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 54 19

BUILDING HEATING SYSTEMS, WARM AIR

11/08, CHG 2: 08/18

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USACE / NAVFAC / AFCEC / NASA	**UFGS-23 54 19 (November 2008)** **Change 2 - 08/18**
Preparing Activity: NAVFAC	**Superseding** **UFGS-23 54 19 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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SECTION 23 54 19

BUILDING HEATING SYSTEMS, WARM AIR
11/08, CHG 2: 08/18

****
NOTE: This guide specification covers the requirements for warm air heating systems for buildings (not including Family Housing) using oil-fired or gas-fired; vented; indirect air heating central furnaces, unit heaters, and duct heaters. It does not cover wall furnaces or floor furnaces. Warm air systems are 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).
****

****
NOTE: Identical Terminology: It is highly unlikely that this section will use the same terminology as CADD programs or CADD drafters. Specifier should ensure that each piece of equipment, or item, or system is identified or marked identically in the section paragraphs as the item is identified on the drawings. If this is not done, confusion will result as to which specification paragraph applies to a particular item on the drawings, thereby affecting the quality of the design package.
****

PART 1 GENERAL

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.

****

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, HEATING AND REFRIGERATION INSTITUTE (AHRI)

ANSI/AHRI 640	(2005) Performance Rating of Commercial and Industrial Humidifiers

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
ANSI Z83.8/CSA 2.6	(2016; Errata 2017) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces

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 D396	(2019a) Standard Specification for Fuel Oils
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and

	Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM F872	(1984; R 1990) Filter Units, Air Conditioning: Viscous-Impingement Type, Cleanable
ASTM F1040	(1987; R 2007) Standard Specification for Filter Units, Air Conditioning, Viscous - Impingement and Dry Types, Replaceable

CSA GROUP (CSA)

CSA Directory	(updated continuously online) Product Index

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2018) International Building Code
ICC IMC	(2018) International Mechanical Code
ICC IPC	(2018) International Plumbing Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA DC 3	(2013) Residential Controls - Electrical Wall-Mounted Room Thermostats
NEMA MG 1	(2018) Motors and Generators
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2020) Standard for the Installation of Oil-Burning Equipment
NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020; TIA 20-1; TIA 20-2; TIA 20-3) Liquefied Petroleum Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical 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

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

SMACNA 1780	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 296	(2017; Reprint Sep 2020) UL Standard for Safety Oil Burners
UL 441	(2016; Reprint Jul 2016) UL Standard for SafetyGas Vents
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

1.2 SYSTEM DESCRIPTION

****
NOTE: Insert statements describing performance or design requirements. Descriptions should be limited to operational properties to the extent necessary to link multiple components of a system together and interface with other systems.
****

This specification section specifies the requirements for warm air heating systems using [oil][and][gas]-fired, vented, indirect air heating central furnaces, [and] unit heaters[, and duct furnaces].

Requirements for related system components are specified in other sections including:

[Section [23 81 00 DECENTRALIZED UNITARY HVAC EQUIPMENT] [23 81 00 DECENTRALIZED UNITARY HVAC EQUIPMENT] which specifies unitary heating and cooling system requirements;

][[Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS][NFPA 70] which specifies control system requirements;

][Section [33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS][33 52 10 FUEL SYSTEMS PIPING (SERVICE STATION)] which specifies fuel oil system

requirements;

][Section [23 11 20 FACILITY GAS PIPING] [33 51 15 NATURAL-GAS / LIQUID PETROLEUM GAS DISTRIBUTION PIPELINES] which specifies fuel gas system requirements;

][Section [23 81 00 DECENTRALIZED UNITARY HVAC EQUIPMENT][23 30 00 HVAC AIR DISTRIBUTION] which specifies ductwork system requirements;

][Section 22 00 00, PLUMBING GENERAL PURPOSE which specifies plumbing system requirements;

] Section 09 90 00 PAINTS AND COATINGS which specifies finish painting of system component surfaces not factory finished;

[[Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC][SMACNA HVACTAB] which specifies the system TAB work.

]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

****
NOTE: For design-build projects, include the seismic protection design drawings requirements listed immediately below.
****

[Seismic Design Drawings, Diagrams, and Schedules; G[, [_____]]

] SD-03 Product Data

Self-Contained Furnaces; G[, [_____]]

[Energy Star Label for Residential Gas Fired Furnace Product; S

][Energy Star Label for Residential Oil-Fired Furnace Product; S

] Vent Connections; G[, [_____]]

Controls; G[, [_____]]

Dampers; G[, [_____]]

Air Filters; G[, [_____]]

Humidifiers; G[, [_____]]

Unit Heaters; G[, [_____]]

Seismic Isolators; G[, [_____]]

Vibration Isolators; G[, [_____]]

****
NOTE: For design-build projects, include the seismic protection product data requirements listed immediately below.
****

[Seismic Snubbers; G[, [_____]]

][Seismic Bracing; G[, [_____]]

][Seismic Anchors; G[, [_____]]

] 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. The data shall include 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.

System Diagrams; G[, [_____]]

Similar Services

SD-06 Test Reports

Self-Contained Furnace - Field Acceptance Test Plan; G[, [_____]]

Self-Contained Furnace - Field Acceptance Test Report; G[, [_____]]

Tests; G[, [_____]]

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.

SD-08 Manufacturer's Instructions

Self-Contained Furnaces - Installation Instructions

Vent Connections - Installation Instructions

Controls - Installation Instructions

Dampers - Installation Instructions

Air Filters - Installation Instructions

Humidifiers - Installation Instructions

Unit Heaters - Installation Instructions

SD-10 Operation and Maintenance Data

Self-Contained Furnaces, Data Package 3; G[, [_____]]

Vent Connections, Data Package 3; G[, [_____]]

Controls, Data Package 3; G[, [_____]]

Dampers, Data Package 3; G[, [_____]]

Humidifiers, Data Package 3; G[, [_____]]

Unit Heaters, Data Package 3; G[, [_____]]

Submit data packages in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Field Training

Indoor Air Quality During Construction; S

Provide instructions for start-up, normal operating, shutdown, and emergency shutdown procedures. Submit proposed schedule for field training, at least 2 weeks prior to the start of related training.

1.4 QUALITY ASSURANCE

1.4.1 Standard Products

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the products. Equipment shall essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

1.4.2 Alternative Products

Products having less than a two 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 or laboratory tests, can be shown.

1.4.3 Service Support

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

The equipment items shall be supported by service organizations. Submit a certified list of qualified, service organizations for support of the equipment which includes their addresses and qualifications with the Operation and Maintenance data. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.4.4 Modification to Reference

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.5 Nameplates

Each major component of equipment shall have the manufacturer's name, type or style, and model or serial number, all permanently and legibly marked on a plate secured to the equipment.

1.4.6 System Diagrams

Proposed system diagrams, must be submitted, approved and posted prior to start of related testing. 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.

1.5 DELIVERY STORAGE AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's

recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.7 ACCESSIBILITY

****

NOTE: The following requirement is intended to solicit the installer's help in the prudent location of equipment when he has some control over locations. However, designer's should not rely on it at all since enforcing this requirement in the field would be difficult. Therefore, the system designer needs to layout and indicate the locations of equipment, control devices, and access doors so that most of the accessibility questions are resolved inexpensively during design.

****

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

****

NOTE: Reference NFPA 31 for oil -fired units. Reference NFPA 54 for gas-fired units. Reference NFPA 58 for liquid petroleum gas-fired units.

****

Provide warm air heating system, including equipment, equipment, materials, installation, workmanship, fabrication, assembly, erection, inspection, examination, and testing in accordance with the applicable requirements contained in ICC IBC, ICC IMC, ICC IPC, NFPA 90A or NFPA 90B, and [NFPA 31][NFPA 54] [NFPA 58] as modified and supplemented by this specification section and accompanying drawings.

2.1 SELF CONTAINED FURNACES

****

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).

NOTE: Dual fuel (oil & gas) fired equipment is only available for large units (450 MBtuh and larger). Factory Mutual (FM) is the governing standard for these units.

NOTE: When using fuel burning appliances, ensure safety requirements in the International Mechanical Code (IMC) have been provided to monitor and alarm any carbon monoxide build up inside any spaces.

****

Provide manufacturer's standard, self-contained, indirect, [oil] [and] [gas]-fired, forced-air, furnaces conforming to [UL 727] [ANSI Z21.47/CSA 2.3]. Furnace and furnace components shall be completely factory-assembled and shall consist of a [aluminized] [stainless] steel heat exchanger; burner; centrifugal blower, a sheet metal cabinet-type casing with provisions for duct, vibration isolators, and all required operating, limit, and safety controls. 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. Provide a 24 volt control transformers, high temperature limit, and fan time delay relay.

Provide [upflow, high-boy] [upflow, low-boy] [downflow] [horizontal flow] [duct mounted] style designed to supply heated air through a duct system. [Provide cooling evaporator coil module with cabinet suitable for use with furnace.]

2.1.1 Gas-Fired Unit

****

NOTE: High efficiency type units will be specified unless the conventional type units are calculated to be more life cycle cost effective.

For conventional type furnace with a capacity less than 65.9 kW (225 MBtuh) require a minimum AFUE of 78 percent. FEMP requires gas-fired warm air furnaces with a capacity greater than 65.9 kW (225 MBtuh) have a minimum thermal efficiency of 80 percent at the maximum rated capacity.

For residential applications, Energy Star requires warm air furnaces with capacity less than 65.9 kW 225 MBtuh have a minimum AFUE of 90 percent for US South applications, and a minimum AFUE of 95 percent

for US North applications. Refer to Energy Star "Furnaces Key Product Criteria" for identification of US North and US South applications.

The first cost of a high efficiency, condensing type furnace is approximately 60 to 75 percent higher than the first cost of a conventional type furnace.

NOTE: Dual fuel (oil & gas) fired equipment is only available for large units (450 MBtuh and larger). Factory Mutual (FM) is the governing standard for these units.

****

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 [_____] percent . Furnace shall be suitable for burning [natural] [propane] gas (_____Btu's per cubic foot), [combination [natural] [propane] gas (_____Btu's per cubic foot)][and [light oil (Grade 2)]].[Provide Energy Star labeled equipment for high efficiency furnaces installed in residential applications (input less than 65.9 kW 225 MBtuh). Provide proof of Energy Star label for residential gas fired furnace product.]

2.1.1.1 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.

2.1.1.2 Ignition System

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.

2.1.2 Oil-Fired Unit

****

NOTE: Furnace with a capacity less than 65.9 kW (225 MBtuh) require a minimum AFUE of 78 percent. FEMP requires oil-fired warm air furnaces with a capacity greater than 65.9 kW (225 MBtuh) have a minimum thermal efficiency of 81 percent at the maximum rated capacity.

For residential applications, Energy Star requires oil-fired warm air furnaces with capacity less than 65.9 kW 225 MBtuh have a minimum AFUE of 85 percent.

NOTE: Dual fuel (oil & gas) fired equipment is only available for large units (450 MBtuh and larger). Factory Mutual (FM) is the governing standard for these units.

****

Oil-fired furnace shall be in accordance with UL 727 and have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of [_____] percent. Equipment shall be suitable for burning [[No. 2], [No. 4] oil], [combination [natural] [propane] gas (_____Btu's per cubic foot) and [[No. 2], [No. 4] oil]].[Provide Energy Star labeled equipment for high efficiency furnaces installed in residential applications (input less than 65.9 kW 225 MBtuh). Provide proof of Energy Star label for residential oil-fired furnace product.]

2.1.2.1 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 oil 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 is operating at rated speed.

2.1.2.2 Ignition System

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

2.1.3 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 multi-speed, as indicated, to provide the specified range of air temperature rises. Shafts shall be supported by a minimum of two self-aligning bearings. Direct-drive blowers may have variable speed motors to change blower speed. Belt-drive blowers shall be provided with an adjustable base, and with a belt 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. Belt drive blower speed shall be adjusted by the use of variable pitch drive sheaves.

2.1.4 Burners

****

NOTE: Verify that positive pressure has been provided in the mechanical room to ensure proper burner performance and prevent carbon monoxide build-up.

NOTE: In climates where high efficiency furnaces may be exposed to freezing temperatures, provide

heat in the furnace/mechanical room to prevent freezing of the condensate.
****

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 400,000 Btu's per hour.

2.1.4.1 Oil Burners

****
NOTE: Choose this subparagraph or the subparagraph below, GAS BURNERS. Use both subparagraphs if combination gas-oil burning equipment is to be specified.
****

The oil burner shall include motor, ignition equipment, safety devices, and accessories necessary for a fully automatic system that conforms to IMC and UL 296. Use fuel oil conforming to ASTM D396 of grade specified. Burners shall be factory installed, wired, and fire tested.

2.1.4.2 Gas Burners

****
NOTE: Choose this subparagraph or the subparagraph above, 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 ANSI Z21.47/CSA 2.3 and NFPA 54.

2.2 VENT CONNECTIONS

****
NOTE: Induced draft fans shall be required on units with inputs of 200,000 to 400,000 Btu's per hour intended for horizontal, inverted, or other special installations. On units with inputs above 400,000 Btu's per hour, provide with a power burner.
****

Flue vent connections shall be furnished as indicated. Provide a [draft regulator of the barometric-type for oil-fired draft control] [draft hood for atmospheric gas-fired draft control]. Flue vent 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 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.]

A 9 mm 0.3125 inch diameter hole shall be provided in the vent stack not greater than 150 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.

2.2.1 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 unacceptable for vent piping of combustion gases.

2.2.2 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 unacceptable for vent piping of combustion gases.

2.2.3 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 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 the condensate across the 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 furnace manufacturer. A separate combustion air intake vent and exhaust shall be provided for each furnace. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are unacceptable for vent piping of combustion gases.

2.2.3.1 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 [and rain hood].

2.2.3.2 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.

2.3 CONTROLS

****
NOTE: The designer should 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, the designer should coordinate the availability of the selection with the manufacturers. The designer should 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, the designer should consider moving the appropriate portions of 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.

2.3.1 Thermostat

****
NOTE: For Navy projects, include the last bracketed option restricting the use of mercury.
****

Provide wall mounted, low voltage type conforming to NEMA DC 3 with an operating range from 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]. 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. 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 sub-base of the thermostat. [Mercury shall not be allowed in switches and thermometers.]

2.3.2 [OPTIONAL CONTROLS

On units with input capacities over 400,000 Btu/hr, [electronic] [electrical] controls may be provided for regulation of temperature and

operation of power operators.]

2.4 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.

2.5 HUMIDIFIERS

****
NOTE: Delete inapplicable paragraphs. Verify steam availability if steam humidifiers are specified. Recirculating or reservoir type will not 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 ARI 640 assuming average building construction and single glass windows are used in calculations.
****

2.5.1 Steam Spray Type

Steam spray humidifiers shall be ANSI/AHRI 640 rated, ARI labeled, and 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 condensate 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 pounds of steam per hour and at steam pressure as indicated.

****
NOTE: Humidifiers specified in this paragraph are available with capacities up to 21 gallons per 24 hours. Where larger capacities are required, humidifiers as specified in Section 23 30 00 HVAC AIR DISTRIBUTION should be used and this rewritten to refer thereto. Recirculating or reservoir type shall not be used with automatic bleed where the supply water has a high mineral content greater than 0.53 ounces per gallon. Capacity shall be computed as recommended by ARI 640 assuming average building construction and single glass windows are used in calculations.
****

2.5.2 Wetted Element Type

[Humidifiers shall be ANSI/AHRI 640 rated and ARI labeled and be of the wetted element type permitted herein, and of the manufacturer's standard catalog product. 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. Humidifiers employing a fan or electric heating coil for normal operation are not permitted. 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 shall 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.]

2.5.3 Operation

Humidifier shall be controlled by a manually adjustable humidistat [located in occupied spaces] [with sensing bulb in [return] [supply]]. Humidifier shall operate when the furnace operates.

2.6 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 filters types will be deleted.
General recommended MERV value is 7 to 11. For Air Force, use a minimum filter of MERV 7, however, filters up to MERV 11 may be considered.
****

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

2.6.1 Replaceable Media Filters

The air flow capacity of the filter shall be based on net filter face velocity not exceeding [1.5][_____] m/s [300][_____] feet per minute, with initial resistance of [3][_____] mm [0.13][_____] inches water gauge. Minimum Efficiency Reporting Value (MERV) shall be not less than [_____]when tested according to ASHRAE 52.2.

[a. Provide ASTM F1040 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 F1040 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.

]2.6.2 Sectional Cleanable Filters

Cleanable filters with media frame and media support conforming to ASTM F872, and shall be [25] [50] mm [1] [2] inches thick. Metallic filter media shall be adhesive coated. Viscous adhesive shall be provided in 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than 1 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. Initial pressure drop for the clean filters shall not exceed the applicable values listed in ASTM F872.

2.7 UNIT HEATERS

Provide manufacturer's standard, self-contained, indirect, [oil] [gas]-fired, unit heater conforming to ANSI Z83.8/CSA 2.6. Unit heater and components shall be completely factory-assembled and shall consist of a [aluminized] [stainless] steel heat exchanger; burner; fan, a sheet metal cabinet-type casing and all required operating, limit, and safety controls. Unit heater shall be provided with removable service panels which allow access to all internal components requiring cleaning, servicing, or adjustment. Provide a 24 volt control transformer, high temperature limit, and fan time delay relay. Provide [down] [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 pre-selected 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.]

2.8 FACTORY PAINTING

New equipment painting shall be factory or shop applied, and shall be as specified herein, and provided under each individual section.

2.8.1 Factory Painting of New Equipment

New equipment shall be coated with a manufacturer's factory-applied finish that meets the following requirements:

The finish system designed for the equipment shall have been tested in accordance with Federal Test Method Standard No. 141 (Method 6061) and passed the 125-hour salt-spray fog test of that standard, except that equipment located outdoors shall have passed the 500-hour salt-spray fog test of that standard. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the successful test specimens.

If manufacturer's standard factory painting system is being proposed for use o n surfaces subject to working temperatures above 50 degrees C 120 degrees F, the factory painting system shall be designed for service at the finished surface's working temperature and shall meet the test requirements specified above for Federal Test Method Standard No. 141 when the finished

surface temperature is at the service working temperature.

2.9 ELECTRICAL WORK

****

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

2. 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 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS. The methods for calculating the economy of using an adjustable speed drive is described in 3-520-01, "Interior Electrical Systems".

****

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 ELECTRICAL WORK, INTERIOR][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.

Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

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

[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. All variable frequency drive motors, regardless of configuration, shall be fed from individual K-rated isolation transformers.] [Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.]

PART 3 EXECUTION

3.1 INSTALLATION

****
NOTE: Reference NFPA 31 for oil -fired units. Reference NFPA 54 for gas-fired units. Reference NFPA 58 for liquid petroleum gas-fired units.
****

The warm air heating system installation shall be in accordance with the manufacturer's written instructions and be in compliance with the requirements contained in ICC IBC, ICC IMC, ICC IPC, NFPA 90A or NFPA 90B, and [NFPA 31] [NFPA 54] [NFPA 58].

****
NOTE: For design-build projects, include the seismic protection design and construction requirements listed immediately below.
****

[Provide seismic protection design and construction, in accordance with ICC IBC, for each mechanical component, including [inertia base][, machinery base][, platform][, rails][, saddles][, seismic isolators][, seismic snubbers][, seismic bracing][, seismic anchors] and other associated material and equipment. Provide seismic design drawings, diagrams, and schedules as a coordinated package. Isolators shall provide uniform deflection, even when mechanical components weight is not evenly distributed.]

Combustion air supply and ventilation shall be in accordance with [NFPA 31] [NFPA 54] [NFPA 58]. Systems and equipment include:

Self-contained furnaces - installation instructions

[Vent connections - installation instructions

][Controls - installation instructions

][Dampers - installation instructions

][Air filters - installation instructions

][Humidifiers - installation instructions

][Unit heaters - installation instructions

]3.1.1 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 non-shrinking 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.

3.1.2 Automatic Vent Dampers

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

3.1.3 Humidifiers

Humidifiers shall be installed in accordance with manufacturer's instructions and in an arrangement that will permit access and ease of maintenance. Provide water piping, drain, manual shut-off valve, and solenoid valves when required for type of humidifier furnished and install in accordance with the ICC IPC and paragraph SYSTEM DESCRIPTION. 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. Provide an access door in the ductwork located two feet downstream of the humidifier for verifying operation and inspecting the ductwork. When humidifier is installed in glass fiber ductwork, ductwork shall be adequately reinforced to support the humidifier. [For reservoir or re-circulating type humidifier, the automatic bleed shall be connected to the humidifier drain.]

3.1.4 Unit Heaters

Provide suspensions for mounting equipment and accessories, including but not limited to supports, vibration isolators, anchors, clamps, and brackets. Suspension for equipment shall conform to the recommendations of the manufacturer, unless otherwise indicated. Set anchor bolts 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. Locate equipment as indicated and in such a manner that working space is available for all servicing, such as replacing or adjusting drives, motors or shaft seals, access to automatic controls, and lubrication. Prime all uncoated ferrous-metal work and apply a finish coat of paint as specified in paragraph SYSTEM DESCRIPTION.

3.1.5 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][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].

3.1.6 Flexible Connectors

****

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

****

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

3.1.7 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, the Contractor shall [provide a new second set of replaceable filters, where utilized] [clean the permanent type filters]. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, [new filters were provided and installed][the permanent filters were cleaned].

3.1.8 Dust Control

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

3.1.9 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 FIELD PAINTING

Finish painting of items only primed at the factory or surfaces not specifically noted otherwise, are specified in paragraph SYSTEM

DESCRIPTION.

3.3 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, the ducts, plenums, casings, and other items specified have been vacuum cleaned, and after completion of all tests. 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.

3.4 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 no less frequently than at half-hour intervals.

3.4.1 Tests

Upon completion and prior to acceptance of the installation, the Contractor shall furnish all equipment, instruments, materials, labor, and supervision required for the tests as specified. Water, electricity, and fuel required for testing [shall] [will] be furnished by the [Contractor][_____]. Defects disclosed by the tests shall be rectified by the contractor, at no additional expense to the Government, and retested until satisfactory. 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.

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:

Products	Inch-Pound	Metric
a. Central Furnaces Input Capacities	= 22,000-225,000 Btu/hr	= 6446-65,925 W

Products	Inch-Pound	Metric
b. Burners Input Capacities	= 400,000 Btu/hr	= 117,200 W
c. Thermostats Operating Range	= 55-90 degrees F	= 12-13 degrees C

3.6 TESTING, ADJUSTING, AND BALANCING

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

][Perform in accordance with SMACNA 1780, Chapter VII, "Air System TAB Procedures," to achieve and confirm compliance with drawings and specifications; prepare complete report of final test results.

]3.7 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 at the humidistat(s) location(s),] and the outside air temperature [and humidity] in an immediately adjacent shaded and weather protected outside area.

3.8 OPERATING TEST

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 humidity of air entering and leaving the humidifier during steady state furnace operation.] 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].

3.9 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 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.

3.10 FIELD TRAINING

****

NOTE: Use the following equipment test paragraphs for systems with inputs greater than 400,000 Btu's per hour or other special installations.

****

3.10.1 Field Acceptance Test Plans and Test Reports

a. Manufacturer's Test Plans: Within [120] [_____] calendar days after contract award, submit the self-contained furnace field acceptance test plan for each furnace.

   Field acceptance test plans shall developed by the furnace manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

   The Contracting Officer will review and approve the field acceptance test plan for each of the furnaces prior to commencement of field testing of the furnaces. The approved field acceptance test plans shall be the plan and procedures followed for the field acceptance tests of the furnaces and resultant test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of furnace controls which interlock and interface with controls factory prewired or external controls for the equipment provided under Section [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS].

c. Prerequisite testing: Equipment for which performance testing is dependent upon the completion of the work covered by Section [23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC][SMACNA 1780] must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Manufacturer shall furnish with each test procedure a description of acceptable results that have been verified.

Manufacturer shall identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.

f. Job specific: Each test plan shall be job specific and shall address the particular item of equipment and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such temperature control valves, or pressure control valves.

3.10.2 Field Acceptance Testing

a. Equipment Requiring Test Reports: Each self-contained furnace shall be field acceptance tested in compliance with its approved field acceptance test plan and the resulting self-contained furnace field acceptance test report submitted for approval.

b. Manufacturer's recommended testing: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. [Furnish a factory trained field representative authorized by and to represent the equipment manufacturer throughout the complete execution of the field acceptance testing.]

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of each test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables. Submit test logs for each test period.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director and the QC manager. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.11 FIELD TRAINING

****

NOTE: The number of hours of instruction should be determined based on the number and complexity of the systems specified.

****

The Contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of [_____] hours of normal working time shall start after the system is functionally complete but prior to the performance tests. The field instruction shall cover all of the items contained in the approved operating and maintenance instructions.

-- End of Section --