Preparing Activity: NAVFAC

Superseding
UFGS-23 54 19 (November 2008)
UFGS-23 82 01.00 10 (April 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION 23 54 19

BUILDING HEATING SYSTEMS, WARM AIR

08/21

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USACE / NAVFAC / AFCEC / NASA	**UFGS-23 54 19 (August 2021)**

Preparing Activity: NAVFAC	**Superseding** **UFGS-23 54 19 (November 2008)** **UFGS-23 82 01.00 10 (April 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023

****

SECTION 23 54 19

BUILDING HEATING SYSTEMS, WARM AIR
08/21

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NOTE: This guide specification covers the requirements for warm air heating systems for buildings (not including Family Housing) using direct or indirect; oil-fired or gas-fired; vented; forced air furnaces. It does not cover wall furnaces or floor furnaces. Warm air systems applications include but are not limited to barracks, offices, warehouses, maintenance, and production facilities.

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).

****

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NOTE: Coordinate with the Installation and provide specific requirements "to match existing systems" when necessary. If specifying proprietary products, insure that appropriate "Justification and Authorization (J & A)" documentation has been obtained by project manager and "proprietary language requirements" have been added to Division 1 as well as adding the following lines above the section number and title at the top of the first

page of this section of this section:

"********
This Specification Contains Brand Name Products.
**********"**

The use of brand name items has been the subject of many Contract claims. Project designers and specifiers must be aware of the restriction on the specification of brand name items and take special precautions to avoid their use unless formal written approval is obtained.
****

****
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 MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 210 (2016) Laboratory Methods of Testing Fans

	for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430	(2009) Central-Station Air-Handling Units
AHRI 640	(2017) Performance Rating of Commercial and Industrial Humidifiers

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 611	(2014) Voluntary Specification for Anodized Architectural Aluminum

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.47/CSA 2.3	(2021) Gas-Fired Central Furnaces
ANSI Z21.66/CGA 6.14	(2015; R 2020) Automatic Vent Damper Devices for Use with Gas-Fired Appliances
ANSI Z83.4/CSA 3.7	(2017; R 2022) Non-Recirculating Direct Gas-Fired Heating and Forced Ventilation Appliances for Commercial and Industrial Application
ANSI Z83.8/CSA 2.6	(2016; R 2021) 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 A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A269/A269M	(2022) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

CSA GROUP (CSA)

CSA Directory	(updated continuously online) Product Index

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2021) International Building Code
ICC IMC	(2021) International Mechanical Code
ICC IPC	(2021) International Plumbing Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA DC 3	(2013) Residential Controls - Electrical Wall-Mounted Room Thermostats
NEMA MG 1	(2021) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
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	(2023) National Electrical Code
NFPA 90A	(2024) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2024) 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 Nov 2022) UL Standard for Safety Oil Burners
UL 441	(2016; Reprint Jul 2016) UL Standard for SafetyGas Vents
UL 499	(2014; Reprint May 2023) UL Standard for Safety Electric Heating Appliances
UL 641	(2010; Reprint Oct 2022) UL Standard for Safety Type L Low-Temperature Venting Systems
UL 727	(2018) UL Standard for Safety Oil-Fired Central Furnaces
UL 900	(2015; Reprint Aug 2022) UL Standard for SafetyStandard for Air Filter Units
UL 1738	(2020; Reprint Aug 2021) UL Standard for SafetyVenting Systems for Gas-Burning Appliances, Categories II, III and IV
UL 1995	(2015; Reprint Aug 2022) UL Standard for Safety Heating and Cooling Equipment

1.2 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 data packages in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor Qualifications; G[, [_____]]

SD-02 Shop Drawings

Equipment Layouts

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[, [_____]]

Duct Furnace; G[, [_____]]

[Heating and Ventilating Units; G[, [_____]]

][Heating Only Makeup Air Units; G[, [_____]]

] System Diagrams; G[, [_____]]

SD-06 Test Reports

Field Acceptance Test Plans and Test Reports; G[, [_____]]

Field Acceptance Testing; G[, [_____]]

Test Reports; G[, [_____]]

SD-08 Manufacturer's Instructions

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

Vent Connections - Installation Instructions; G[, [_____]]

Controls - Installation Instructions; G[, [_____]]

Dampers - Installation Instructions; G[, [_____]]

Air Filters - Installation Instructions; G[, [_____]]

Humidifiers - Installation Instructions; G[, [_____]]

Duct Furnace - Installation Instructions; G[, [_____]]

[Heating and Ventilating Units - Installation Instructions; G[, [_____]]

][Heating Only Makeup Air Units - Installation Instructions; G[, [_____]]

] 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[, [_____]]

[Duct Furnace, Data Package 3; ; G[, [_____]]

][Heating and Ventilating Units, Data Package 3; G[, [_____]]

][Heating Only Makeup Air Units, Data Package 3; G[, [_____]]

] SD-11 Closeout Submittals

Field Training

Indoor Air Quality During Construction; S

1.3 QUALITY CONTROL

1.3.1 Installing Contractor Qualifications

Submit contractor qualifications demonstrating successful completion of similar services by the mechanical contractor on at least five projects of similar award amount and scope with equipment submittal.

1.3.2 Service Contractor Qualifications

****

NOTE: Prior to selecting a bracketed distance (or inputting a custom distance), confirm a minimum of three suppliers are within the selected radius. Consult with the installation to determine if further edits to this paragraph are required to align with sole- or limited-source Justification and Approval's (J&A's) that would further restrict the manufacturer pool.

****

The submitted equipment must be supported by manufacturer-approved service organization[s]. Provide service organization names and locations along with the Operation and Maintenance submittal. The service organization[s] must have an office within [_____][50][100] miles of the site with factory certified technicians, spare parts inventory and all necessary test and diagnostic equipment for the installed system. The service organization must be able to render service to the equipment on both a regular and emergency basis during the warranty period of the contract as determined by the Contracting Officer.

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 must 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.

1.3.3 Modification to Reference

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "must" 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.

1.3.3.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For government owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.3.3.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.3.4 Equipment Layouts

Submit Equipment Layouts showing equipment assembly and installation details with electrical, ductwork layout, supports, utility connections, and details. Include any information required to demonstrate that the system has been coordinated and functions properly as designed.

1.3.5 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 must be framed under glass or laminated plastic. After approval, these items must be posted where directed.

1.4 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.

1.5 ACCESSIBILITY

****

NOTE: The following requirement is intended to solicit the installer's and HVAC shop senior mechanical'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. Access door must be adequately sized for removal and replacement. Installation must provide both manufacturer and code required clearances.

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 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate equipment that has been in satisfactory use at least [1][_____] year[s] prior to bid opening.

2.1.2 Material and Equipment Qualifications

****

NOTE: Prior to selecting a bracketed distance (or inputting a custom distance), confirm a minimum of two suppliers are within the selected radius. Consult with the installation to determine if further edits to this paragraph are required to align with sole- or limited-source Justification and Approval's (J&A's) that would further restrict the manufacturer pool.

****

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products and materials must have a local supplier within [_____][50][100] miles of the site. Standard products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

2.1.3 Alternative Qualifications

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.

2.1.4 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and

catalog number. As applicable, affix an Energy Star label to the product.

2.1.5 Bearings

Motor bearings must be fitted with grease supply fittings and grease relief to outside of the enclosure.

2.2 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 (ASD) 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 INTERIOR DISTRIBUTION SYSTEM. Provide 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, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

2.2.1 Motors

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

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

c. 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. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered

interval between start and stop. Provide motor torque 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. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.

d. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW 10 hp or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

2.3 AIR SYSTEMS EQUIPMENT

2.3.1 Ductwork and Accessories

Ductwork and accessories must be as specified in Section 23 30 00 HVAC AIR DISTRIBUTION.

2.3.2 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans must not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly. Indirectly connected motors must use V-belt drives designed for not less than [150][140][120] percent of the connected driving capacity. Provide variable pitch motor sheaves for 11 kW 15 hp and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated.

2.3.3 Air Filters

****

NOTE: Normally, replaceable type filters must 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 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. Include below section if specification 23 30 00 HVAC AIR DISTRIBUTION is not included.
****

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

2.3.4 Replaceable Media Filters

The air flow capacity of the filter must 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) must be not less than [_____] when tested according to ASHRAE 52.2.

2.4 GAS-FIRED COMPONENTS

****
NOTE: Gas-fired and oil-fired components must be applied to Self-Contained Furnaces, Duct Furnaces and Heating and Ventilating Units.
****

2.4.1 Gas-Burning Components

Gas-burning equipment must 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 must be furnished both with high and with low gas supply pressure switches in the fuel supply piping.[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.]

2.4.2 Gas Burners

The gas burners must include ignition equipment, gas-control valve, gas piping, gas-pressure regulating valve, gas shut-off cocks,[combustion air blower,] when applicable, and accessories necessary for a fully automatic system that conforms to ANSI Z21.47/CSA 2.3 and NFPA 54.

Do not provide manually ignited type burners. Burners must 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 kW 400,000 Btu's per hour.

2.4.3 Ignition System

Ignition systems must be of the [direct spark][hot surface][or][interrupted intermittent]type with automatic electric ignition. The pilots must be of the electrically-ignited proven type. Continuous pilots will not be permitted. Burner must be designed in accordance with NFPA 54 and located so that parts are protected against overheating. Provisions

must be made in the burner housing for inspection of the pilot flame.

2.4.4 Fuel-Gas Supply System

Fuel-gas supply system must be as specified in Section 23 11 20 FACILITY GAS PIPING.

2.5 OIL-BURNING COMPONENTS

2.5.1 Oil-Burning Components

The equipment must 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 must be furnished with low oil-pressure switches in the fuel supply piping. Oil-fired units not equipped with programming controls must be equipped with a delayed opening or shutoff valve. The valve must automatically delay delivery of oil to the burner until such time as the combustion air fan and, when applicable, the induced draft fan are operated at rated speed.[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 burning furnace product.]

2.5.2 Ignition System

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

2.5.3 Fuel-Oil Systems

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

2.6 VENT CONNECTIONS

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NOTE: Induced draft fans must 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.

When using room direct intake systems, confirm requirements in UFC 3-410-01, NFPA 31, NFPA 54, and NFPA 58 have been included in the mechanical room design to ensure that positive pressure has been provided in the mechanical room to ensure proper burner performance and prevent carbon monoxide build-up.

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.

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Flue vent connections must 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, must conform to NFPA 211 and must be galvanized sheet steel having a nominal thickness not less than that required by NFPA 211. The weight of zinc-coating must not be less than 1.25 ounces per square foot commercial. If the standard flue connection on the furnace 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.]

A 9 mm 0.3125 inch diameter hole must 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 must be provided to seal the hole to prevent exhaust gases from entering the indoor space when samples are not being taken. Each exhaust stack must be provided complete with bird screen and rain hood.

2.6.1 Gas-Fired Units

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

2.6.2 Oil-Fired Units

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

2.6.3 Vents for High Efficiency Furnaces

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

2.6.3.1 Combustion Air Intake Vent

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

2.6.3.2 Exhaust Vent

The exhaust vent piping must be constructed of Schedule 40 CPVC or stainless steel in accordance with UL 1738 and the furnace manufacturer's recommendations. The exhaust vent must be suitable for the maximum anticipated furnace exhaust temperature and must withstand the corrosive effects of the condensate.

2.6.4 Automatic Vent Dampers

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

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Automatic vent dampers must be provided in the vents of all gas burning equipment that uses indoor air for combustion. Vent dampers must conform to ANSI Z21.66/CGA 6.14.

2.6.5 Condensate Neutralization Kit

Factory-supplied condensate trap[with condensate trip sensor], high capacity condensate receiver prefilled with appropriate medium.

2.7 CONTROLS

2.7.1 Thermostat

Provide wall mounted, low voltage type conforming to NEMA DC 3 with an operating range from 12 to 32 degrees C 55 to 90 degrees F. Housing must 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].[Provide clear, lockable with key thermostat cover.] The mounting plate or base must be made of thermal insulating material or must support the thermal element not less than 6 mm 1/4 inch from the wall. The control unit of the thermostat must consist of a temperature sensing element, control switch, and anticipating heater. The control switch must be a hermetically-sealed switch. Thermostat must have provisions for calibrating the unit to the accuracy specified in NEMA DC 3. The design must 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 must be provided integral to or mounted on a sub-base of the thermostat. Mercury must not be allowed in switches and thermometers.

2.7.2 Carbon Monoxide Detection

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NOTE: The designer should refer to UFC 3-600-01 FIRE PROTECTION ENGINEERING FOR FACILITIES for carbon

monoxide detection requirements
****

Provide Carbon Monoxide Detector(s) and monitoring system for all installations.

Carbon monoxide detection systems must conform to Sections 28 31 60 INTERIOR FIRE ALARM SYSTEM, NON-ADDRESSABLE, 28 31 66 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, NON-ADDRESSABLE, 28 31 70 INTERIOR FIRE ALARM SYSTEM, ADDRESSABLE, and 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE.

[2.7.3 OPTIONAL CONTROLS

On units with input capacities over 117 kW 400,000 Btu/hr, [electronic][electrical] controls may be provided for regulation of temperature and operation of power operators.

]2.7.4 Cybersecurity

Control systems must conform to Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.8 SELF CONTAINED FURNACES

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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 up to 35.1 kW 40 MBtuh up to 120 MBtuh.

Dual fuel (oil & gas) fired equipment is only available for large units (131.9 kW 450 MBtuh and larger). Factory Mutual (FM) is the governing standard for these units.

When using fuel burning appliances, ensure safety requirements in UFC 3-600-01 and IMC (as adopted by UFC 3-410-01) have been provided to monitor and alarm any carbon monoxide build up inside any spaces.
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NOTE: Aluminized steel heat exchangers will be satisfactory in most applications. Omit the aluminized steel if the project is in a Corrosion Prone Location. Refer to UFC 1-200-01 for definition of Corrosion Prone Locations.

Carefully consider the selected casing construction based on material availability and installed location (indoor, outdoor, or outdoor corrosion prone). Refer to UFC 1-200-01 for definition of Corrosion Prone Locations.
****

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 must be completely factory-assembled and must consist of a[n] [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 must be [galvanized sheet steel with factory painting as specified in paragraph FACTORY PAINTING][or][corrosion-resisting sheet steel conforming to ASTM A167, type 316][or][aluminum with factory painting as specified in paragraph FACTORY PAINTING]. Dissimilar materials must be separated by appropriate means to avoid creation of galvanic cells. Furnace casing must be factory insulated and be compatible with the operating temperatures. Furnace must 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.]

2.8.1 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 and gas) fired equipment is only available for large units(131.9 kW 450 MBtuh and larger). Factory Mutual (FM) is the governing standard for these units.

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NOTE: Use both subparagraphs if combination gas-oil burning equipment is to be specified.

When using room direct intake systems, confirm requirements in UFC 3-410-01, NFPA 54, and NFPA 58 have been included in the mechanical room design to ensure that positive pressure has been provided in the mechanical room to ensure proper burner performance and prevent carbon monoxide build-up.

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.

****

Gas-fired furnace must be the [conventional][high efficiency, condensing]type in accordance with ANSI Z21.47/CSA 2.3. Furnace design must be certified by the AMERICAN GAS ASSOCIATION LABORATORIES (AGA). Furnace must have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of [_____] percent . Furnace must be suitable for burning [natural][propane]gas ([_____] kJ per cubic meter Btu's per cubic foot), [combination [natural][propane]gas ([_____] kJ per cubic meter 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.]

2.8.2 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 and gas) fired equipment is only available for large units (131.9 kW 450 MBtuh and larger). Factory Mutual (FM) is the governing standard for these units.

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NOTE: Use both subparagraphs if combination gas-oil burning equipment is to be specified.

When using room direct intake systems, confirm requirements in UFC 3-410-01 and NFPA 31 have been included in the mechanical room design to ensure that positive pressure has been provided in the mechanical room to ensure proper burner performance and prevent carbon monoxide build-up.

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.
****

Oil-fired furnace must be in accordance with UL 727 and have a minimum certified Annual Fuel Utilization Efficiency (AFUE) of [_____] percent. Equipment must be suitable for burning [[No. 2][No. 4] oil][,][combination [natural][propane] gas ([_____] kJ per cubic meter 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.]

2.9 HUMIDIFIERS

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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 must be computed as recommended by ARI 640 assuming average building construction and single glass windows are used in calculations.
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NOTE: Steam generators for humidifiers should be located indoors to the greatest extent possible to minimize corrosion and the need to protect the steam generator from freezing conditions. Where steam generators are located outdoors, edit the specification to enhance the weather- and corrosion-resistance of the casing.
****

2.9.1 Steam Spray Type

Steam spray humidifiers must be AHRI 640 rated, ARI labeled, and must inject steam directly into the [surrounding air][or][air stream] as indicated.[Single grid humidifiers must consist of a stainless steel distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condensate traps must be field-installed.][Enclosed grid must be housed in a copper enclosure with a build-in condensate drain connection. Exposed grid must be wick wrapped.][Package type steam spray humidifiers must be equipped to trap out and to re-evaporate condensate and to supply dry steam to a single distribution grid. Grid must be steam jacketed and condensate drained. Unit must trap excess condensate to return system. Package type steam spray humidifiers must have modulating electric, electronic, or pneumatic steam control valve, as indicated.] Unit must have internal drain water tempering to 60 degrees C 140 degrees F. Steam spray humidifiers must 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 must not be used with automatic bleed where the supply water has a high mineral content greater than 4 grams per liter 0.53 ounces per gallon. Capacity must be computed as recommended by ARI 640 assuming average building construction and single glass windows are used in calculations.

****

2.9.2 Steam Diffuser Type

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

[2.9.3 Ultrasonic Type

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NOTE: Ultra sonic type humidifiers should only be use water with total dissolved solids level of less than 5 mg/L 5 ppm in order to minimize particulate matter. In general reverse osmosis or deionized water will be required

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Humidifiers must be AHRI 640 rated and ARI labeled and be of the ultrasonic type permitted herein, and of the manufacturer's standard catalog product. The ultrasonic type must introduce moisture into the air stream in the form of 1 micron water droplets. The ultrasonic unit must be installed in the ductwork. The humidifiers must consume less than 33 watts per lb/hr 100 btu per lb/hr of water introduced to the air stream. Water with a total dissolved solids level of less than 5 mg/L 5 ppm must be supplied to the humidifier. The piezoelectric transducers must be capable of a minimum of 10,000 hours of continuous operation. Provide a manual on-off switch [remotely located][or][integral with the humidifier]. Unit must have an internal solenoid valve for drain command from the internal controller and must automatically drain if the humidifier is idle for 72 hours. Humidifier must be designed for easy maintenance and must not require removing or disconnecting sheet metal duct work for ordinary cleaning and service procedure. Humidistat must be furnished by the humidifier manufacturer and must be factory calibrated in percent relative humidity.

]2.9.4 Electrode Steam Humidifier

Provide steam electrode humidifiers to generate steam from potable water. Unit must utilize an electrode steam cylinder. The cylinder must be replaceable assembly that complies with UL 499. Unit cabinet must be sheet metal enclosure with baked enamel finish and must be hinged or feature a removable access door. The cabinet must feature integral control panel. Unit must have internal drain water tempering to 60 degrees C 140 degrees F and a drain pump system complete with integral pump discharge check valve, integral float switch, reservoir, and pump motor assembly. Provide unit with supply domestic water backflow preventer.

2.9.4.1 Unit Mounted Distribution Manifold

Provide unit mounted manifold with integral fan to discharge vapor directly into occupied space.

2.9.4.2 Remote Mount Blower Pack

Provide remote mount blower pack with integral fan to discharge vapor directly into occupied space. Steam must be constructed of 316 stainless steel. The steam line must have a constant slope (minimum upslope of 10 degrees or minimum downslope of 2 degrees), and have no restrictions in the line.

2.9.5 Gas Fired Steam Humidifier

Provide natural gas-fired humidifier to generate steam from potable water. Unit cabinet must be sheet metal enclosure with baked enamel finish and must be hinged or feature a removable access door. Insulated humidifier tank must ensure safe surface temperature. The cabinet must feature integral control panel. Unit must feature at Category IV sealed combustion condensing appliance featuring a stainless steel combustion chamber/heat exchanger. The burner must be capable of no less than 5:1 modulation with an overall efficiency of 90 percent. Humidifier is to feature variable speed blower, modulating gas valve, precision water fill and is to have internal safeties. Unit must have internal drain water tempering to 60 degrees C 140 degrees F[and a drain pump system complete with integral pump discharge check valve, integral float switch, reservoir, and pump motor assembly]. Provide unit with supply domestic water backflow preventer.

2.9.5.1 Duct Mounted Manifold

Provide remote duct mounted stainless steel humidifier manifold. Distributor must be sized to have a maximum absorption length of ten feet. Provide type 316 stainless steel tubing and fittings for steam and steam condensate in accordance ASTM A269/A269M. Pipe must be suitable for 150 percent of humidifier steam pressure and temperature. Pipe insulation must be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Installation of steam and steam condensate between humidifier and manifold in accordance with manufacturer's requirements. Unit installation and venting must comply with NFPA 54. Intake air and flue vent must be per paragraph VENT CONNECTIONS and must be stainless steel. Intake and flue must be installed per humidifier manufacturers recommendations.

2.9.6 Operation

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

2.10 DUCT FURNACE

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NOTE: Aluminized steel heat exchangers will be satisfactory in most applications. Omit the aluminized steel if the project is in a Corrosion Prone Location. Refer to UFC 1-200-01 for

definition of Corrosion Prone Locations.
****

Duct furnace must be in accordance with ANSI Z83.8/CSA 2.6. Furnace must be [power][gravity]-vented type. Furnace must have automatic ignition. Furnace must employ metered combustion air with enclosed draft diverter (no open flue collar). Furnace heat exchangers must be [aluminized steel][or][stainless steel]. Furnace must have minimum steady state thermal efficiency of 80 percent at maximum rated capacity and 75 percent at minimum rated capacity that is provided and allowed by the controls. Furnace must be provided with a [space][discharge air] thermostat which controls the unit's burner.

2.11 [HEATING AND VENTILATING UNITS][HEATING ONLY MAKEUP AIR UNITS]

Units must be equipped for and adjusted to burn [natural][liquified petroleum][dual fuel natural/liquified petroleum] gas. Each heater must be provided with a gas pressure regulator that will satisfactorily limit the main gas burner supply pressure. Heaters must have an intermittent or interrupted electrically ignited pilot or a direct electric ignition system. Safety controls must conform to the ANSI standard specified for each heater. Mounting brackets and hardware must be furnished by the heater manufacturer and must be factory finished to match the supported equipment.

****
NOTE: Select paragraph below for Heating and Ventilation Unit or Heating Only Makeup Air Unit with heating coil. Coordinate with paragraph Coils.
****

[Provide [single-zone draw-through type][or][single-zone blow-through type][or]units as indicated. Units must include fan(s), coils, airtight insulated casing,[prefilters,][secondary filter sections,][and][diffuser sections where indicated,][air blender,][adjustable V-belt drives, belt guards for externally mounted motors,][directly driven motors,] access sections where indicated,[mixing box,][combination sectional filter-mixing box,][[pan][drysteam][spray type] humidifier,] vibration-isolators, and appurtenances required for specified operation . Provide vibration isolators as indicated. Physical dimensions of each air handling unit must be suitable to fit space allotted to the unit with the capacity indicated. Provide unit that is rated in accordance with AHRI 430.

]2.11.1 [Direct Fired Heating and Ventilating Units][Heating Only Makeup Air Units]

Units must be in accordance with ANSI Z83.4/CSA 3.7. Direct fired [heating and ventilating units][heating only makeup air units] use outdoor air[and return air] directly ducted to the heater. The products of combustion generated by the heater are released into the air stream being heated. Heaters must be equipped with[motorized [inlet][, return][and][outlet]][backdraft] dampers,[discharge air diffuser,][duct collar,][air filters,][mixing box][and][bird screen]. Gas control valve must be [single-stage][two stage][modulating] type. Maximum air temperature rise during minimum burner fire must be 2 degrees C 5 degrees F. Fan must be [single-speed][two speed, with low speed approximately two-thirds of high speed][variable speed]. Motorized [inlet][and][outlet] dampers must be closed when the unit is shut down. Dampers must be interlocked to prevent burner operation when dampers are closed. Heaters must be provided with a

[space][discharge air] thermostat, a low limit air stream thermostat, and an ambient air thermostat. The [space][discharge air] thermostat must control the gas control valve. The low limit air stream thermostat must shut down the entire unit if the discharge air temperature drops below the [space][discharge] thermostat setting. The ambient air thermostat must shut down the burner if the outdoor air exceeds the [discharge][space] thermostat setting.

2.11.2 Indirect Fired [Heating and Ventilating Units][Heating Only Makeup Air Units]

Units must be in accordance with ANSI and CSA Standards. Indirect fired [heating and ventilating units][heating only makeup air units] use heat exchanger to isolate products of combustion generated by the heaters from the air stream being heated. Heaters must be equipped with[motorized [inlet,] [return,][and][outlet]] [backdraft] dampers,[discharge air diffuser,][duct collar,][air filters,][mixing box,][and][bird screen]. Gas control valve must be [single-stage][two stage][modulating] type. Maximum air temperature rise during minimum burner fire must be 2 degrees C 5 degrees F. Fan must be [single-speed][two speed, with low speed approximately two-thirds of high speed][variable speed]. Motorized [inlet][and][outlet] dampers must be closed when the unit is shut down. Dampers must be interlocked to prevent burner operation when dampers are closed. Heaters must be provided with a [space][discharge air] thermostat, a low limit air stream thermostat, and an ambient air thermostat. The [space][discharge air] thermostat must control the gas control valve. The low limit air stream thermostat must shut down the entire unit if the discharge air temperature drops below the [space][discharge] thermostat setting. The ambient air thermostat must shut down the burner if the outdoor air exceeds the [discharge][space] thermostat setting.

2.11.3 Coils

****

NOTE: Research local conditions to determine the effect of corrosive atmosphere on dissimilar metals. Where coils are to be installed in corrosion-prone locations, as defined in UFC 1-200-01, and locations with air-pollution or water quality causing corrosion issues, choose coated coils and fins listed in a, b, and c, and materials and thickness providing the best life-cycle-cost for the best corrosion resistance in these locations.

For existing installations within ESC C3, C4, and C5 locations, where installation space is limited and coatings cannot be used, choose the more robust material items d or e. Coatings tend to require more space as the coating limits the maximum face velocities across the coils which plausibly results in a larger unit size. In other locations, specify coil and fin combinations based on past experience with the suitability of these materials in dealing with the local conditions.

a. Copper coil and aluminum fins, coated.
b. Copper coil and copper fins, coated.
c. Aluminum coil and aluminum fins, coated.

d. Aluminum coil and aluminum fins, uncoated.
e. Copper coil and copper fins, uncoated.

Provide either phenolic, vinyl or epoxy/electrodeposition coating. For coils with relatively close fin spacing, the phenolic or epoxy/electrodeposition coating is preferred, as these have less tendency to bridge across the fins than vinyl, better thermal conductivity than vinyl and in many conditions weathers better than vinyl.
****

Provide fin-and-tube type coils constructed of seamless [copper][red brass] tubes and [aluminum][or][copper] fins mechanically bonded or soldered to the tubes.[Provide copper tube wall thickness that is a minimum of [0.406][0.508][0.6096] mm [0.016][0.020][0.024] inches.][Provide red brass tube wall thickness that is a minimum of [0.89][1.24] mm [0.035] [0.049] inches.][Provide aluminum fins that are [0.14][0.19] mm [0.0055][0.0075] inch minimum thickness.][Provide copper fins that are 0.114 mm 0.0045 inch minimum thickness.] Provide casing and tube support sheets that are not lighter than 1.6 mm 16 gauge galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI 410.[Provide factory applied phenolic, vinyl, or epoxy/electrodeposition coating uniformly applied to all coil surfaces without material bridging between fins. Provide complete coil encapsulation and a uniform dry film thickness of 0.8 - 1.2 mils on all surface areas including fin edges. Coating must have a corrosion durability through testing of no less than 5000 hours salt spray per ASTM B117.]

2.11.3.1 Water Coils

Install water coils with a pitch of not less than 10 mm/m 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans. Pressure test coils in accordance with UL 1995.

2.11.3.2 Steam Heating Coils

Construct steam coils from cast semisteel, welded steel or copper headers, and [red brass][copper] tubes. Construct headers from cast iron, welded steel or copper. Provide fin tube and header section that float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide each coil with a field or factory installed vacuum breaker. Provide single-tube type coils with tubes not less than 13 mm 1/2 inch outside diameter, except for steam preheat coils. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure test coils in accordance with UL 1995.

2.11.3.3 Electric Heating Coil

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NOTE: Use this paragraph for Navy projects only.

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

2.11.4 Unit Casing

****

NOTE: Carefully consider the selected casing construction based on material availability and installed location (indoor, outdoor, or outdoor corrosion prone). Refer to UFC 1-200-01 for definition of Corrosion Prone Locations.

****

Casing must be insulated [single][double] wall panels constructed of minimum 18-gage [galvanized sheet steel with factory painting as specified in paragraph FACTORY PAINTING][or][corrosion-resisting sheet steel conforming to ASTM A167, type 316][or][aluminum with factory painting as specified in paragraph FACTORY PAINTING]. Reinforce casing with [angles][a formed structural metal frame] and provided with easily removable panels located for access to all parts of the equipment. Ensure that the casing and insulation are designed to limit noise and vibration within acceptable levels. Outdoor heaters must be weatherized. Dissimilar materials must be separated by appropriate means to avoid creation of galvanic cells.

2.11.5 Fans

Fan must be [centrifugal][airfoil][backward curve][mixed flow][plenum] type. Statically and dynamically balance fan and motor. Fan ratings are to be determined in accordance with AMCA 210. Motor must be heavy-duty, permanently lubricated type with [belt-drive][direct-drive]. Provide fan assembly with internal vibration isolation.

2.12 FACTORY PAINTING

Equipment painting must be factory or shop applied, and must be as specified herein, and provided under each individual section.

2.12.1 Factory Painting of Indoor Equipment

Indoor Equipment must be coated with a manufacturer's factory-applied finish that meets the following requirements:

a. The finish system designed for the equipment must 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. The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the successful test specimens.

b. If manufacturer's standard factory painting system is being proposed

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

****

NOTE: Select the first set of brackets for outdoor equipment in locations that do not meet the definition of Corrosion Prone Locations as defined in UFC 1-200-01. Select the second set of brackets for outdoor equipment in Corrosion Prone Locations as defined in UFC 1-200-01. When using the Corrosion Prone Location paragraph also edit Section 09 90 00 PAINTS AND COATINGS, Part 3, "MPI Division 5: Exterior Metal, Ferrous And Non-Ferrous Paint Table" to include Division 23 and include the appropriate metallic surfaces included in this specification (galvanized steel or aluminum).

****

[2.12.2 Factory Painting of Outdoor Equipment

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

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

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

][2.12.3 Factory Painting of Exterior Equipment in Corrosion Prone Locations

a. Galvanized Steel: Provide three-part coating system Epoxy Primer / Waterborne Light Industrial Coating as specified in Section 09 90 00 PAINTS AND COATINGS.

b. Type 316 or Duplex Stainless Steel: No requirement for factory painting.

c. Aluminum: Provide either coating or anodized finish that meets the following requirements:

(1) Coating Provide three-part coating system Waterborne Light Industrial Coating as specified in Section 09 90 00 PAINTS AND COATINGS.

(2) Anodized finish: Clean exposed aluminum surfaces and provide an anodized finish conforming to AA DAF45 and AAMA 611. Finish must be Architectural Class I (0.0175 mm 0.7 mil or thicker), designation AA-M10-C22-[A41, clear (natural)][A42, integral color][A44, electrolytically deposited color] anodized.

]2.12.4 Shop Applied Painting of Equipment

Shop applied painting must meet same requirements as factory painting. Field retouch only if approved by the Contracting Officer. Otherwise, return equipment to the factory for refinishing.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

****
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 must 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].

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

a. Self-contained furnaces - Installation Instructions

[b. Vent connections - Installation Instructions

][c. Controls - Installation Instructions

][d. Dampers - Installation Instructions

][e. Air filters - Installation Instructions

][f. Humidifiers - Installation Instructions

][g. Duct Furnace - Installation Instructions

][h. Heating and Ventilating Units - Installation Instructions

][i. Heating Only Makeup Air Units - Installation Instructions

][3.2.1 Seismic

****
NOTE: Select first bracket for Navy projects. Select second bracket for all others and coordinate

any other required references with Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC.
****

[Provide vibration isolation, seismic bracing and sound data as specified in Sections 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL and 23 05 48.19 [SEISMIC] BRACING FOR HVAC.][Provide seismic bracing as specified in Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC.]

][3.2.2 Anti-Terrorism

****
NOTE: Review UFC 4-010-01 DoD Minimum Antiterrorism Standards For Buildings and revise requirements and use to edit section below.
****

Provide outdoor air intakes, relief air, and exhaust openings with low leakage dampers that are automatically closed when the emergency air distribution shutoff switch is activated. Exterior wall penetrations for outdoor air intakes must be a minimum of 3 meters 10 feet above grade. Emergency air distribution shutoff switches must clearly labeled and located in an accessible location. Switch must be mushroom type pushbutton with plastic clear cover.[If shutting down an exhaust system will violate building or fire codes or create an unsafe condition, then the exhaust system may continue to operate.]

Mount all overhead utilities and other fixtures weighing 14 kilograms 31 pounds or more (excluding distributed systems such as piping networks that collectively exceed that weight) using either rigid or flexible systems to minimize the likelihood that they will fall and injure building occupants. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any horizontal direction and 1.5 times the equipment weight in the downward direction. Requirement must does not preclude the need to design equipment mountings for forces required by other criteria such as seismic standards.

]3.2.3 Furnaces

Foundations, settings, or suspensions for mounting equipment and accessories including supports, vibration isolators, stands, guides, anchors, clamps, and brackets must be provided. Foundations and suspension for equipment must conform to the recommendations of the manufacturer, unless otherwise indicated on drawings. Anchor bolts and sleeves must be set accurately using properly constructed templates. Anchor bolts, when embedded in concrete, must be provided with welded-on plates on the head end and guarded against damage until equipment is installed. Equipment bases must be leveled, using jacks or steel wedges, and when resting on concrete must be neatly grouted-in with a non-shrinking type of grout. Equipment must 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 must be provided between dissimilar metals for the purpose of minimizing galvanic corrosion. The interior of cabinets or casings must be cleaned before completion of installation. The furnace must be connected to the vent or chimney with the specified connectors, draft regulators, draft loads, and induced draft fans, as applicable, in accordance with NFPA 211.

3.2.4 Automatic Vent Dampers

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

3.2.5 Humidifiers

Humidifiers must 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 must be provided for humidifiers and must be piped to drains shown. Humidifiers installed in a bypass arrangement must 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 must 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 must be adequately reinforced to support the humidifier.[For reservoir or re-circulating type humidifier, the automatic bleed must be connected to the humidifier drain.]

3.2.6 Access Panels

Access panels must be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels must be of sufficient size and so located that the concealed items may be serviced and maintained or completely removed for replacement. Access panels must be as specified in[Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].

3.2.7 Flexible Connectors

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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 must 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, must be of the type recommended by the connector or duct manufacturer and must be provided at the intervals recommended.

3.2.8 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation must be packed as specified in Section 07 84 00 FIRESTOPPING

for fire rated penetrations. For non-fire rated penetrations, the space must be packed as specified in Section 07 92 00 JOINT SEALANTS.

3.2.9 Ductwork

Ductwork and accessories must be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.2.10 Air Filters

Air filters must be installed[in heater casings][in return air ducts at furnaces][in return air grilles]. Fans or blowers must not be operated until filters are installed. After completion of tests and before the building is accepted by the Government, the Contractor must[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].

3.2.11 Dust Control

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

3.2.12 Insulation

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

3.2.13 Duct Test Holes

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NOTE: The location of duct test holes will be shown on the drawings. Locate holes so as to implement the requirements of Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.
****

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

3.2.14 Condensate Collection and Disposal

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NOTE: Coordinate collection system arrangement and condensate disposal method with installation mechanical and installation environmental.
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For high efficient, condensing type units provide condensate collection

system consisting of p-traps, acid neutralizers,[condensate pump,] and corrosion resistant piping. Provide drains for heating unit and exhaust vents. All condensate must be captured and appropriately treated prior to entering sanitary system or discharging to outdoors. Install system in accordance manufacturer's installation instructions, ICC IMC and ICC IPC requirements. Provide piping as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Provide [dedicated collection system per heating unit][combined collection system serving multiple heating units].

3.2.15 Fuel-Oil System

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

3.2.16 Fuel-Gas Supply System

Fuel-gas supply system must be installed in accordance with Section 23 11 20 FACILITY GAS PIPING.

3.3 FIELD PAINTING

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

3.4 CLEANING

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

3.5 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.

3.6 TESTS

Upon completion and prior to acceptance of the installation, furnish all

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

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

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

c. System diagrams that show the layout of equipment and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system must be framed under glass or laminated plastic. After approval, these items must be posted where directed.

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

3.7 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 must 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.

]3.7.1 Firing Tests

a. 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 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.

b. Record temperature rises across heat exchangers.

c. Minimum requirements for satisfactory combustion efficiency must 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 must be 38 degrees C 100 degrees F above the flue-gas dew points.] The observed smoke at all firing rates during the prescribed tests must 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.

[3.7.2 Operating Test

Perform the following operating tests to demonstrate satisfactory [furnace][and][humidifier] operation. Check burner safety controls by simulating flame failure in accordance with the manufacturer's instructions. Operate furnace 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][,][circulating blower motor][,][induced draft fan motor][,][and][humidifier motor].

]3.7.3 Performance Tests

After testing, adjusting, and balancing has been completed as specified, each system must 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 must be conducted by an experienced engineer. Tests must cover a period of not less than [_____] days for each system and must demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings must be made at points indicated on the drawings for the duration of the time period and must record the temperature at space thermostats or space sensors,[the humidity at the humidistat(s) location(s),] and the outdoor air temperature[and humidity] in an immediately adjacent shaded and weather protected outdoor area.

3.8 FIELD ACCEPTANCE PROCEDURES

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

****

3.8.1 Field Acceptance Test Plans and Test Reports

a. Manufacturer's Test Plans: Within [120] [_____] calendar days after contract award, submit the Field Acceptance Test Plan. Field acceptance test plans must 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 must 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 must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must 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 must 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 must 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 must furnish with each test procedure a description of acceptable results that have been verified.

f. Job specific: Each test plan must be job specific and must 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 must include procedures for field testing and field adjusting specialized components, such temperature control valves, or pressure control valves.

3.8.2 Field Acceptance Testing

a. Equipment Requiring Test Reports: Each self-contained furnace must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting 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 must 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 must be reviewed, approved, and signed by the Contractor's test director and the QC manager. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.

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

3.9 FIELD TRAINING

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

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Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of [_____] hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals, manufacturer’s troubleshooting and repair manuals, as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals, manufacturer's troubleshooting and repair manuals, and at least 14 days prior to conducting the training course.

3.10 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 must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work. Instruction must 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. 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.

-- End of Section --