ASTM INTERNATIONAL (ASTM)

ASTM A 36/A 36M (2004) Carbon Structural Steel

ASTM D 396 (2004) Fuel Oils

ASTM F 1040 (1987; R 2001) Filter Units, Air  
Conditioning: Viscous-Impingement and Dry  
Types, Replaceable

ASTM F 872 (1984; R 1990) Filter Units, Air  
Conditioning: Viscous-Impingement Type,  
Cleanable

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA DC 3 (2003) Residential Controls - Electrical  
Wall-Mounted Room Thermostats

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 211 (2003) Chimneys, Fireplaces, Vents, and  
Solid Fuel-Burning Appliances

NFPA 31 (2001) Installation of Oil Burning  
Equipment

NFPA 54 (2002) National Fuel Gas Code

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

NFPA 90B (2002) Installation of Warm Air Heating  
and Air Conditioning Systems

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

SMACNA HVACTAB (2002, 3rd Ed) HVAC Systems - Testing,  
Adjusting and Balancing

SMACNA Leakage Test Mnl (1985, 1st Ed) HVAC Air Duct Leakage Test  
Manual

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS WW-F-2743 (Rev A) Furnaces, Warm Air and Heaters,  
Unit, Forced Air Circulation, Oil- and Gas

- Fired

UNDERWRITERS LABORATORIES (UL)

UL 103 (2001; Rev thru Dec 2003) Factory-Built  
Chimneys for Residential Type and Building  
Heating Appliances

UL 441 (1996; Rev thru Dec 1999) Gas Vents

1.2 RELATED REQUIREMENTS

Section 15050N NBASIC MECHANICAL MATERIALS AND METHODS applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

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

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

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

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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

#### SD-03 Product Data

Central furnaces

Unit heaters

Humidifiers

Air filters

Include types and ratings of utilities required, efficiency of item under installed conditions, and size and mounting requirements.

#### SD-06 Test Reports

Operating tests

Firing tests

Submit field test reports in accordance with the paragraph entitled "Field Quality Control."

#### SD-07 Certificates

Central furnaces

Submit certification that the humidifier has been tested and rated in accordance with ARI 610 and that the humidifier has the required capacity when adjusted in accordance with ARI Guideline F assuming that the [furnace] [unit heater] will operate 18 hours out of every 24 hours. The manufacturer shall also certify that no unevaporated water will enter the [furnace] [unit heater] plenum or ducts.

#### SD-10 Operation and Maintenance Data

Central furnaces, Data Package 3

Unit heaters, Data Package 3

Humidifiers, Data Package 3

Submit in accordance with Section 01781 OPERATION AND MAINTENANCE DATA.

#### SD-11 Closeout Submittals

Posted operating instructions

### 1.4 POSTED OPERATING INSTRUCTIONS

Provide instructions for start-up, normal operating, shutdown, and emergency shutdown procedures.

## PART 2 PRODUCTS

### 2.1 HEATING EQUIPMENT

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NOTE: The drawings shall show the required minimum bonnet capacity in kilowatt Btu's per hour for each furnace and unit heater installation, as well as the expected cubic meter per second cfm, and the external static pressure the furnace blower will be expected to produce. For equipment with over 117 kW 400,000 Btu/hr input capacities, use [heavy oil (Grade 4)], [combination \_\_\_\_\_ gas (\_\_\_\_\_ joule per cubic meter Btu's per cubic foot) and [light oil (Grade 2)], and [heavy oil (Grade 4)]] fired burners only.

\*\*\*\*\*

Provide self-contained, indirect, oil- or gas-fired, forced-air, furnaces and unit heaters conforming to FS WW-F-2743. Heating equipment shall consist of a heat exchanger; burner; centrifugal blower or propeller fan, as applicable; a sheet metal cabinet-type casing with provisions for duct, discharge-nozzle, or louvered connection; and all required operating, limit, and safety controls. Equipment shall be suitable for burning [light oil (Grade 2)], [heavy oil (Grade 4)], [\_\_\_\_\_ gas (\_\_\_\_\_ joule per cubic meter Btu's per cubic foot)], [combination \_\_\_\_\_ gas (\_\_\_\_\_ joule per cubic meter Btu's per cubic foot) and [light oil (Grade 2)] [heavy oil (Grade 4)]]. Provide a 24 volt control transformers, high limit, and fan time delay relay. Minimum annual fuel utilization efficiency (AFUE) shall be 78 percent for 6446 to 65,925 Watts (W) 22,000 to 225,000 Btu/hr input capacities gas- and oil-fired units. The steady state efficiencies for 65,926 to 117,200 W 225,001 to 400,000 Btu/hr and over 117,200 W 400,000 Btu/hr input capacities gas-fired units shall not be less than 80 percent at maximum rated capacity and not less than 78 percent at minimum rated capacity that is provided and allowed by the controls. The steady state efficiencies for the same input capacities oil-fired units shall not be less than 81 percent at minimum rated capacity that is provided and allowed by the controls.

#### 2.1.1 Central Furnaces

FS WW-F-2743 Type I of the [upflow, high-boy] [upflow, low-boy] [downflow] [horizontal flow] style designed to supply heated air through a duct system. Provide only downflow unit for furnace with 6446 to 65,925 W 22,000 to 225,000 Btu/hr input capacities. [Provide cooling evaporator coil module with cabinet suitable for use with furnace.]

#### 2.1.2 Unit Heaters

FS WW-F-2743 Type II of the [upflow, high-boy] [horizontal flow] style and equipped with [direct-diffusion] [rotatable] [sheet metal] [louvered] nozzles as indicated designed to discharge a stream of heated air along a preselected path directly into the space in which the heater is located. Provide suitable hangers for mounting of horizontal style units. Burners shall be readily accessible for service and inspection. [Provide rubber isolators and protective fan guard.]

### 2.1.3 Burners

Do not provide manually ignited type burners. Burners shall always return to low fire for ignition. Provide control system for [on-off] [high-low-off] [modulated] operation. Provide interrupted type ignition systems for burners with input capacities over 117,200 W 400,000 Btu's per hour.

#### 2.1.3.1 Oil Burners

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NOTE: Choose this subparagraph or the subparagraph below, entitled "Gas Burners." Use both subparagraphs if combination gas-oil burning equipment is to be specified.  
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The oil burner shall include motor, ignition equipment, safety devices, and accessories necessary for a fully automatic system that conforms to FS WW-F-2743. Furnish low oil-pressure switches in the fuel supply piping for oil-fired units equipped with programming controls. Provide a delayed opening oil shutoff valve, as specified in FS WW-F-2743, for oil-fired units not equipped with programming controls. Use fuel oil conforming to ASTM D 396 of grade specified. Burners shall be factory installed, wired, and fire tested.

#### 2.1.3.2 Gas Burners

\*\*\*\*\*  
NOTE: Choose this subparagraph or the subparagraph above, entitled "Oil Burners." Use both subparagraphs if combination gas-oil burning equipment is to be specified.  
\*\*\*\*\*

The gas burners shall include ignition equipment, gas-control valve, gas piping, gas-pressure regulating valve, gas shut-off cocks, when applicable, and accessories necessary for a fully automatic system that conforms to FS WW-F-2743. Furnish both high and low gas supply pressure switches in the fuel supply piping for gas-fired units equipped with programming controls.

### 2.2 ACCESSORY EQUIPMENT

#### 2.2.1 Humidifiers

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NOTE: Humidifiers specified in this paragraph are available with capacities up to 80 liters 21 gallons per 24 hours. Where larger capacities are required, humidifiers as specified in Section 15810, "Ductwork and Ductwork Accessories," should be used and this paragraph rewritten to refer thereto. Recirculating or reservoir type shall not be used without automatic bleed where the supply water has a mineral content greater than 4 kg per cubic meter 0.53 ounces per gallon. Capacity shall be computed as recommended by ARI Guideline F assuming average building construction and single glass windows are used in calculations.  
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Humidifiers shall be ARI 610 rated and ARI labeled and be of the [atomizing] [or] [wetted element] type permitted herein, and of the manufacturer's standard catalog product. [The atomizing type shall introduce small particles of water in mist form into the air stream.] [The wetted element type shall introduce moisture into the air stream in the form of saturated air by allowing the warm air to circulate through or over a wetted media. The wetted element equipment shall be restricted to the by-pass and duct-mounted types.] Do not permit humidifiers employing fan or electric heating coil for normal operation. Provide reservoir or recirculating type humidifier with a drain outlet and cock to permit manual draining of the pan. In addition, provide the recirculating or reservoir type humidifier with an automatic bleed which operates when the humidifier operates. Provide a manual on-off switch [remotely located] [or] [integral with the humidifier]. Humidifier shall be designed for easy maintenance and does not require removing or disconnecting sheet metal duct work for ordinary cleaning and service procedure. Humidifier shall be constructed of filled phenolic, reinforced polyester resins or non-corrosive metals. Humidistat shall be furnished by the humidifier manufacturer and shall be factory calibrated in percent relative humidity or outside temperature in degrees F at which condensation on single glass windows will occur.

## 2.2.2 Air Filters

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**NOTE: Normally, throwaway type filters shall be specified; however, permanent type filters may be included in the project specifications provided maintenance facilities are available for cleaning.**

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### 2.2.2.1 Cleanable Units

Provide ASTM F 872 viscous-impingement air filters with media frame and media support. Metallic filter media shall be adhesive coated.

### 2.2.2.2 Replaceable Units

- a. Provide ASTM F 1040 Type 1, throw-away frames and media, Grade [A] [B] [C] and [25] [50] mm [1] [2] inches thick. Form frames to provide positive support for the media pad and sufficient structural rigidity for normal handling and installation.
- b. Provide ASTM F 1040 Type 2, permanent frames with replaceable media, Grade [A] [B] [C] and [25] [50] mm [1] [2] inches thick. Provide aluminum or steel frames designed to permit ready removal of the soiled media pad and replacement with a clean pad.

### 2.2.3 Automatic Vent Dampers

Provide in the vents of all gas burning equipment that uses indoor air for combustion. Vent dampers shall conform to ANSI Z21.66.

### 2.2.4 Thermostat

Provide wall mounted, low voltage type conforming to NEMA DC 3 with an operating range from 12 to 33 degrees C 55 to 90 degrees F. Housing shall have concealed setpoint dials [,covers with allen head screws] [,aspirator

type wall box with flushplate and locking screws] [,built-in concealed thermometers] [,exposed adjustment covers with visible thermometers for family housing] and plug-in gage ports. The mounting plate or base shall be made of thermal insulating material or shall support the thermal element not less than 6 mm 1/4 inch from the wall. The control unit of the thermostat shall consist of a temperature sensing element, control switch, and anticipating heater. The control switch shall be a hermetically-sealed switch. Thermostat shall have provisions for calibrating the unit to the accuracy specified in NEMA DC 3. The design shall preclude calibration adjustment with ordinary tools, such as screwdriver or pliers. When mercury switches are used in the control unit, a leveling surface which is an integral part of the thermostat, shall be provided for use in leveling the thermostat during installation. Unless otherwise specified, a system selector switch having "heat" and "off" positions, and a fan selector switch having "auto" and "on" positions shall be provided integral to or mounted on a subbase of the thermostat.

## 2.3 FLUE CONNECTIONS

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**NOTE:** Induced draft fans shall be required on units with inputs of 58,600 to 117,200 W 200,000 to 400,000 Btu's per hour intended for horizontal, inverted, or other special installations. On units with inputs above 117,200 W 400,000 Btu's per hour, induced draft fans are included together with the furnace or space heater, in accordance with FS WW-F-2743.

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Flue connections shall be furnished [as specified in FS WW-F-2743] as indicated. Provide a [draft regulator of the barometric-type for oil-fired draft control] [draft hood for atmospheric gas-fired draft control]. Flue connections, including pipe and fittings, shall conform to NFPA 211 and shall be galvanized sheet steel having a nominal thickness not less than that required by NFPA 211. The weight of zinc-coating shall not be less than 0.38 kilogram per square meter 1.25 ounces per square foot commercial.

If the standard flue connection on the [furnace] [and] [unit heater] is other than the size specified for the furnace pipe, provide a suitable adapter. Provide suitable cleanouts to permit cleaning of the entire flue connection without dismantling. [Provide a resilient mount induced draft fan with an integral sail switch to sense flow, in the exhaust system.] [Provide double-wall metal chimneys for multifamily residential and larger buildings.]

### 2.3.1 [Chimneys] [Vents] [and] [Smokestacks or Metal Chimneys]

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**NOTE:** Furnaces and unit heaters shall be vented into masonry or prefabricated chimneys engineered and constructed to develop a positive flow adequate to remove all flue gases to the outside atmosphere.

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Design and construct to safely convey flue gases to the outside atmosphere.

Provide parts and accessories designed for firm attachment to ensure strength, rigidity, and durability. [Provide chimney connectors formed of not lighter than 20-gage zinc-coated steel sheets between chimneys and appliances and between chimneys and heating plants.] Fire stops, thimbles,

and support assemblies shall conform to the NFPA 211, UL Gas and Oil Equipment Directory, UL 103, UL 441, as applicable.

#### 2.3.1.1 [Chimneys] [Vents]

Shall be factory built, conforming to [UL 103] [UL 441] and installed in accordance with NFPA 211. The listing in the UL Gas and Oil Equipment Directory will be acceptable evidence that the [chimneys] [vents] conform. In lieu of such listing, the Contractor may submit a written certificate from any nationally recognized testing agency, that the [chimneys] [vents] have been tested in accordance with methods of testing of the UL and conform to [UL 103] [UL 441]. Provide the inside diameter and other required dimensions as indicated. Install weather hood or roof housing weathertight. [Label gas vents as required by NFPA 211.]

#### 2.3.1.2 [Smokestacks or Metal Chimneys]

Design for low and medium-heat appliances conforming to NFPA 211. Design and construct stacks to withstand a wind pressure of 147 kilogram per square meter 30 pounds per square foot of surface based on 67 percent of the projected area. Provide cleanout opening with a tight-fitting, hinged, cast iron door and frame at the base of each stack.

- a. Prefabricated Lined Stacks: Sectional type conforming to the applicable requirements of UL, for materials, heat tolerances, dimensions, and linings. The listing of chimneys in the UL, Gas and Oil Equipment Directory will be acceptable evidence that the stacks meet the requirements. In lieu of such listing, the Contractor may submit a written certificate from any nationally recognized testing agency that the stacks have been tested in accordance with methods of testing of the UL, and conform to NFPA 211. Provide sections to be joined with acid-resisting high-temperature cement and steel draw bands. Provide roof housing, rain cap, downdraft diverter, and other accessories required.
- b. Unlined Stacks: Shall be constructed of black-steel plates not less than 5 mm 3/16 inch thick conforming to ASTM A 36/A 36M. Weld seams and joints. Provide an angle flange for connection to the boiler, other equipment, and stack support. Provide means to prevent accumulation of water in the smokestack.
- c. Cleanout Doors: Provide [galvanized] [cast iron], complete with frames, and unless otherwise indicated, sized to match flues. Provide the frames with a continuous flange and anchors for securing into masonry. Provide doors hinged as standard with the manufacturer and fastening devices to hold the door in the closed position.

#### 2.4 WARM AIR CONNECTIONS

For central furnaces, provide discharge and return air ductwork, including air terminal devices, as specified in Section 15810N DUCTWORK AND DUCTWORK ACCESSORIES.

#### 2.5 FUEL-OIL SYSTEM

\*\*\*\*\*  
**NOTE: Choose this paragraph or the paragraph below,**

entitled "Fuel-Gas System." Use both paragraphs if combination gas-oil burning equipment is to be specified.

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Provide as specified in Section 15192N FUEL OIL PIPING.

## 2.6 FUEL-GAS SYSTEM

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NOTE: Choose this paragraph or the paragraph above, entitled "Fuel-Gas System." Use both paragraphs if combination gas-oil burning equipment is to be specified.

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Provide as specified in Section 15195N NATURAL GAS AND LIQUID PETROLEUM PIPING.

## 2.7 ELECTRICAL EQUIPMENT

Provide complete with motors, motor starters, thermal overload protection, and controls. Equipment and wiring shall be in accordance with Section 16402 INTERIOR DISTRIBUTION SYSTEM.

## 2.8 OPTIONAL CONTROLS

On units with input capacities over 117,200 W 400,000 Btu/hr, [pneumatic] [electronic] [electrical] controls may be provided for regulation of temperature and operation of power operators. Provide as specified in Section 15901N SPACE TEMPERATURE CONTROL SYSTEMS.

## 2.9 INSULATION

Provide shop and field applied insulation as specified in Section 15080N MECHANICAL INSULATION.

## 2.10 ASBESTOS PROHIBITION

Asbestos and asbestos containing products are prohibited.

# PART 3 EXECUTION

## 3.1 PREPARATION

Provide storage for equipment and material at the project site. All parts shall be readily accessible for inspection, repair, and renewal. Protect materials and equipment from the weather.

## 3.2 INSTALLATION

Warm air heating system 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, as applicable.

### 3.2.1 [Furnace] [Unit Heater]

Provide foundations, settings, or suspensions for mounting equipment and

accessories, including but not limited to supports, vibration isolators, stands, guides, anchors, clamps, and brackets. Foundations and suspension for equipment shall conform to the recommendations of the manufacturer, unless otherwise indicated. Set anchor bolts and sleeves accurately using templates. Provide anchor bolts and lag screws with welded-on plates on the head end and guard against damage until equipment is installed. Level bases using jacks or steel wedges, and when resting on concrete, neatly grout-in with a non-shrinking grout. Locate equipment as indicated and in such a manner that working space is available for all servicing, such as shaft removal, replacing or adjusting drives, motors or shaft seals, air filters, access to automatic controls, humidifiers, and lubrication. Provide electrical isolation between dissimilar metals to minimize galvanic corrosion. Clean the interior of cabinets or casings before completion of installation. Prime all uncoated ferrous-metal work and apply a finish coat of paint as specified in Section 09900 PAINTS AND COATINGS.

### 3.2.2 Flue Connections

Connect [furnace] [and] [unit heater] to the stack with the specified flue connections, draft regulators, draft hoods, and induced draft fans, as applicable, in accordance with NFPA 211.

### 3.2.3 Humidifiers

Install humidifiers in accordance with the manufacturer's instructions and in an arrangement that will permit access and easy maintenance. Provide water piping, drain, manual shut-off valve, and solenoid valves when required for type of humidifier furnished and install in accordance with Section 15400N PLUMBING SYSTEMS. Provide a manual shut-off valve in the water supply line to the humidifier. Provide a drain for the humidifier piped to a suitable drain as shown. Pitch the drain line down in the direction of flow with a grade not less than 21 mm per meter 1/4 inch per foot. [For reservoir or recirculating type humidifier, the automatic bleed shall be connected to the humidifier drain.] Provide humidifiers installed in a by-pass arrangement with an integral damper to stop air flow through the humidifier during the summer cooling season. Control humidifier by a manually adjustable humidistat [located in living spaces] [with sensing bulb in [return] [supply]]. Humidifier shall be operable when the furnace operates.

### 3.2.4 Ductwork

Install as specified in Section 15810N DUCTWORK AND DUCTWORK ACCESSORIES. When humidifier is installed in glass fiber ductwork, adequately reinforce ductwork to support the humidifier. Atomizing type humidifiers shall not be installed in glass fiber ductwork unless a sheet metal duct section extending 600 mm 2 feet upstream and 600 mm 2 feet downstream of the humidifier is provided.

### 3.2.5 Air Filters

Provide air filters where indicated. Do not operate fans or blowers until filters are installed. After completion of tests and before the building is accepted by the Government, provide a new set of throwaway filters, where utilized, or clean the permanent type filters.

## 3.3 FIELD QUALITY CONTROL

Inspect equipment when it is delivered to the job site. The right is

reserved to inspect any equipment at the plant of the manufacturer, during or after manufacture. Inspect and repair all refractory after installation and prior to startup. Continually inspect equipment during installation, after installation, and during the tests. Upon completion and prior to acceptance, perform tests and furnish all necessary equipment and materials required for the tests as specified herein to demonstrate that warm air heating system is in compliance with contract requirements. Make all tests under the direction of the [Contracting Officer] [Contractor Quality Control representative]. Read all indicating instruments at half-hour intervals.

#### 3.3.1 Start-Up

Prior to start up, clean all equipment, adjust belts to proper tension, lubricate motors and pulley bearings, and install air filters. Adjust safety and operating controls as necessary to place them in proper operation and sequence.

#### 3.3.2 Operating Tests

Perform the following operating tests to demonstrate satisfactory [furnace] [and] [unit heater] [and humidifier] operation. Check burner safety controls by simulating flame failure in accordance with the manufacturer's instructions. Operate [furnace] [and] [unit heater] for a period sufficient to make the following observations and record the following data but in no case less than one hour. These tests may be run concurrent with fire tests specified below to the extent practical. Demonstrate satisfactory operation of all heat-regulating controls and safety controls.

[Observe the humidifier for satisfactory operation and check humidifier drain to insure proper drainage.] Record temperature rise across the heat exchanger under all firing rates after equilibrium conditions have been reached at each firing rate. Record ammeter and voltmeter readings for the [furnace motor] [and] [unit heater motor] [and] [circulating blower motor] [and] [induced draft fan motor] [and] [humidifier motor].

#### 3.3.3 Firing Tests

Test combustion controls and equipment with [each] specified fuel at 100 percent rated load. Demonstrate satisfactory smoke-count numbers and combustion efficiency. Maintain firing for at least 4 hours [, and where high-low-off combustion controls are provided, operate the [furnace] [and] [unit heater] for one hour at low fire and 3 hours at high fire]. During tests, verify proper operation of controls. Adjust burners for maximum efficiency using Orsat or similar apparatus. Record temperature rises across heat exchangers. Minimum requirements for satisfactory combustion efficiency shall be [10.0 percent carbon dioxide for oil burners] [and] [8.5 percent carbon dioxide for gas burners]. Minimum temperatures of flue gas at the stack shall be 37 degrees C 100 degrees F above the flue-gas dew points. The observed smoke at all firing rates during the prescribed tests shall not exceed that indicated by a number 2 spot for the burners firing a distillate fuel or gas and a number 4 spot for burners firing a residual type fuel on the Shell-Bacharach scale.

#### 3.3.4 Air Duct Leakage Test

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**NOTE: Designer must determine if any justification for testing exist. Use this paragraph if there is a need for air duct leakage test.**

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Comply with SMACNA Leakage Test Mnl. Test ducts, plenums, and casings for air leakage. Prior to application of insulation, subject new ductwork to static pressure equivalent to that indicated. Before installing supply outlets, apply temporary caps where outlets will be connected. Connect a test blower temporarily to inlet end of duct and, by throttling its intake, adjust static pressure in duct to required value. Read voltage and current to blower motor and total static pressure across blower wheel. Apply data to AMCA certified performance table for the test blower to derive volumetric flow rate (cfm) of air injected into duct. Remove temporary caps and test blower. Verify the maximum allowable air leakage of the total air that duct is required to deliver. Perform the measurement of leakage using a calibrated orifice tube with its individual calibration curve.

### 3.4 TESTING, ADJUSTING, AND BALANCING

Perform in accordance with SMACNA HVACTAB, Chapter VII, "Air System TAB Procedures," to achieve and confirm compliance with drawings and specifications; prepare complete report of final test results.

#### 3.4.1 Markings of Settings

Following final acceptance of the balancing report, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked so that adjustment can be restored if disturbed at anytime.

#### 3.4.2 Sound Level Tests

Upon completion of testing and balancing of air systems, conduct sound level tests of conditioned spaces. Use sound level meter required by ANSI S1.4, Type 2, calibrated in accordance with NBS standards and guidelines, and accompanied by a certificate of calibration. Record sound levels in dBA with air systems off, [with heating system only operating] [and] [with cooling system only operating]. Record the following data for each room and system:

- a. Background sound level (systems off);
- b. Total sound level corrected for background; and
- c. Sound power rating by manufacturer of the respective outlet.

Test Locations: Take sound level reading at location 2 meters 6 feet from face of each outlet on a line at 45 degrees with face of outlet. Remedial Action: If sound level at any observation point exceeds [20] [45] [\_\_\_\_\_] dBA, take remedial action as directed.

### 3.5 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurements commonly agreed on by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

<u>Products</u>	<u>Inch-Pound</u>	<u>Metric</u>
a. Central Furnaces Input Capacities	= 22,000-225,000 Btu/hr	= 6446-65,925 W
b. Burners Input Capacities	= 400,000 Btu/hr	= 117,200 W
c. Thermostats Operating Range	= 55-90 degrees F	= 12-13 degrees C
-- End of Section --		