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SUPERSEDING
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MILITARY SPECIFICATION

FURNACES, VACUUM, HEAT TREATING AND BRAZING

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers horizontal and vertical type, vacuum, heat-treating and brazing furnaces of the electrically heated, fully automatic cycle, cold wall design.

1.2 Classification. The furnaces shall be of the following types and classes. The type and class furnished shall be as specified (see 6.2.1).

Type I - Horizontal, end loading (see 3.1.1).

Type II - Vertical, top loading (see 3.1.2).

Type III - Vertical, bottom loading, elevator hearth (see 3.1.3).

Class 1 - 1200 - 2200 degrees F operating temperature range.
Class 2 - 1400 - 2400 degrees F operating temperature range.
Class 3 - 1800 - 3000 degrees F operating temperature range.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Defense Industrial Plant Equipment Center, ATTN: DIPEC-SSM, Memphis, Tennessee 38114-5051, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 3424

2. APPLICABLE DOCUMENTS.

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issue of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATION

MILITARY

MIL-F-3296 - Forges, Furnaces, and Ovens (Exclusive of Space Heating and Cooking): Packaging of.

STANDARDS

FEDERAL

FED-STD-H28 - Screw Thread Standards for Federal Services.

FED-STD-376 - Preferred Metric Units for General Use by the Federal Government.

2.1.2 Other Government documents and publications. The following other Government documents and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

U. S. DEPARTMENT OF LABOR

29 CFR 1910 - Occupational Safety and Health Standards (OSHA)

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402-0001.)

(Copies of specifications, standards, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the

issue of the documents which are DoD-adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issue of documents not listed in the DoDISS shall be the issue of the non- Government documents which are current on the date of the solicitation.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/ASME - Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels, Division 1 and Division 2.

ANSI/NEMA MG 1 - Motors and Generators.

ANSI/NEMA ICS 1 - Industrial Control and Systems.

ANSI/NFPA 86D - Industrial Furnaces, Vacuum, Atmosphere.

(Application for copies should be addressed to the American National Standards Institute, ATTN: Sales Dept., 1430 Broadway, New York, NY 10018-3351.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 3951 - Standard Practice for Commercial Packaging.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

(Non-Government standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specification, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Design. The furnace and equipment shall be new and one of the manufacturer's current models. The furnaces shall be electrically heated and of the vacuum type with a water cooled shell. The heating elements shall be located in the vacuum chamber surrounding the work space. Design of the furnace and

equipment shall provide for programming any desired vacuum pressure, heating rate, and cooling modes within the capability of the systems specified. The vacuum cycle shall provide for the pumping system to evacuate the furnace chamber to a preselected vacuum pressure before the heating cycle starts. The heating cycle shall provide for controlled power input and preheat soak periods. The cooling cycle shall provide a selection of vacuum cooling, partial vacuum, or partial pressure of inert gas cooling. Each furnace shall be furnished complete with the necessary vacuum systems, piping, motors, fans, instruments, and control equipment so that when installed and connected to the supply sources, and operation of the system is initiated, the furnace shall operate automatically through the programmed sequence.

3.1.1 Type I. The type I furnace shall be of the horizontal design having a heating chamber with a hearth to support the charge and a single opening located in the end of the furnace for inserting and removing the charge in a horizontal plane.

3.1.2 Type II. The type II furnace shall be of the vertical top loading design with a cylindrical heating chamber. The furnace shall be designed with the opening located in the top of the furnace for inserting and removing the charge in a vertical plane.

3.1.3 Type III. The type III furnace shall be of the vertical bottom loading design with a cylindrical heating chamber. The furnace shall be elevated above the floor and supported on legs with the opening located in the bottom of the chamber. The hearth and bottom of the furnace shall form an elevator for loading at floor level and shall be raised to the chamber by a powered lift mechanism.

3.1.4 Measurement systems. Unless otherwise specified, either the U.S. Customary System of Units (US) or the International System of Units (SI) shall be used in the design and construction of the furnace. When only one system of measurements is acceptable, the particular system required shall be as specified (see 6.2.1). In this specification, all measurements, dimensions, sizes, and capacities are given in US units. These measurements may be converted to SI units through the use of the conversion factors and methods specified in FED-STD-376.

3.1.5 Safety and health requirements. The furnace shall be provided with safety features and devices for the protection of personnel, with a fail-safe vacuum valve that will automatically close in case of power failure. A mushroom head, manually operated, panic button shall be provided that will close the vacuum valve and turn off the heat source. Each furnace shall be provided with an automatic resetting switch to shut off the furnace heat if the furnace vacuum

pressure exceeds a preset limit. The system shall be provided with low water pressure interlocks, and pressure relief valves in the water jacket system to by-pass water if pressure exceeds a preset limit. The safety system of the furnace shall conform to NFPA Standard 86D and with the standards promulgated under OSHA 29 CFR 1910 applicable to the furnace itself.

3.1.6 Material. All material used in the fabrication of the furnace and related equipment shall be new and of the quality necessary to produce a furnace to meet the requirements described herein. Materials that are exposed to internal environment of the furnace chamber shall be compatible with the type of atmosphere, vacuum pressure, and temperature conditions for which the furnace is designed. Materials containing chromium shall not be used in areas where temperature exceeds 1800 degrees F. All metals in the heating chamber shall be compatible with each other.

3.1.6.1 Reclaimed material. The furnace may contain reclaimed materials provided such materials will not jeopardize the furnace's intended use and performance. The reclaimed materials shall have been reprocessed, remanufactured, or recycled in a manner which will restore them to the same chemical composition and physical properties as the materials originally selected for use on the machine.

3.1.7 Mercury restriction. The furnace shall not contain mercury or mercury compounds nor be exposed to free mercury during manufacture.

3.1.8 Asbestos restriction. Asbestos and materials containing asbestos shall not be used on or in the furnace.

3.1.9 Environmental protection. The furnace shall be so designed and constructed that, under the operating, service, transportation, and storage conditions described herein, the furnace shall not emit materials hazardous to the ecological system as prescribed by Federal, state, or local statutes in effect at point of installation.

3.1.10 Lubrication. Means shall be provided to ensure adequate lubrication for all moving parts. Recirculating lubrication systems shall include a filter which is cleanable or replaceable. Each lubricant reservoir shall have means for determining fluid level. All oil holes, grease fittings, and filler caps shall be accessible.

3.1.11 Accessibility. All parts subject to wear, breakage, or distortion and all parts which require periodic maintenance shall be accessible for adjustment and replacement, as applicable.

3.1.12 Interchangeability. To provide for replacement of worn parts, all parts shall be manufactured to definite dimensions and tolerances that will permit installation of replacement parts without modification of the part or furnace.

3.2 Construction. The furnace shall be constructed of parts which are new, without defects, and free of repairs. The structure shall be capable of withstanding all forces encountered during operation of the furnace to its maximum rating and capacity without permanent distortion.

3.2.1 Castings and forgings. All castings and forgings shall be free of defects such as scale and mismatching. Processes such as welding, peening, plugging, or filling with solders or pastes shall not be used on castings or forgings to reclaim any defective components for use on the furnace. Such processes may be used only for enhancing surface finish and appearance.

3.2.2 Welding, brazing or soldering. Welding, brazing, or soldering shall be employed only where specified in the original design. None of these processes shall be employed as a repair measure for any defective part.

3.2.3 Fastening devices. All screws, pins, bolts, and other fasteners shall be installed in a manner to prevent change of tightness. Fastening device subject to removal or adjustment shall not be swagged, peened, staked, or otherwise permanently installed.

3.2.4 Surfaces. All surfaces shall be clean and free of sand, dirt, fins, sprues, flash, scale, flux, and other harmful or extraneous materials. All edges shall be either rounded or beveled unless sharpness is required to perform a necessary function. Except as otherwise specified herein, the condition and finish of all surfaces shall be in accordance with the manufacturer's commercial practice.

3.2.5 Painting. All surfaces to be painted shall be cleaned of all foreign matter. Unless otherwise specified (see 6.2.1), the furnace shall be painted in accordance with manufacturer's standard commercial practice which shall be not less than one coat of primer and one coat of finish color.

3.2.6 Threads. All threaded parts used on the machine and its related attachments and accessories shall conform to FED-STD-H28 and the applicable "Detailed Standard" section referenced therein.

3.2.7 Dials. Dial diameters shall be such that graduations may be read from the normal operating position. Dials shall be permanently and legibly engraved or etched on a nonglare background.

3.2.8 Plates. All words on instruction and indicating plates shall be in the English language. Characters shall be engraved, etched, embossed or stamped in boldface on a contrasting background.

3.3 Electrical equipment. The furnace shall be furnished complete with electrical motors, contractors, controls, relays, transformers, signal lights, and switches prewired where possible for operation upon connection to source of power. Except as otherwise specified herein, all electrical equipment and wiring shall be in accordance with NEMA ICS 1.

3.3.1 Power supply. Unless otherwise specified (see 6.2.1), furnaces with a power input in excess of 30 KW shall operate from a single service 460-volt, 60-hertz (Hz), 3-phase primary power supply and furnaces with power input of 30 KW and less shall operate from a single service 230-volt, 60-Hz, 3-phase primary power supply. All power actuated, manually adjusted, and automatic controls shall operate on 115-volt, 60-Hz power supply.

3.3.2 Motors. Single speed motors rated in excess of 1/3 horsepower shall be of the dual voltage, 230/460-volt, 3-phase, 60-Hz type. All motors (except special vacuum sealed motors) shall conform to NEMA MG-1.

3.3.3 Electrical connections. Electrical connections of conductors and terminal parts shall be of the pressure or solder type. When soldered connections are used, the conductors and terminal parts shall be mechanically secured before soldering. Flux for soldering shall be of a rosin base.

3.4 Size. The size of the furnace shall be as specified (see 6.2.1). The size shall be determined in accordance with 3.4.1, 3.4.2, and 3.4.3 for the type furnace required. The dimensions specified shall be the minimum inside effective working area of the heating chamber in which temperature uniformity, vacuum pressure, and performance requirements specified herein shall be maintained. The chamber shall be capable of accommodating a charge equal in size to not less than the effective working area specified.

3.4.1 Type I. Horizontal loading furnace chamber sizes shall start from a size not less than 6 inches wide by 12 inches long by 6 inches high. Size changes shall increase in increments of 6 inches in any dimension, as required.

3.4.2 Type II. Vertical, top loading furnace chamber sizes shall start from a size not less than 6 inches in diameter by 12 inches deep. Size changes shall increase in increments of 6 inches in any dimension, as required.

3.4.3 Type III. Vertical, bottom loading furnace chamber sizes shall start from a size not less than 18 inches in diameter by 18 inches high. Size changes shall increase in increments of 6 inches in any dimension, as required.

3.5 Performance. Each furnace shall be capable of continuous operation with maximum loads at all vacuum pressures and operating temperatures specified for the furnace. Each furnace shall perform all vacuum pressure cycles, heating cycles, and cooling cycles within the capability of the program controls and instruments specified for the furnace.

3.5.1 Load capacity. The maximum load for the type I furnace shall be not less than 100 lbs/square foot of effective chamber working area at a temperature of 2000 degrees F. The maximum load for the type II and type III furnace shall be based on lbs/cubic foot of effective work chamber volume, at a temperature of 2000 degrees F, and shall be not less than 100 lbs/cubic foot for furnaces with chamber volumes up to 20 cubic feet, not less than 80 lbs/cubic foot for chambers from 20 to 40 cubic feet, and not less than 60 lbs/cubic foot for chambers with volumes above 40 cubic feet. The maximum load specified for each furnace may decrease up to 5 percent for each 200 degrees F rise in temperature above 2000 degrees F, with the overall decrease not to exceed 25 percent. Each furnace shall be capable of heating the maximum load specified for the type and size furnace from a temperature of 75 degrees F to an indicated control temperature of 2000 degrees F, in a time of 1 hour or less.

3.5.2 Temperature uniformity. With the furnace charged and temperature and pressure stabilized, the temperature variation from instrument control point in the chamber to any other point within the effective chamber working area shall not vary more than ±10 degrees F. Each furnace shall be capable of maintaining the temperature uniformity specified with any size charge up to maximum load at any desired temperature within its operating range and chamber vacuum pressure within the control range of the systems.

3.5.3 Vacuum systems.

3.5.3.1 Operating pressure. Unless otherwise specified, the operating vacuum pressure of each furnace shall be not more than 10 microns Hg. When specified (see 6.2.1), the operating vacuum pressure of each furnace shall be not more than 0.1 microns.

3.5.3.2 Pumping capacity. Empty, dry, and out-gassed furnaces with work chamber volumes up to 20 cubic feet shall attain the specified operating pressure in not more than 20 minutes. Furnaces with work chamber volumes larger than 20

cubic feet shall attain the specified operating pressure in not more than 30 minutes. The vacuum chamber pressure shall be constant with ±5 percent of operating pressure. Chamber leakage rate shall not exceed 5 microns Hg per hour within the furnace chamber blanked off at a pressure of 10 microns.

3.6 Components and systems.

3.6.1 Shell. The furnace shell shall be of double wall construction, cylindrical in shape, and designed for full water jacket cooling. The water jacket or space between the inner and outer shell may be divided into a suitable number of cooling zones with the necessary baffles to provide a uniform surface chamber temperature. The furnace chamber, end, and door shall be designed and fabricated in accordance with Section VIII, Division 1 of ASME Boiler and Pressure Vessel Code. Unless otherwise specified (see 6.2.1), formal ASME approval and certification shall not be required. The inner shell and all structural material exposed to the vacuum environment shall be constructed of material that will not oxidize, or constructed of materials that have been plated or coated to prevent oxidation under all furnace operating temperatures, atmosphere, and vacuum pressures specified herein.

3.6.2 Door, cover, and elevator.

3.6.2.1 Type I and type II. Unless otherwise specified (see 6.2.1), the door for the type I furnace shall be hinged on the left side of the shell and shall open from right to left when facing the opening. Covers for the type II furnace shall slide or swing horizontally. Each door or cover shall be provided with a glass viewing port. When specified (see 6.2.1), the door or cover shall be power operated and have powered door clamps, either pneumatic or hydraulic as specified.

3.6.2.2 Type III. The elevator and work load of the type III furnace shall be raised and lowered by screw jacks, synchronized to a single electric motor drive system or similar positive drive electric motor driven mechanism. The lifting mechanism shall be provided with a safety system to prevent overtravel in the upper position and the necessary safety locks to assure security of the cover in the sealing position. With the elevator in the lower, or normal loading position, the dimension from the top of the hearth to the lowest point of the chamber housing shall be not less than the height dimension specified for the size furnace. The elevating speed shall be not less than 12 inches per minute. When required, the elevator shall be designed to disconnect from the lifting mechanism at the floor level to form a transfer car with wheels and a track system. The elevator shall be self-aligned to the rails when lowering to the track and self-guided on the track. Number of extra transfer cars required, track length, and arrangement shall be as specified (see 6.2.1).

3.6.3 Water cooling system. The water cooling system shall be capable of maintaining the surface temperature of the furnace shell, end and door at a temperature of no more than 40 degrees F above ambient, when operating from a utility water supply. The cooling system shall be provided with the necessary controls to maintain the specified surface temperature and control condensation in the furnace chamber and vacuum systems under all operating conditions. When specified (see 6.2.1), the water cooling system shall have a mechanical freon-type refrigeration system, or a cooling tower type cooling system as specified. If either of these systems are required, the system shall have adequate provisions for cooling the water and recirculating the cooled water to the furnace and all accessory equipment. These systems, when required, shall be capable of maintaining the same surface temperature as specified for the furnace when operating from a utility water supply.

3.6.4 Chamber. The work area shall be surrounded with either a series of radiation heat shields or radiation heat shield(s) backed up with thermal or graphite insulation. When specified (see 6.2.1), radiation heat shield(s) only shall be used, with no insulating material used that will contaminate the heating chamber environment. The number of heat shields or the thickness of the insulation and design of the heat shields shall be sufficient to minimize heat loss and assure the temperature uniformity specified for the furnace. Class 1, class 2, and class 3 furnaces shall be provided with either graphite-or molybdenume-type heating elements. The class 4 furnace shall be provided with either graphite- or tungsten-type elements. Element terminal connections of each furnace shall be water cooled. The hearth or work supports shall be constructed of molybdenum or graphite material with ceramic inserts. The hearth shall be capable of supporting maximum loads without sagging or warping at all temperatures within the range of the furnace. When required, type I furnace chambers shall be provided with either an overhead monorail system, chamber shelves, or a manually operated, hydraulic forklift device, as specified (see 6.2.1).

3.6.5 Gas cooling system. Each furnace shall provide for back filling the heating chamber with an inert gas. The cooling system shall consist of the necessary blowers, fans or gas injection nozzle system and control valves to distribute and circulate argon or other specified gas through the work chamber for uniform cooling of the workload. Fan or blower motors and drive assemblies, if used, shall have water cooled vacuum sealed enclosures. With the furnace operating with a maximum load at a temperature of 2000 degrees F for not less than 30 minutes, the cooling system shall be capable of cooling the load from the 2000 degrees F to 300 degrees F in not more than 60 minutes, using argon gas. The system shall provide for optional vacuum cooling, partial pressure from 10 microns Hg to 1000 microns Hg gas cooling (1.0 microns to 1000 microns for furnaces operating with a chamber pressure from 0.1 microns Hg) or gas cooling

from a pressure of 380 mm Hg to 760 mm Hg. If fans are used, fan operation shall be optional. The system shall operate automatically through program controls and switches to provide controlled cooling rates with either mode selected. When specified, a heat exchanger shall be provided to recirculate the cooling gas and expedite the cooling of the workload, and the cooling rate of the workload shall be as specified (see 6.2.1).

3.6.6 Vacuum system. Each furnace shall be provided with an automatically operated vacuum system. The system shall consist of the necessary pumps, manifolds, valves, traps, controls, gauges and piping to provide a constant operating vacuum pressure specified for furnace chamber. The system shall have a pneumatically actuated high vacuum valve that will automatically close in case of power failure. When specified (see 6.2.1), the system shall be provided with dust traps or filters to prevent dust and particles from entering the systems mechanical pump.

3.6.6.1 Diffusion pump. Furnaces required to operate with a heating chamber vacuum pressure of 0.1 microns Hg shall be furnished with a diffusion pumps system to operate in the lower pressure range. The diffusion pumps shall be water cooled and provided with an excess temperature audible warning device. The pump shall be provided with means to minimize backstreaming from the diffusion pump.

3.6.7 Thermocouple. Thermocouples shall be used as the temperature sensing device. One thermocouple shall be used with each indicating recording and controlling instrument and one with each excess temperature control instrument. Class 1 and class 2 furnaces shall have type "S" thermocouples and class 3 and class 4 furnaces shall have type "W" thermocouples. Lead wires shall be not less than 25 feet in length and of the same material as the thermocouples or of a material having the same thermo-electric characteristics. When specified, the chamber shall be provided with an externally mounted junction box with thermocouples of the same type as specified for the instruments mounted through the chamber shell for calibrating temperature uniformity in the work zone. The number of test thermocouples required shall be as specified (see 6.2.1).

3.6.8 Multi-zone control. When necessary to maintain the temperature uniformity and performance requirements specified for the furnace, the chamber shall be divided into a suitable number of control zones and the required blowers, instruments and controls provided for multi-zone control.

3.6.9 Controls.

* 3.6.9.1 Program control. Each furnace shall be provided with microprocessor based digital programmable control system to automatically control the temperature, vacuum level and cooling modes, with output signals for vacuum and

temperature recorder. The processor shall provide for not less than 50 read/write programmable segments of random access memory. Input to the system shall be selectable between manual keyboard and magnetic tape cassette. Vacuum system performance for the range of 10 microns Hg and 1000 microns Hg, shall initiate the heating cycle at any pressure within this range. For furnaces designed to operate in the region of 0.1 microns, the heating cycle shall be initiated at any pressure between 1.0 microns and 1000 microns. Each furnace shall provide for raising the pressure to any desired level by the introduction of an inert gas at any preset temperature during the heating cycle. Unless otherwise specified, the system of each furnace shall provide for not less than two heat soak periods of up to 1 hour each and a heat of up to 6 hours, with controlled heating rates for each period and controlled cooling rates specified in 3.6.5 following the heating cycles. When specified see 6.2.1), the program control system shall provide infinitely variable purge cycles, heat cycles, soak cycles, cooling modes and vacuum levels, shall have the capability to store 100, 20-segment recipes, with all functions displayed on not less than a 12-inch panel with operator input entered on sealed membrane key pads. Additional or different program capability shall be provided when specified (see 6.2.1).

* 3.6.9.2 Instruments. All instruments using thermocouples as temperature sensing devices shall be marked to designate the particular type of thermocouple for which it was calibrated. Automatic reference junction compensation shall be provided in all instruments using thermocouples as the primary temperature sensing elements. External thermocouple lead lengths shall not affect calibration of the instruments other than for minor adjustments. Solid-state design shall be used throughout for electronic components.

* 3.6.9.3 Power controller. Unless otherwise specified (see 6.2.1), the temperature control system shall be either of the saturable core reactor, silicon controlled rectifier, or variable reactance transformer type. The control system shall limit power input to any desired maximum and shall be accurate within 1/2 of 1 percent of full scale reading and capable of maintaining the set control temperature within a maximum deviation of $\pm$2 degrees F.

* 3.6.9.3.1 Digital display. The indications of the control shall be direct reading in degrees F with a resolution of 1 degrees F. The instrument shall provide simultaneous display of temperature and pressure set points and actual temperature and pressure values in both analog and digital forms.

* 3.6.9.4 Temperature recorder. Unless otherwise specified (see 6.2.1), the furnace shall be provided with a temperature recorder, of the strip-chart, self-balancing type and shall be accurate within 0.3 percent of full scale.

* 3.6.9.4.1 Process reporter. When specified (see 6.2.1), the furnace shall be provided with a digital process reporter in lieu of the strip chart recorder.

* 3.6.9.4.2 Combined temperature and pressure recorder. When specified (see 6.2.1), the temperature recorder and vacuum pressure recorder shall be combined in a single instrument. (A two-pen recorder) A dual scale indictor chart shall be furnished, calibrated in temperature and pressure units as specified for the charts herein.

* 3.6.9.4.3 Multi-point recorder. When specified (see 6.2.1), a multi-point recorder shall be furnished capable of recording chamber pressure and 12 temperature points, with the ability to skip unused points, printing only points of interest.

* 3.6.9.5 Vacuum recorder. Unless otherwise specified (see 6.2.1), a separate vacuum pressure recorder shall be furnished to monitor chamber pressure. The instrument shall be a single-point strip chart recorder with calibrated indicator chart from 0.1 microns to atmospheric pressure, with maximum readability from 1 to 1000 microns. When specified (see 6.2.1), two additional vacuum pressure sensing devices shall be provided. One shall be located in the main vessel and one located in the vacuum system between the diffusion pump and main valve with a switch provided for checking and recording the pressure when required.

* 3.6.9.5.1 Chart. Unless otherwise specified (see 6.2.1), the width of the calibrated chart for the vacuum and temperature recorder shall be not less than 9 inches, and the length shall be not less than 90 feet to the roll. The chart speed shall be infinite variable up to not less than 20 inches per hour. A platen shall be provided behind the chart plane to permit the marking of notations on the chart while the instrument is in operation. The chart mechanism shall be furnished in a dust proof housing with a hinged door. The door shall be provided with a glass that will permit full view of the chart width and not less than 10 inches of chart length.

* 3.6.9.6 Vacuum gauge. Furnaces designed to operate with a chamber pressure of 1 micron Hg and less shall be provided with an ionization vacuum gauge to monitor chamber pressure from not less than 1 micron Hg to minimum pressure.

* 3.6.9.7 Excess temperature control. The furnace shall be provided with an excess temperature controller. The controller may be either an integrated function of the microprocessor controller programmer or a separate instrument. In either case the excess temperature control circuit shall be independent of the control circuitry. The controller shall function to shut off the heat source to the furnace in the event the overtemperature control point is reached. In case the furnace is shut down by the excess temperature control system, the system

shall sound an audible alarm, and the furnace shall remain off until started manually. Calibrated accuracy shall be within 1 percent of full scale reading.

* 3.6.9.8 Control panel. Each furnace shall be provided with a floor mounted, factory wired, control panel conforming to NEMA Standard 12 for mounting all instruments and accessory controls. Two NEMA-1 fusible safety switches or circuit breakers shall be provided in the control system, one for the main incoming power to the heating elements and one for the pumps, motors, and control system. Signal lights shall be provided to indicate furnace cycle performance. The panel shall provide for either semi-flush mounting or flush mounting of all instruments. When specified (see 6.2.1), the instruments or panel shall be provided with shock absorbing mounting.

3.7 Trays and fixtures. When specified (see 6.2.1), work trays and fixture shall be furnished. Design and dimensions shall be as specified.

3.8 Repair parts. Such repair parts as are specified (see 6.2.1), shall be furnished.

3.9 Nameplate. A corrosion-resistant metal nameplate shall be securely attached to each furnace. The nameplate shall contain the information listed below. If the furnace is a special model, the designation shall include the model of the basic standard furnace and a suffix keyed to the manufacturer's permanent records.

Nomenclature
Manufacturer's name
Manufacturer's model designation
Manufacturer's serial number
Power input characteristics and ratings
Operating vacuum pressure range (microns Hg)
Effective chamber dimensions
Operating temperature range (degrees F)
Date of manufacture
Contract Number or Order Number
National Stock Number or Plant Equipment Code
U S

3.10 Technical data. When technical data is required it shall be furnished in accordance with the requirements of the contract. All technical data furnished shall be written in the English language.

3.11 Workmanship. Workmanship of the furnace and accessories shall be of a quality equal to that of the manufacturer's commercial equipment of the type specified herein.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Quality conformance inspection (see 4.3).
b. Acceptance test (see 4.4).

4.3 Quality conformance inspection. Quality conformance inspection shall be applied to the furnace prior to being offered for acceptance under the contract. Unless otherwise specified (see 6.2.1), quality conformance inspection shall consist of the examination in 4.5, the tests in 4.6.1, and 4.6.2 and the inspection 4.7. Failure of the furnace to pass the examination, test, or inspection shall be cause for rejection.

4.4 Acceptance test. Acceptance test shall be performed on the furnace to ensure conformance with this specification. Unless otherwise specified (see 6.2.1), the acceptance test shall be performed only after the furnace is

installed at its final location, and the test shall consist of the examination in 4.5 and all tests in 4.6. Failure of the furnace to pass one or more tests or any part of a test shall be cause for rejection.

4.5 Examination. The furnace and equipment shall be examined for design, dimensions, construction, materials, components, electrical equipment, and workmanship to determine compliance with the requirements of this specification and the requirements of NFPA Standard 86D.

4.6 Tests. All tests shall be conducted at an ambient temperature of 77 degrees F ±18 degrees F. The instruments and sensing elements used to perform the tests specified for the furnaces and instruments shall have been calibrated with a standard potentiometer type instrument and a calibrated thermocouple or sensing devices of known accuracy within the previous six months to assure an accuracy within ±2 degrees F.

4.6.1 Instrument test. Indicating and recording instruments shall be tested by impressing various predetermined voltage, simulating thermocouple outputs for different furnace temperatures to terminals where normally the thermocouples would be connected. The instruments shall be tested through their operating range. Each circuit shall be tested to determine compliance with 3.5.9 through 3.5.9.8.

4.6.2 Circuit test. Each circuit of the electrical system shall be tested for continuity, short circuits, and dielectric strength in accordance with NEMA ICS-1.

4.6.3 Operational test. The furnace selected for test shall be prepared for operation and operated in accordance with the manufacturer's handbook of instructions. After the system has dried and been outgassed, the furnace shall be cooled to a chamber temperature of 77 ±18 degrees F. The regulating controls shall be set to attain minimum specified vacuum pressure and maximum specified temperature. The vacuum system shall evacuate the furnace chamber to minimum pressure in a time limit not greater than the time limit specified for the size furnace under test. With the furnace operating at maximum rated temperature, the outside surface temperature shall be checked at random locations and shall not exceed 40 degrees F above ambient temperature. The furnace shall be operated at maximum rated temperature with a chamber pressure of 10 micron Hg, and all systems shall be turned off. The leakage rate shall not exceed 5 microns Hg per hour from an initial pressure of 10 micron Hg.

4.6.4 Performance test. The furnace shall be loaded with a maximum charge as specified in 3.4.1 for the type and size furnace under test. The charge and chamber shall be at ambient temperature. The controls shall be programmed for

the furnace to operate with maximum power input to a temperature of 2000 degrees F and for 30 minutes, at minimum chamber pressure with the heating cycle to start at a pressure of 50 microns Hg and maximum cooling, using argon gas. At the end of 60 minutes from the start of the heating cycle, the work chamber temperature shall be 2000 degrees F ±10 degrees F and the chamber pressure shall be at the minimum pressure specified for the furnace. At the end of 60 minutes from the start of the cooling cycle, the work chamber temperature shall be 300 degrees F or less. The above heating and cooling temperature requirements shall be as indicated on temperature control instruments. After the furnace and load have cooled to ambient temperature, the controls shall be programmed for the furnaces to perform the following cycle sequence.

a. Begin chamber evacuation.

b. Start heat cycle at 50 microns Hg.

c. Attain minimum chamber pressure.

d. Raise temperature to 1500 degrees F; hold for 20 minutes.

e. Raise temperature to 1800 degrees F; hold for 12 minutes.

f. Raise temperature to 1850 degrees F; vacuum pressure to 200 microns Hg.

g. Raise temperature to 2000 degrees F; hold for 50 minutes.

The furnace shall operate automatically through the specified cycle sequence and record the complete performance. At least three additional performance tests shall be run and different individual cycles selected for each performance tests.

4.6.5 Temperature uniformity test. The furnace shall be loaded with a charge of metallic material that will not vaporize under minimum vacuum pressure at a temperature of 2150 degrees F. Carbon steel may be used unless otherwise specified. The charge shall be equivalent to not less than 80 percent of maximum load and a chamber temperature survey performed to determine conformance with the uniformity requirements specified for the furnace. A minimum of nine test locations shall be used with eight thermocouples located symmetrically through the charge so as to scan the work space. One thermocouple shall be located within six inches of each control thermocouple. The survey shall be performed with equilibrium established at minimum operating temperature and at 2150 degrees F for each class furnace. Three survey readings shall be taken at intervals of five to ten

minutes under different chamber pressure in the range between 1000 microns Hg and minimum chamber pressure. The maximum temperature variation between instrument control point in the chamber and all other points under test shall vary not more than plus or minus 10 degrees F. Type "K" thermocouples may be used to perform the above survey. When specified (see 6.2.1), the above test shall also be performed on class 3 and 4 furnaces at maximum operating temperature (see 6.2.3). If uniformity tests are required at the maximum temperature of class 3 and class 4 furnaces, the same type thermocouples shall be used in the survey as specified in 3.6.7 for the control instruments.

4.7 Inspections of packaging. Packaging shall be inspected to determine compliance to the requirements of section 5.

5. PACKAGING

5.1 Packaging, packing and marking. Unless otherwise specified, packaging, packing, and marking shall be in accordance with ASTM D 3951. When specified preservation, packing and marking shall be in accordance with specification MIL-F-3296. Level of preservation and packing shall be as specified (see 6.2.1).

6. NOTES

6.1 Intended use. Furnaces covered by this specification are intended for such heat treating operations as hardening, tempering, annealing, normalizing, brazing, de-gassing and sintering in vacuum atmosphere with optional gas quenching.

6.2 Ordering data.

6.2.1 Acquisition requirements. Purchases should specify their requirements in acquisition documents, including whether each choice is required or not required, by entering an appropriate statement identified to each of the following:

a. Title, number, and date of this specification.

b. Type and class required (see 1.2).

c. If furnace is required to be configured in a specific measurement system (US or SI), state required system (see 3.1.4).

d. Painting, if different (see 3.2.5).

e. Electrical system and input power, if different (see 3.3.1).

f. Size required, specify heating chamber length, width and height for type I or diameter and depth for type II, or diameter and height for type III (see 3.4).

g. Operating vacuum pressure, if different (see 3.5.3.1).

h. ASME Certification of Compliance of Boiler and Pressure Vessel Code, when required (see 3.6.1).

i. Door hinge location, if different (see 3.6.2.1), (type I only).

j. Power door or cover and powered clamps, when required, specify pneumatic or hydraulic (see 3.6.2.1).

k. Transfer car, when required (see 3.6.2.2), specify number of transfer cars, track length and arrangement.

l. If mechanical refrigeration system is required, so specify. If cooling tower system is required, so specify (see 3.6.3).

m. Radiation shields only, if required (see 3.6.4).

n. Chamber monorail system, shelves, or hydraulic forklift loading device, when required (see 3.6.4).

o. Heat exchanger and cooling rate, when required (see 3.6.5). (Specify cooling rate in pounds of steel per hour if different cooling rates required.)

p. Vacuum system dust traps or filters, when required (see 3.6.6).

q. Number of test thermocouples, when required (see 3.6.7).

r. Infinite variable cycles and storage capability of 100, 20-segment recipes, if required (see 3.6.9.1).

s. Program requirements, if different (see 3.6.9.1).

t. Power controller, if different (see 3.6.9.3).

u. Temperature recorder, if different (see 3.6.9.4).

v. Process reporter in lieu of recorder (see 3.6.9.4.1).

w. Combined temperature and pressure recorder, (see 3.6.9.4.2) if required.

x. Multi-point recorder, if required (see 3.6.9.4.3).

y. Vacuum recorder, if different (see 3.6.9.5).

z. Additional pressure sensing devices, when required (see 3.6.9.5).

aa. Chart, if different (specify width), (see 3.6.9.5.1).

bb. Shock absorbing of instruments panel, when required (see 3.6.9.8).

cc. Trays and fixtures, when required (see 3.7).

dd. List of repair parts, if required (see 3.8).

ee. Quality conformance inspection, if different (see 4.3).

ff. Acceptance test and location of test, if different (see 4.4).

gg. Temperature uniformity test on class 3 and 4 furnaces at maximum operating temperature, when required (see 4.6.5).

hh. Preservation, packaging, packing and special marking, if different (see 5.1).

6.2.2 Consideration of data requirements. The requirements for technical data should be considered when this specification is applied on a contract. The Data Item Descriptions (DIDs), DD Form 1664, for required data should be listed on a Contract Data Requirements List (DD Form 1423). The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements List, (AMSDL) should be researched for the applicable DD Form 1664 and to ensure that only current approved DIDs are cited on the DD Form 1423.

6.2.3 High temperature materials. Material required for test loads above 2150 degrees F will have a to be molybdenum or a material that will not melt or vaporize under the vacuum pressure an maximum temperature of the furnace. Also molybdenum type heating elements become brittle after they are heated and are subject to damage during movement and transit of the furnace. For these reasons, consideration should be given to performing acceptance tests after the furnace has been installed at the site of operation.

6.2.4 Marginal notations. The margins of this specification are marked with asterisks to indicate where changes (addition, modifications, corrections, deletions) from previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractor are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.2.5 Subject term (keyword) listing.

Brazing
Diffusion pump
Furnace
Heat-treating
Thermocouples
Vacuum

Custodians:
Navy - SH
Air Force - 99

Review activities:
Army - AL
Air Force - 84

User activities:
Navy - OS, AS

Preparing activity:
DLA - IP

Project (3424-0113)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-F-80113D	Furnaces, Vacuum, Heat Treating and Brazing

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
	☐ USER
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ MANUFACTURER
	☐ OTHER *(Specify)*:

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426

PREVIOUS EDITION IS OBSOLETE.