****

NASA-15700 (June 2004)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA

Superseding NASA-15700 (December 2003)

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SECTION 15700

HEATING / VENTILATION / AIR CONDITIONING SYSTEMS

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SECTION 15700

HEATING / VENTILATION / AIR CONDITIONING SYSTEMS
06/04

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NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This broadscope section covers general requirements, equipment, material, installation, and testing of heating, ventilation, and air conditioning systems.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: The following references should not be manually edited except to add new references. References not used in the text will automatically be deleted from this section of the project specification.

****

The publications listed below form a part of this section to the extent referenced:

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 520	(1997) Positive Displacement Condensing Units

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 300	(1996) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(1990) Methods for Calculating Fan Sound Ratings from Laboratory Test Data

AMERICAN GAS ASSOCIATION (AGA)

AGA Z21.13	(1991) Gas-Fired Low-Pressure Steam and Hot Water Boilers
AGA-02	(1998) Directory of AGA and CGA Certified Appliances and Accessories

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 317	(1992) Manual of Steel Construction, Volume II, Connections

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI SG-913	(1991) LRFD Cold-Formed Steel Design Manual

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

ASHRAE 15	(2001) Safety Code for Mechanical Refrigeration
ASHRAE 51	(1999) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
ASHRAE-04	(1997) Handbook, Fundamentals (SI Edition)
ASHRAE-05	(1999) Handbook, HVAC Applications (SI Edition)
ASHRAE-06	(1997) Handbook, HVAC Systems and Equipment (IP Edition)
ASHRAE-08	(1998) Handbook, Refrigeration Systems and Applications (SI Edition)
ASHRAE-Hdbk SE-SI	(2000) Handbook, HVAC Systems and Equipment (SI Edition)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C504	(2000) Standard for Rubber-Seated Butterfly Valves

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 1992) Pipe Threads, General Purpose (Inch)
ASME B1.21M	(1997) Metric Screw Threads - MJ Profile
ASME B16.21	(1992) Nonmetallic Flanged Gaskets for Pipe Flanges
ASME B16.22	(2002) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.3	(1998) Malleable Iron Threaded Fittings Classes 150 and 300
ASME B16.34	(1996) Valves - Flanged, Threaded and Welding End
ASME B16.5	(1996) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24

ASME B16.9	(2001) Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.5	(2001) Refrigeration Piping and Heat Transfer Components
ASME B36.10M	(2000) Welded and Seamless Wrought Steel Pipe
ASME B40.100	(1998) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2001) Boiler and Pressure Vessel Code; Section IV, Recommended Rules for the Care and Operation of Heating Boilers
ASME BPVC SEC VIII D1	(2001) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME SI-01	(2001) Units, Boiler and Pressure Vessel Codes, Section I - IX

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1	(2002) National Standards for Total System Balance

ASTM INTERNATIONAL (ASTM)

ASTM A 106	(2002) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 123/A 123M	(2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 234/A 234M	(2003) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperatures
ASTM A 307	(2003) Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 36/A 36M	(2003a) Standard Specification for Carbon Structural Steel
ASTM A 436	(1984; R 2001) Standard Specification for Austenitic Gray Iron Castings
ASTM A 527/A 527M	(1990) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM A 53/A 53M	(2002) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated

	Welded and Seamless
ASTM A 694/A 694M	(2003) Standard Specification for Forgings, Carbon and Alloy Steel, for Pipe Flanges, Fittings, Valves and Parts for High Pressure Transmission Service
ASTM A 90/A 90M	(2001) Standard Test Method for Weight (Mass) of Coating on Iron or Steel Articles with Zinc or Zinc Alloy
ASTM B 280	(2003) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B 61	(2002) Standard Specification for Steam or Valve Bronze Castings
ASTM B 62	(2002) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 88	(2003) Standard Specification for Seamless Copper Water Tube
ASTM B 88M	(2003) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM C 1139	(1990; R 2002) Standard Specification for Fibrous Glass Thermal Insulation and Sound Absorbing Blanket and Board for Military Application
ASTM C 552	(2003) Standard Specification for Cellular Glass Thermal Insulation
ASTM C 553	(2002) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 612	(2000a) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM D 1784	(2003) Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM F 568M	(2002) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

CSA INTERNATIONAL (CSA)

CSA Directory	Canadian Standard Associations Certified Product Listings

FM GLOBAL (FM)

FM P7825	(2003) Approval Guide

HYDRONICS INSTITUTE DIVISION OF GAMA (HYI)

HYI RATINGS	(2004) 1=B=R Ratings for Boilers, Baseboard Radiation, and Finned Tube (Commercial)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003) Mechanical Vibration - Balance Quality Requirements of Rigid Rotors - Part 1: Determination of Permissible Residual Unbalance

ISA - THE INSTRUMENTATION, SYSTEMS AND AUTOMATION SOCIETY (ISA)

ISA RP60.9	(1981) Piping Guide for Control Centers

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-104	(2003) Wrought Copper LW Solder Joint Pressure Fittings
MSS SP-67	(2002) Butterfly Valves
MSS SP-72	(1999) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2003) Bronze Gate, Globe, Angle and Check Valves
MSS SP-86	(2002) Guidelines for Metric Data in Standards for Valves, Flanges, Fittings and Actuators

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2002) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 220	(1999) Standard on Types of Building Construction
NFPA 70	(2002) National Electrical Code
NFPA 90A	(2002) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF 14	(2003) Plastics Piping Components and Related Materials

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

SMACNA 1481	(1995; 6th Ed) HVAC Duct Construction

	Standards - Metal and Flexible
SMACNA TAB HVAC SYSTEMS	(2002) HVAC Systems - Testing, Adjusting and Balancing

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J513	(1999) Refrigeration Tube Fittings - General Specifications Standards

U.S. DEPARTMENT OF DEFENSE (DOD)

MS DOD-G-24508	(1998d) Grease, High Performance, Multipurpose (Metric)
MS MIL-B-18796	(1998f) Burners, Single: Oil, Gas, and Gas-Oil Combination for Packaged Boilers
MS MIL-P-26915	(1992c) Primer Coating, Zinc Dust Pigmented, for Steel Surfaces

U.S. DEPARTMENT OF ENERGY (DOE)

DOE CE-3	(2001) How to Buy an Energy-Efficient Commercial Unitary Air Conditioner
DOE CE-5	(2000) How to Buy an Energy-Efficient Commercial Boiler
DOE RA-1	(2000) How to Buy an Energy-Efficient Room Air Conditioner
DOE RE-5	(2000) How to Buy an Energy-Efficient Gas Water Heater

UNDERWRITERS LABORATORIES (UL)

UL 181	(2003) UL Standards for Safety Factory-Made Air Ducts and Air Connectors
UL 726	(2001) UL Standard for Safety Oil-Fired Boiler Assemblies
UL 795	(1999) Commercial-Industrial Gas Heating Equipment
UL 834	(1998) UL Standard for Safety Heating, Water Supply and Power Boilers - Electric

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal

description.
****

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES in sufficient detail to show full compliance with the specification:

SD-02 Shop Drawings

Connection Diagrams and Control Diagrams shall be submitted for the following systems in accordance with paragraph entitled, "Diagrams," of this section.

Air Systems
Hydronic Systems
Air-Hydronic Systems
Unitary Systems

Schematics shall be submitted for each HVAC duct system in accordance with paragraph entitled, "Diagrams," of this section.

Fabrication drawings shall be submitted for the following items:

Valves
Air Diffusers
Boilers
Chillers
Coils
Ductwork
Compressor
Heat Exchangers
Vibration Isolators
Condenser
Unit Heaters
Air Handling Units
Air-Conditioning Units
Mixing Boxes

Installation Drawings shall be submitted for the following systems in accordance with the paragraph entitled, "Installation," of this section.

Air Systems
Hydronic Systems
Air-Hydronic Systems
Unitary Systems

SD-03 Product Data

Equipment and performance data shall be submitted for the following items including sound data for supply air-diffusion devices in terms of Noise Criteria (NC) index for the capacity range of the device. Data shall also include air and hydronic pressure differences, the direction of air and water flow, temperature differentials, power rating, operating temperatures and pressures, efficiencies and limit or safety temperatures and pressures.

Air Diffusers

Fans
Boilers
Chillers
Coils
Valves
Ductwork
Compressor
Heat Exchangers
Piping
Vibration Isolators
Insulation
Condenser
Unit Heaters
Air Handling Units
Air-Conditioning Units
Mixing Boxes
Filters

Manufacturer's catalog data shall be submitted for the following items in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Air Diffusers
Fans
Boilers
Chillers
Coils
Ductwork
Compressor
Heat Exchangers
Piping
Vibration Isolators
Insulation
Condenser
Unit Heaters
Air Handling Units
Air-Conditioning Units
Mixing Boxes
Filters
Spare Parts
Accessories

Equipment foundation data for the following items shall include equipment weight and operating loads; horizontal and vertical loads; starting torques and their direction; rpm of equipment; size, location and projection of anchor bolts; horizontal and vertical clearances for installation, operation, and maintenance; plan dimensions of foundations and relative elevations; and installation requirements such as noise abatement, vibration isolation, and utility services.

Vibration Isolators
Boilers
Piping
Compressor
Condenser
Coils
Valves
Unit Heaters

Fans
Air Handling Units
Air-Conditioning Units
Ductwork
Air Diffusers
Mixing Boxes

SD-05 Design Data

Design analysis and calculations shall be submitted for HVAC Systems and shall include the following items when applicable.

Flow Rates
Air Distribution
Design Pressures and Losses
Fan and Pump Design Speeds
Sound and Comfort Design
Vibration Calculations
Insulation Requirements
Filter Requirements
Boiler and Chiller Design

SD-06 Test Reports

Test reports shall be submitted for the following items on each type of HVAC system.

Pressure Tests
Vacuum Testing
Operating Test

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions shall be submitted in accordance with paragraph entitled, "Installation," of this section.

Operating Instructions shall be submitted for all proposed equipment.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals shall be submitted for the following systems in accordance with paragraph entitled, "Operation and Maintenance," of this section.

Air Systems
Hydronic Systems
Air-Hydronic Systems
Unitary Systems

1.3 MECHANICAL SYSTEMS IDENTIFICATION

Contractor shall provide a coordinated system of piping identification which includes:

A framed and plastic-protected diagrammatic layout of piping systems, showing and identifying piping, ducting, automatic or manual control locations, equipment, and valve locations. Where existing systems are

being modified, existing layouts shall be brought up to date to include such modifications.

Metal tag-identified major valves, piping systems components, and equipment

1.3.1 Diagrams

Connection, control and installation diagrams for Air Systems, Hydronic Systems, Air-Hydronic Systems and Unitary Systems shall be submitted meeting referenced standards within this section.

Design analysis and calculations shall be submitted for HVAC Systems and shall include the following items when applicable. Chart listing of equipment shall be by designation numbers and showing capacities to include Flow Rates, Air Distribution, Design Pressures and Losses, Fan and Pump Design Speeds, Sound and Comfort Design, Vibration Calculations, Insulation Requirements, Filter Requirements and Boiler and Chiller Design. They shall also include heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

Diagrams shall be neat mechanical drawings provided with extruded aluminum frames and 1/8-inch 4 millimeter acrylic plastic protection. Location shall be as directed by the Contracting Officer.

Connection diagrams shall be submitted for the following systems indicating the relations and connections of devices and apparatus by showing the physical layout of all controls, the interconnection of one system (or portion of system) to another, and internal tubing, wiring, and other devices.

Control diagrams shall be submitted for the following systems indicating the physical and functional relationship of equipment, electrical diagrams showing size, type and capacity of the systems, and pneumatic diagrams for air and gas systems.

Schematics shall be submitted for each HVAC duct system indicating dampers, regulating devices, terminal units, supply outlets, return and exhaust inlets, and the size, velocity and flow (cfm or gpm) (cubic meter per minute or liter per second) for main branch circuits or ducts. Drawings shall include air intakes and exhaust air and relief air louvers where applicable.

1.3.2 Metal Tags

Identification tags made of brass or aluminum indicating function of a control or similar component shall be installed on system devices. Tags shall be 2 inches 50 millimeter in diameter; marking shall be stamped.

1.3.3 Service Labeling

Piping, including that concealed in accessible spaces, exposed, bare, painted, or insulated, shall be labeled to designate service. Each label shall include an arrow or arrows to indicate flow direction.

1.4 STORAGE AND PROTECTION OF EQUIPMENT AND MATERIALS

Equipment and materials stored at the site shall be fully protected from damage, dirt, debris, and weather.

1.5 AUTOMATIC CONTROL OF SYSTEMS

Automatic control systems shall be complete in all details and shall include accessories to maintain specified conditions.

Automatic temperature control systems may be equivalent pneumatic, electronic, electric/electronic, low-voltage electric, or pneumatic/electronic.

Sequence of operations to be controlled shall be as shown on drawings.

1.6 GENERAL REQUIREMENTS

****
NOTE: If Section 15003 GENERAL MECHANICAL PROVISIONS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted. If Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted.If Section 16225 MOTORS is not included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.
****

[Section 15003 GENERAL MECHANICAL PROVISIONS applies to work specified in this section.]

[Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT applies to work specified in this section.]

[Section 16225 MOTORS applies to this section.]

PART 2 PRODUCTS

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NOTE: Pump, fan, compressor, and motor balance shall conform to ISO Std. 1940/1 - (1986) Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels shall conform to NEMA Specification MG-1, Motors and Generators, Part 7 unless otherwise noted.
****

2.1 STANDARD PRODUCTS

Mechanical materials and equipment, including chillers, spare parts and accessories, to be provided under this contract shall be current standard catalog products of manufacturers regularly engaged in the manufacture of the products.

2.2 MATERIAL AND EQUIPMENT

Mechanical material and equipment shall meet the specified requirements and

shall be suitable for the installation shown. Components bearing the same part number shall be identical in form, fit, and function. Materials and equipment shall be new and free from defects.

2.3 IDENTIFICATION PLATES

Standard manufacturer's identification plates shall be provided for each individual piece of equipment.

2.4 STEEL PIPING FOR STEAM, CONDENSATE, CHILLED AND HOT WATER

Steam, condensate, and water piping for 150-, 350-pound per square inch (psi) 1050-, 2500-kilopascal service shall be black carbon steel (BCS).

2.4.1 Type BCS (150-psi 1000-kPa Service)

Pipe or tube (1/8 through 10 inches) (DN6 through DN250): Schedule 40 for steam and water, Schedule 80 for condensate, seamless black carbon steel, conforming to ASTM A 53/A 53M, or ASTM A 106, and ASME B36.10M

Fittings (1/8 through 2 inches) (DN6 through DN50): 300-psi 2100-kilopascal working steam pressure (wsp) banded malleable iron, screwed end, conforming to ASME B16.3 and ASTM A 234/A 234M

Fittings (2-1/2 through 10 inches) DN65 through DN250): Wall thickness to match pipe, long radius, butt weld, black carbon steel, conforming to ASTM A 234/A 234M, Grade WPB.

Unions (1/8 through 2 inches) (DN6 through DN50): 250-psi 1800-kilopascal wsp, malleable iron, screwed end, ground joint, with brass or bronze seat insert.

Flanges (2-1/2 through 10 inches) (DN65 through DN250): 150-pound 1000-kilopascal, forged carbon steel, welding neck, with raised face or flat face and concentric finish, conforming to ASME B16.5 and ASTM A 694/A 694M

Flange gaskets: Gaskets shall conform to MSS SP-86 and ASME B16.21.

Bolting: Hexhead bolts and nuts shall conform to ASTM A 307 ASTM F 568M.

2.4.2 Type BCS (350-psi 2500-kPa Service)

Pipe or tube (1/8 through 10 inches) (DN6 through DN250): Schedule 40 for water, Schedule 80 for steam and condensate; seamless black carbon steel, conforming to ASTM A 106 and ASME B36.10M

Fittings (2-1/2 through 10 inches) (DN65 through DN250): Schedule 40 for water, Schedule 80 for steam and condensate long-radius, butt weld, black carbon steel, conforming to ASME B16.9 and ASTM A 234/A 234M

Flanges (2-1/2 through 10 inches) (DN65 through DN250): 300-pound 2100-kilopascal, forged carbon steel, weld neck, with raised face and concentric serrated finish, conforming to ASME B16.5 and ASTM A 694/A 694M

Gaskets: Spiral-wound, non-asbestos fiber material filled, carbon steel, with centering provisions, conforming to ASME B16.5, Group 1 , and ASTM A 694/A 694M

Bolting: Heavy hexhead, carbon-steel bolts or bolt studs and semifinished heavy hex-nuts, conforming to ASTM A 307 ASTM F 568M, Grade B

2.5 VALVES

2.5.1 Gate Valves

Body end connections shall be flanged for valves larger than 2 inches, DN50, unless butt weld ends are required. Screwed or socket weld shall be used for sizes 2 inches DN50 and under.

For water usage, seat and seal material shall be of the manufacturer's standard Teflon, Viton, or nylon. For steam usage, the materials shall be as specified on the drawing depending on pressures and temperatures.

2.5.1.1 Type 350 2500

Valves shall be rated 300 psi 2100 kilopascal wsp and shall conform to ASME B16.34.

Body to bonnet connection shall be union or gasketed-bolted type for valves 2 inches DN50 and under and gasketed-bolted type for valves larger than 2 inches DN50. Bonnet shall be OS&Y type, rising stem.

2.5.1.2 Type 150 1000

Valves shall be rated 150-psi 1000-kilopascal wsp and shall conform to ASME B16.34.

Body to bonnet connection shall be union or gasketed-bolted type for valves 2 inches DN50 and under and gasketed-bolted type for valves larger than 2 inches DN50. Bonnet shall be OS&Y type, rising stem.

For condensate service, screwed-end gate valves shall be 150-psi 1000-kilopascal, wsp-rated, forged steel, conforming to ASME B16.34, as modified and supplemented herein, except that trim shall be manufacturer's standard corrosion-resistant steel.

2.5.1.3 Type 125 850

Valves shall be rated 125-psi 850-kilopascal wsp and shall conform to ASME B16.34.

Valves, in sizes 2 inches DN50 and under, shall be union-bonnet type.

Stem shall be rising and backseating type.

2.5.2 Globe and Angle Valves

Body end connections shall be flanged for valves larger than 2 inches DN50, unless butt weld ends are required. Screwed or socket weld shall be used for sizes 2 inches DN50 and under.

For water usage, seat and seal material shall be of the manufacturer's standard Teflon, Viton, or nylon. For steam usage, the materials shall be as specified on the drawing depending on pressures and temperatures.

2.5.2.1 Type 350 2500

Valves shall be rated 350-psi 2100-kilopascal wsp and shall conform to ASME B16.34.

2.5.2.2 Type 150 1000

Valves shall be rated 150-psi 1000-kilopascal wsp and shall conform to ASME B16.34.

Pressure-regulating station bypass valves shall be Type 150.

2.5.2.3 Type 125 850

Valves shall be rated 125-psi 850-kilopascal wsp and shall conform to MSS SP-86 and MSS SP-80, globe or angle.

Valves 2 inches DN50 and under in size shall be union bonnet type.

Stem shall be rising and backseating type.

2.5.3 Check Valves

2.5.3.1 Type 350 2500

Valves shall be rated 300-psi 2100-kilopascal wsp and shall conform to applicable portions of ASME B16.34.

Valves shall be horizontal swing-check type.

Body end connections shall be flanged for valves larger than 2 inches DN50 unless butt weld ends are required. Screwed or socket weld shall be used for sizes 2 inches DN50 and under.

Body-to-cover connection shall be union or gasketed-bolted type.

Trim materials, including hinge pin, shall be manufacturer's standard corrosion-resistant alloys for the specified service.

2.5.3.2 Type 125 850

Valves shall be rated 125-psi 850-kilopascal wsp and standard horizontal swing type.

Body end connections shall be flanged for valves larger than 2 inches DN50 and screwed in sizes 2 inches DN50 and under.

Body-to-cover connection in sizes larger than 2 inches DN50 shall be gasketed-bolted type.

Swing-check pin shall be corrosion-resistant steel, bronze, or brass. Swing check angle of closure shall be manufacturer's standard, unless a specific angle is required.

Valve disk shall be regrindable metal or renewable composition type.

2.5.4 Manual Radiator Valves

Valves to control heating medium to heating element shall be packless type.

Valve end connection shall be the same size as the supply line.

2.5.5 Cone-Plug Balancing Valve (CPBV)

Cone-plug balancing valves in sizes through 1-1/4 inches DN32 shall be thread end, conforming to ASME B1.20.1 and ASME B1.21M, and shall be rated for service at not less than 175 psi at 250 degrees F 1200 kilopascal at 121 degrees C. Valve body and components shall be ASTM B 61 bronze or manufacturer's equal-strength brass materials. Valve plug shall be swivel-type contoured cone and shall not rattle or make any noise in service at any balancing position. Valve shall have high temperature, service-rated packing, with bushing in bottom of gland and gland adjustment. Valves shall be fitted with a memory device which shall permit a valve set at a balance point to be opened or closed but not opened beyond the balance point. Valve shall be nonrising stem type.

2.5.6 Eccentric Plug Valves (EPV)

Eccentric plug valves in sizes 2 inches DN50 and smaller shall be constructed of manufacturer's standard brass or bronze materials conforming to ASTM B 61 or ASTM B 62. Valves shall be rated for service at 175-psi 1200-kilopascal maximum nonshock pressure at 250 degrees F 121 degrees C. Valve body shall have screwed ends. Eccentric plug surfaces in contact with flow shall be coated with a 60 to 70 Shore A durometer hardness elastomer, resistant to treated water.

Reopening, limited to eccentric plug valves in sizes 2-1/2 inches DN65 and larger, shall be constructed of Type 2 nickel-alloy iron conforming to ASTM A 436. Valves shall be rated for service at 175-psi 1200-kilopascal maximum nonshock pressure at 250 degrees F 121 degrees C. Valve body shall have screwed ends. Eccentric plug surfaces shall be coated with a 60 to 70 Shore A durometer hardness elastomer, resistant to treated water.

2.5.7 Ball Valves (BAV)

2.5.7.1 Metal

Valves shall conform to MSS SP-72.

Valves shall be rated for service at not less than 175 psi at 200 degrees F 1200 kilopascal at 93 degrees C.

Valve bodies in sizes 2-inch DN50 iron pipe size (ips) and smaller shall be screwed-end-connection type, constructed of Class A copper alloy.

Valve bodies in sizes 2-1/2-inch DN65 ips and larger shall be flanged-end connection type, constructed of Class D, E, or F material.

Balls and stems of valves 2-inch DN50 ips and smaller shall be manufacturer's standard Class A copper alloy with 900 Brinell hard-chrome plate finish or Class C corrosion-resistant steel alloy with hard-chrome plate.

Ball and stems of valves 2-1/2-inch DN65 ips and larger shall be manufacturer's standard Class C, corrosion-resistant steel alloy with hard-chrome plate. In valves 6-inch DN150 ips and larger, balls shall be Class D with 900 Brinell hard-chrome plate.

Valves shall be suitable for flow from either direction and shall seal

equally tight in either direction.

Valves shall have full-pipe-size flow areas.

Valves with ball seals kept in place by spring washers are not acceptable. Valves shall have adjustable packing glands. Seats and seals shall be tetrafluoroethylene.

2.5.7.2 Polyvinylchloride (PVC)

Ball valves shall be manufactured from a PVC compound that meets the requirements of Class 12454-B PVC as outlined in ASTM D 1784. Valves shall also conform to NSF 14.

Valves shall have Teflon ball seals and Viton stem and body seals. Ball valves shall carry a pressure rating of 150-psi 1000-kilopascalcirculating water pressure (cwp) at 75 degrees F 24 degrees C.

2.5.7.3 Chlorinated Polyvinylchloride (CPVC)

Ball valves shall be manufactured from a compound that meets or exceeds the requirements for Class 23447-B CPVC in ASTM D 1784. Valves shall also conform to NSF 14.

Valves shall have Teflon ball seals and Viton stem and body seals. Ball valves shall carry a pressure rating of 150-psi 1000-kilopascal cwp at 75 degrees F 24 degrees C.

2.5.8 Butterfly Valves (BUV)

Butterfly valves shall conform to MSS SP-67, except as modified and supplemented herein.

Butterfly valves shall be wafer type for mounting between specified flanges and shall be rated for 150-pounds per square inch, gage (psig) 1000 kilopascal (150 psig) shutoff and nonshock working pressure.

Valves installed in insulated piping systems shall be provided with extended bonnets placing the operator beyond the specified insulation.

Disk shall be free of external ribs and shall be streamlined.

Use of taper pins to secure the valve disk to the shaft is prohibited.

Shafts shall be a standard manufacturer's component for the valve provided.

Seats and seals shall be resilient-elastomer type designed for field removal and replacement. Elastomers shall be Buna-N, ethylene propylene terpolymer, chloroprene, or approved equivalent, formulated for continuous immersion service at 250 degrees F 121 degrees C, minimum, and shall be applied at least 10 percent below maximum continuous service temperature. Bonding adhesives, if used, shall comply with elastomer temperature requirements and shall have an effective life equal to or greater than the elastomer.

Seals on 20-inch DN500 and smaller valves shall be designed to use standard split-V packing, dual O-rings, and quad rings or they shall be of the adjustable pull-down type.

Seats may be installed in the valve body or on the disk except that circular cross-section O-ring construction is not acceptable.

Seat or disk matting surfaces shall be corrosion-resistant material such as austenitic gray cast iron and bronzes specified for the disk or the materials specified for stems. These materials shall be welded to substrate and ground or shall be mechanically retained. Plated or similarly applied surfacing materials are not acceptable.

Bearings shall be permanently lubricated sleeve type of manufacturer's standard corrosion-resistant steel, bronze, nickel-copper alloy, nylon, or filled tetrafluoroethylene. Bearings shall be designed for a pressure not exceeding the published design load for the bearing material or one-fifth of the compressive strength of the bearing or shaft material. The operating end of the shaft shall be provided with dual inboard bearings or a single inboard and an outboard bearing in or beyond the operator.

Padlocking feature shall be provided to make valve tamperproof.

For balancing service, valve operators shall have provision for infinite position locking.

Manual nonchain-operated valves through 6 inches DN150 shall be provided with not less than nine-position, lever-lock handles not exceeding 18 inches 450 millimeter in length.

Manual valves 8 inches DN200 and larger, or smaller if the application torque exceeds a pull of 80 foot-pounds 110 newton meter shall be provided with gear operators.

Where valves are indicated to be chain operated, all sizes shall be equipped with gear operators, and chain length shall be suitable for proper storage and operation.

Gear operators shall be worm-gear type. Operator shall be totally enclosed in a cast-iron housing, suitable for grease or oil lubrication. Gears shall be hobcut. Cast-iron-housed traveling-nut operators conforming to AWWA C504 and MSS SP-86 are acceptable. Maximum manual pull on the handwheel or chain wheel shall be 80 foot-pounds 110 newton-meter.

Modulating or remotely actuated two-position service valves shall be provided with pneumatic operators, pilot positioners, valve position indicators, boosters, and relays where necessary. Operating air supply pressure shall be as indicated in the contract documents.

Pneumatic operator and adjustable stroke crosslink system shall be provided for bypass operation.

Maximum load on a pneumatic operator shall not exceed 85 percent of rated operator capacity.

2.5.9 Dial Cocks

Dial cocks in sizes 2-1/2-inch DN65 ips and smaller with pointer and etched position dial shall be rated 150-psi 1000-kilopascal wsp and shall be of manufacturer's standard all-brass construction.

2.5.10 Diaphragm Control and Instrument Valves (DCIV)

Diaphragm control and instrument valves in sizes 1/4 and 3/8 inch DN8 and DN10 shall have a forged-brass body with reinforced tetrafluoroethylene diaphragm, and an AISI 300 series corrosion-resistant steel spring with round phenolic handle. Handle shall be fitted with disks color-coded in accordance with MSS SP-86 and ISA RP60.9.

2.6 VIBRATION ISOLATORS

Rubber shall be natural rubber. Elastomer shall be chloroprene. Shore A durometer measurement of both materials shall range between 40 and 60.

Weather-exposed metal vibration-isolator parts shall be corrosion protected. Springs shall be chloroprene coated.

Exact mounting sizes and number of vibration isolators shall be determined by the isolator manufacturer based on equipment that will be installed. Equipment rpm and spring deflections shall be checked to verify that resonance cannot occur.

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NOTE: Refer to Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT if design may induce vibration considerations.

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2.6.1 Mountings

Type A: Composite pad, with 1/4-inch 6 millimeter thick elastomer top and bottom layers, molded to contain a pattern with nonslip characteristics in all horizontal directions. Elastomer loading shall not exceed 40 psi 275 kilopascal. Minimum overall thickness shall be 1 inch 25 millimeter. Deflections shall be limited to 0.25 inch 6.4 millimeter or less.

Type B: Double rubber-in-shear or elastomer-in-shear with molded-in steel reinforcement in top and bottom. Deflections shall be limited to 1/2 inch 13 millimeter or less.

Type C: Free-standing laterally stable open-spring type for deflections over 1/2 inch 13 millimeter, with built-in bearing and leveling provisions, 1/4-inch millimeter thick Type A base elastomer pads, and necessary accessories. Outside diameter of each spring shall be equal to or greater than 0.9 times the operating height of the spring under rated load.

Type D: Partially housed type, containing one or more vertically restrained springs with at least 1/2-inch 13 millimeter clearance maintained around springs, with adjustable limit stops, 1/4-inch 6 millimeter thick Type A base elastomer pads, and necessary accessories.

Type E: Pendulum-suspension configuration with free-standing stable spring with resilient horizontal and vertical restraints to allow movements of not more than 1/4 inch 6 millimeter in each direction, 1/4-inch 6 millimeter thick Type A base elastomer pads.

Type F: Combination spring and rubber-in-shear or elastomer-in-shear steel framed for hanger-rod mounting. Minimum total static deflection shall be 1 inch 25 millimeter.

2.6.2 Bases

Type U: Unit isolators without rails, structural-steel bases, or inertia blocks

Type S: Structural-steel bases common to a supported assembly, made from welded-joint mill-rolled structural steel with closed-perimeter configuration, isolators attached to outrigger supports

Height of steel members shall be sufficient to provide stiffness required to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components.

2.6.3 Pipe and Duct Vibration Isolation

Type G: Isolators shall be devices with in-series contained steel springs and preformed fibrous-glass or chloroprene-elastomer elements for connecting to building-structure attachments. Devices shall be loaded by supported system during operating conditions to produce a minimum spring and elastomer static deflection of 1 inch 25 millimeter and 3/8 inch 10 millimeter, respectively.

Type H: Isolators shall be devices with contained chloroprene-elastomer elements for connecting to building-structure attachments. Devices shall be loaded by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8 inch 10 millimeter.

Type J: Isolators shall be devices with elastomers mounted on floor-supported columns or directly on the floor. Devices shall be loaded by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8 inch 10 millimeter.

2.6.4 Floor-Mounted Piping

Type K: Isolators shall be devices with springs mounted on floor-supported columns or directly on the floor. Devices shall be loaded by supported system during operating conditions to produce a minimum spring static deflection of 1 inch 25 millimeter.

2.6.5 Vertical Piping

Type L: Isolators shall be pipe base-support devices with one or more contained steel springs. Devices shall be loaded by supported system during operating conditions to produce a minimum static deflection of 1 inch 25 millimeter Devices shall be equipped with precompression and vertical-limit features, as well as a minimum 1/4-inch 6 millimeter thick elastomer sound pad and isolation washers, for mounting to floor.

Type M: Isolators shall be elastomer mounted baseplate and riser pipe-guide devices. Elastomer elements shall be contained double acting, and elastomers under rated load shall have a minimum static deflection of 3/8 inch 10 millimeter. Isolator shall be sized to accommodate thermal insulation within the stationary guide ring.

2.7 INSULATION

Thermal-insulation system materials shall be noncombustible, as defined by NFPA 220.

Surfaces to be insulated, extent of insulation, and thickness of insulation shall be as indicated on the contract drawings.

Insulation thickness and duct sizes are in inches millimeter. Nominal duct thickness sizes are internal dimensions. Internal insulation is [not] permitted. Pipe callouts are nominal pipe sizes in inches millimeter.

Insulation shall not impede access to duct covers/door used for duct cleaning and/or maintenance.

Mineral fiber blanket and felt insulation shall have a thermal conductivity less than 0.26 BTU inch/HR/square foot/degree F 0.037 watt per square meter per degrees K at operating temperatures, a density greater than 4 pounds per cubic foot. 64 kilogram per cubic meter. Insulation shall conform to ASTM C 553.

Mineral fiber rigid board and block insulation shall have a thermal conductivity less than 0.44 BTU inch/HR/square foot/degree F 0.063 watt per square meter per degrees K at operating temperature, a density greater than 3 pounds per cubic foot 48 kilogram per cubic meter. Insulation shall conform to ASTM C 612.

Fibrous glass blanket and board insulation shall have a thermal conductivity less than 0.27 BTU inch/HR/square foot/degree F 0.039 watt per square meter per degrees K at operating temperature, a density greater than 1 pound per cubic foot 16 kilogram per cubic meter. Insulation shall conform to ASTM C 1139.

Cellular glass shall have a minimum thermal conductivity less than 0.33 BTU inch/HR/square foot/degree F 0.048 watt per square meter per degrees K a density of 7.5 to 8.5 pounds per cubic foot 120 to 136 kilogram per cubic meter.

Cellular elastomer shall have a minimum thermal conductivity less than 0.27 BTU inch/HR/square foot/degree F/inch 0.039 watt per square meter per degrees K.

Cellular glass shall conform to ASTM C 552, Type II (pipe covering).

2.7.1 Adhesives

Adhesives shall be as recommended by the insulation manufacturer.

2.7.2 Jacketing

Jacketing shall be as recommended by the insulation manufacturer.

2.7.3 Coatings

Coatings shall be as recommended by the insulation manufacturer.

Coating color shall be as selected by the Contracting Officer.

Finish coating for cellular elastomer insulation shall be a polyvinylchloride lacquer approved by the manufacturer of the cellular elastomer.

2.8 BOILERS

Boilers shall have efficiencies in accordance with the recommended levels specified in DOE CE-5

Certificates shall be submitted for boilers showing efficiencies in accordance with the certification program specified in HYI RATINGS.

2.8.1 Factory Testing

Boilers, completely factory-assembled, shall be tested at the manufacturer's plant, and a certificate by an independent testing agency shall be submitted to the Contracting Officer for approval.

2.8.2 Firetube Boiler

Boiler shall be of the self-contained, multipass, package type, complete with accessories, mounted on a structural-steel base. A unit shall include the boiler, gas-burning equipment, boiler fittings, automatic controls, forced- or induced-draft fan, insulation, electric wiring, integral piping, and protective housing. Boiler shall be a horizontal, tubular, three-pass, Scotch marine type, constructed in accordance with ASHRAE-Hdbk SE-SI, Chapter 28, UL 834, and ASME BPVC SEC IV. Boiler shall have a minimum of 5 square feet 1/2 square meter of effective fireside heating surface per boiler horsepower wattage.

2.8.3 Watertube Boiler

Boiler shall be of the self-contained, package-type, complete with accessories, mounted on a structural-steel base. A unit shall include the boiler, gas-burning equipment, boiler fittings, automatic controls, forced-or induced-draft fan, insulation, electric wiring, integral piping, and protective housing. Boiler shall be constructed in accordance with ASHRAE-Hdbk SE-SI, Chapter 28, UL 834, and ASME BPVC SEC IV. Heating surface shall be based on a heat transfer of not more than 25,000 Btu per square foot 80 kilowatt per square meter per hour.

2.8.4 Gas-Burning Equipment

Automatic gas-fired units with input capacities of less than 300,000 Btu 87.9 kilowatt per hour shall be rated per DOE RE-5 [_____]. Automatic gas-fired units with input capacities of 300,000 Btu 87.9 kilowatt per hour and greater shall be rated GAMA [AGA-02] [UL] and comply with AGA Z21.13[UL 795]. Gas-fired burners shall be CSA Directory listed.

2.8.5 Atmospheric Gas Burners

Gas burners shall conform to AGA Z21.13. Gas burners shall be of the Bunsen type, the venturi type with raised, drilled ports, or the ribbon type of corrosion-resisting metal in cast-iron body, designed to operate without backfiring.

2.8.6 Fuel Oil Burners

Fuel oil burners shall be Factory Mutual (FM) and IRI (FIA) approved. Fuel oil burners shall have low fire start and may be of high-low, low-medium-high, or full modulation design for operation with No. 2 fuel oil.

2.8.7 Mechanical-Draft Gas Burner Unit

Burner shall be designed for horizontal installation and firing and shall conform to UL 726, ASME SI-01 and MS MIL-B-18796. A burner unit shall consist of a complete fuel system, flame safeguard controls, boiler limit and fuel safety interlocks, combustion controls, fan units, and other accessories and components necessary for safe and efficient operation.

2.8.7.1 Forced-Draft Fan Unit

Forced-draft fans shall be an electric motor direct-driven, damper-controlled, centrifugal or axial-flow type unit. Unit shall have sufficient air capacity for complete combustion of the maximum fuel quantity to be burned at maximum firing ratio plus 15 percent excess volume against a 32-percent static pressure overload. Unit shall be constructed and rated in accordance with ASHRAE-Hdbk SE-SI, Chapter 18, and ASHRAE 51. Adequate adjustments shall be included in the fan selection or design for maximum burner and boiler pressure drop, combustion air, and plant elevation above sea level.

2.8.7.2 Induced-Draft Fan Unit

Fans shall be designed especially for induced-draft service. Specified capacity shall be increased to compensate for the elevation above sea level at the point of installation, and shall be based on a flue-gas temperature of 550 degrees F 288 degrees C. Parts of the fan in contact with the flue gases shall be designed to withstand the corrosive effects of the smoke, gases, and fly ash as well as flue-gas temperature up to 600 degrees F 316 degrees C. Fan bearing shall have approved means to prevent overheating; provision shall be made for lubrication. Water-cooled bearings or air-cooled factory-sealed bearings shall be furnished if recommended by the fan manufacturer. Cleanout and inspection doors shall be provided in each fan housing. Unit shall be constructed and rated in accordance with ASHRAE-Hdbk SE-SI, Chapter 18, and ASHRAE 51.

2.8.8 Boiler Trim and Accessories

2.8.8.1 Gas-Pressure Regulating Valve

Valve shall be of the automatic type and of the proper capacity, shall be adjusted for an outlet pressure of 4 inches 1000 kilopascal of water for natural gas or 2-1/2 inches 625 pascal of water for manufactured gas, and shall be installed in the connection to the gas boiler. Valve shall be selected from those listed in ASHRAE-Hdbk SE-SI, Chapter 28, UL 834, and AGA-02.

2.8.8.2 Gas-Control Valves

Gas burner shall be supplied with an electric gas-control valve. Gas-control valve shall be positive in action, shall operate with a minimum of noise, and shall render satisfactory service with a 10-percent voltage fluctuation. Valve shall be designed to close immediately upon current failure and to remain closed until the current is restored. Manual control valves shall also be provided in the main line to the burner and in the pilot line. Automatic valves shall be selected from those listed in ASHRAE-Hdbk SE-SI, Chapter 28, UL 834, and AGA-02.

2.8.8.3 Pressure Gage and Thermometer

Combination pressure gage and thermometer with suitable pressure and temperature ranges shall be installed on each boiler.

2.8.8.4 Pressure-Relief Valves

Each boiler shall be provided with one or more relief valves constructed and installed in strict accordance with ASHRAE-Hdbk SE-SI, Chapter 28, UL 834, and ASME BPVC SEC IV. Aggregate relieving capacity of the relief valves shall be not less than that required by the above referenced publication. Relief valves shall be ASME rated and stamped.

2.8.9 Combustion Safety Controls

Combustion-control system shall be automatic and shall be installed in strict accordance with the manufacturer's recommendations and under the direct supervision of a representative of the manufacturer. Combustion controls shall conform to applicable requirements of UL 726, ASME SI-01 and MS MIL-B-18796, except as revised herein. Upon completion of the installation, the Contracting Officer shall be furnished with a written statement from the manufacturer's representative certifying that the combustion-control equipment has been properly installed and is in perfect operating condition.

2.8.9.1 Atmospheric Burners

A flame-failure, safety-control system of the electronic type incorporating a flame rod shall be provided. Ignition of electronically supervised pilots shall be accomplished with a suitable start-stop station so that manual depression of the start button will energize only the pilot valve and ignition transformer. On proof of pilot flame, the main gas valve shall cycle on demand of the controller. Upon failure of main and pilot flame, all fuel valves shall be deenergized and an alarm shall sound within 2 to 4 seconds. System shall require manual restart. Pilot shall be supervised during the off-cycle of the main burner and the pilot valve shall close and sound an alarm if any electronically supervised pilot is extinguished.

Components of the system shall consist of, but shall not be limited to, a flame sensing device, electronic relay, pilots, disconnect switch, wiring, pressure regulators, interlocks, gas control valves, and pilot gas control valve.

2.8.9.2 Mechanical-Draft Burners

A complete, fully automatic flame-failure, safety-control system of the electronic type, including a prewired and factory-tested programming assembly, shall be provided. Controls shall conform to the requirements of UL 726, ASME SI-01 and MS MIL-B-18796. Control shall be of the fail-safe design where component failure within the control or the presence of actual or simulated flame prior to startup will prevent burner operation. Flame-failure control shall be readily removable from the chassis for servicing without disconnecting any wiring. Necessary devices for automatic starting and programming of the pilot and main-burner equipment shall be furnished. Flame-failure sensing device shall be of the flame-frequency, ultraviolet-detector, or flame-rectification type operating in conjunction with an electronic relay. Relay shall open the circuit to the fuel valves in not more than 4 seconds if main-burner flame

is not properly established or upon flame failure and shall also actuate an alarm.

Controls shall create a safety shutdown prior to energization of the main fuel valve if the pilot flame is not ignited and detected by the sensing device.

This pilot-proving period shall be limited to 10 to 15 seconds. Trial for main fuel ignition shall be limited to 15 seconds, and repurging the boiler of combustion gases by at least four air changes shall be mandatory if ignition does not occur during the 15-second period. Control shall recycle automatically after a limit or operating control opens or after an electrical failure. A safety shutdown due to flame failure shall require manual reset of safeguard controls before operation can be resumed and shall prevent recycling of the burner equipment. A low-fire start shall be provided on high-low-type burner controls.

Components of the system shall include a motor starter, disconnect switch, electronic flame relay, alarm relays, indicating lights, flame-sensing device, wiring, control cabinet, damper for draft control, gas-shutoff safety valve, fan interlocks, airflow switches, and gas-pressure controls.

2.9 REFRIGERATION PIPING AND SPECIALTIES

2.9.1 Piping and Fittings

Tubing (to 7/8-inch 22 millimeter outside diameter (od)): Annealed Type K, conforming to ASTM B 88 ASTM B 88M, where bending or flare connection is required

Tubing (over 7/8-inch 22 millimeter od): Hard-drawn, seamless-copper tubing conforming to ASTM B 280, No. C12200

Fittings (to 7/8-inch 22 millimeter od): Flared-type, conforming to SAE J513

Fittings (over 7/8-inch 22 millimeter od): 150-psig 1050 kilopascal, wrought-copper socket-joint, conforming to MSS SP-104 and ASME B16.22

Flexible connectors (all sizes): Flexible connections for reciprocating equipment shall be of the seamless, corrugated, all nonferrous-metal type with external nonferrous metal reinforcing braid.

2.9.2 Refrigerant Liquid Receiver

Receiver shall conform to ASHRAE-06, and ASHRAE-Hdbk SE-SI, ASHRAE-05 and ASME BPVC SEC VIII D1 with stamp, and to requirements indicated and specified herein.

Refrigerant liquid receiver shall have all necessary openings, accessories, and support provisions.

Pumpdown capacity of receiver shall be 80 percent of the internal volume of the receiver.

Receiver shall be equipped with inlet-outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ASHRAE 15, and two bull's-eye liquid-level sight glasses. Sight glasses shall be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the

receiver, and not over 3 inches 75 millimeter horizontally from the drop pipe, measured along the axis of the receiver. In lieu of bull's-eye sight glass, external gage glass with metal glass guard and automatic-closing stop valves may be provided.

2.9.3 Shutoff and Check Valves

Shutoff valves shall be packless diaphragm (in sizes commercially available), with packed, ground-finish stem, key operated, back seating, sealed-cap type; otherwise, angle pattern valves shall be used whenever possible. Check valves shall be lift type for gases and vapors and swing-check type for liquids.

2.9.4 Solenoid Valves

Valves shall be brass or steel body, packless type, with corrosion-resistant steel trim, rated for continuous-duty service, direct-or pilot-operated, provided with manual lift stems, and designed for use with type of refrigerant used. Valve capacities shall be sufficient for the requirements of the installation at a pressure drop not in excess of 2 psi 14 kilopascal. Valves in suction lines shall be sized in accordance with temperature rise and superheat normal to the system.

2.9.5 Expansion Valves

Valves shall be thermal-expansion type to suit specific system refrigerant, designed to fit coil distributors, and capable of operating from 40 to 100 percent of full load at system head pressure without hunting or liquid hammer. Valves shall have external equalizer connections and external superheat adjustments with seal caps. Joint connections shall be mechanical threaded or flanged type. Valves shall require not over 4 degrees F 15 degrees C superheat change to move from fully open to fully closed position. Superheat setting shall be 10 degrees F minus 12 degrees C at full load.

Expansion valves shall be balanced double seated or pilot operated, capable of stable operation at 15 percent design load.

Each valve shall be provided with external strainer.

2.9.6 Evaporator Pressure Regulators

Evaporator pressure regulators shall have a maximum pressure drop at design conditions of 3 psi 21 kilopascal with refrigerants R-22 or R-502. Regulators shall be installed with valved gages upstream and downstream and shall be fully adjustable, both for setting and for throttling range from open to closed.

2.9.7 Filter/Dryers

Filter/dryers in sizes 1/2 inch 13 millimeter and larger shall be the full-flow, replaceable-core type. Sizes smaller than 1/2 inch 13 millimeter shall be the sealed type. Cores shall be of a suitable desiccant that will not plug, cake, dust, channel, or break down but shall remove water, acid, and foreign material from the refrigerant. Dryer shall be constructed so that no desiccant will pass into the refrigerant lines. A filter/dryer shall be provided in the liquid line to each evaporator and shall be piped with a three-valve bypass. Pressure drop through the dryer shall not exceed 2 psi 14 kilopascal when operating at full connected evaporator capacity.

2.9.8 Liquid Sight Glasses

Sight glasses shall be double glass, see-through type, with cover cap on each side. Sight glass shall be provided in liquid line immediately preceding each expansion valve. Glass shall be furnished with a color-change-type moisture indicator.

2.9.9 Moisture Indicators

Color-change moisture indicators shall be provided downstream from each filter/dryer and bypass or shall be combined as a single unit in the liquid sight glasses.

2.9.10 Discharge-Line Oil Separator

Discharge-line oil separator of rated capacity equal to or greater than the compressor capacity shall be provided in the discharge line from each compressor when recommended by the compressor manufacturer for the specific installation. Separator shall be provided with an oil float-valve assembly or needle valve and orifice assembly, drain-line shutoff valve, and sight glass. Oil-return line shall be connected to the compressor as recommended by the compressor manufacturer.

2.9.11 Liquid-Suction Interchangers

Liquid-suction interchangers shall be provided to increase system efficiency to subcool liquid refrigerant or to prevent liquid refrigerant from entering the compressor.

2.9.12 Line Strainers

Strainers shall be Y-type with removable basket. Strainers in sizes 2-inch DN50 ips and smaller shall have solder ends; in sizes 2-1/2-inch DN65 ips and larger, strainers shall have flanged ends. Minimum body working-pressure rating shall be 250 psig 1800 kilopascal. Body shall have cast-in arrows to indicate direction of flow. Strainer bodies fitted with screwed screen retainers shall have straight threads and shall be gasketed with nonferrous metal. Strainer bodies fitted with bolted-on screen retainers shall have offset blowdown holes. Body material shall be cast bronze in sizes 2 inches DN50ips and smaller, and cast bronze or cast iron in sizes 2-1/2 inches DN65 ips and larger.

Minimum free-hole area of strainer element shall be equal to not less than 5 times the internal area of connecting piping. Strainer screens for liquid service shall have perforations not to exceed 0.010 inch 0.25 millimeter or equivalent wire mesh. Strainer screens for vapor or gas service shall have perforations not to exceed 0.02 inch 0.50 millimeter or equivalent wire mesh. Strainer screens shall have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material shall be AISI Type 304 or 316 corrosion-resistant steel.

2.9.13 Mufflers

A muffler shall be provided in a hot-gas discharge line.

2.10 RECIPROCATING REFRIGERANT COMPRESSOR UNITS

Reciprocating refrigerant compressor unit shall consist of a multicylinder

compressor, prime mover, drive, and specified accessories for remote location. Unit shall be mounted on a vibration-isolated, welded, rolled structural steel or cast-iron base.

2.10.1 Compressor

Compressor shall conform to performance criteria as shown on the [drawings] [equipment schedule].

2.10.2 Motors

Hermetically sealed motors shall conform to requirements of ARI 520 for motors specified herein, except that two manually resettable thermal overload protective devices shall be located within motor windings.

2.10.3 Accessories

Crankcase oil heaters shall be provided and shall be controlled as recommended by the manufacturer.

An external oil filter (in addition to oil pump suction strainer) and magnetic plugs in crankcase shall be provided.

2.11 RECIPROCATING COMPRESSOR-CONDENSER UNITS

Reciprocating compressor-condenser unit shall include a multicylinder compressor, prime mover, drive, condenser, receiver, intercomponent piping and wiring, control panel, and specified accessories for remote location. Unit shall be mounted on a vibration-isolated, welded structural-steel base ready for terminal field connections.

2.11.1 Compressor

Compressor shall conform to performance criteria as shown on the [drawings] [equipment schedule].

2.11.2 Accessories

Crankcase oil heaters shall be provided and shall be controlled as recommended by the manufacturer.

An external oil filter (in addition to oil pump suction strainer) and magnetic plugs in crankcase shall be provided.

2.11.3 Air-Cooled Condenser

Unit shall conform to performance criteria as shown on the [drawings] [equipment schedule].

2.11.3.1 Fans and Drives

Fans shall be propeller type, of corrosion-resistant construction, and shall be statically and dynamically balanced to ISO 1940-1-1986, [G6.3] [G2,5] [G1,0] [_____]. Fan discharge shall be vertical. Maximum fan tip speed shall be 10,000 feet per minute (fpm) 50 meter per second.

Fan drive shall be direct.

Fan drive shall be V-belt, with corrosion-protected shaft and antifriction

type bearings. [Bearings shall be sealed against moisture and dirt, prelubricated, and suitable for not less than 10,000 operating hours without need of relubrication] [Bearings shall be permanently lubricated sealed bearings].

Condenser fan motors shall be totally enclosed type.

Condenser fan motors shall be resiliently mounted.

2.11.3.2 Condensing Coil

Condensing coils shall be designed and sized specifically for air-cooled condenser service. Coil construction shall be seamless copper tube, with copper or aluminum extended surface integral with or mechanically attached to the tube.

Where a condenser is being used as a combination receiver, the pumpdown capacity shall be 80 percent of the available condenser volume. Coil shall be protected from physical damage.

2.11.3.3 Condensing Pressure Control

Condensing pressure control shall be accomplished by an electronic solid-state control system that will modulate speed of the motor, from 0 to 100 percent by fan cycling or by a combination of methods.

2.11.4 Water-Cooled Condenser

Water-cooled condenser shall include all necessary water and refrigerant connections, purge valve, relief devices and refrigerant valves.

Condenser shall conform to performance criteria as shown on [drawings] [equipment schedule].

Where a condenser is being used as a combination receiver, the pumpdown capacity shall be 80 percent of the available condenser volume.

Unit shall be selected for water velocities not in excess of 7 fps 2 meter per second and a fouling factor of 0.0010.

2.11.4.1 Construction

Condensing surface between halogen refrigerant and cooling water shall be copper; tube sheets shall be nonferrous metal.

Compressor suction and discharge valves shall be flange connected, wrench operated, rising stem type, and with cap. Other valves shall be packless type, wherever possible.

Refrigerant circuit shall be factory cleaned and factory charged with dry nitrogen or refrigerant.

2.12 COILS

2.12.1 Coil Pressure and Temperature Ratings

Coils shall be designed for the following fluid operating pressures and temperatures:

SERVICE	PRESSURE (PSI)	TEMPERATURE (DEGREES F)
Steam - low pressure	25	267
Steam - high pressure	150	366
Steam - superheated	350	500
Hot water	200	250
Chilled water	200	250
Volatile refrigerant	200	300

SERVICE	PRESSURE (kPa)	TEMPERATURE (DEGREES C)
Steam - low pressure	170	131
Steam - high pressure	1050	178
Steam - superheated	2400	260
Hot water	1400	121
Chilled water	1400	121
Volatile refrigerant	1400	149

Coils shall be air-pressure tested under water at following minimum pressures:

SERVICE	PRESSURE (PSI)
Steam (low and high pressure)	250
Water (hot and chilled)	250
Volatile refrigerant	400

SERVICE	PRESSURE (kPa)
Steam (low and high pressure)	1700
Water (hot and chilled)	1700
Volatile refrigerant	2800

2.12.2 Coil Casings

Coil casing shall be mill-galvanized sheet metal with not less than 1.25 ounces of zinc per square foot 0.38 kilogram of zinc per square meterof two-sided metal surface conforming to ASTM A 527/A 527M. Minimum shall be 16-gage 1.6 millimeter, and casing shall be flanged on four sides for bolted assembly.

2.12.3 Coil Headers

Coil headers shall be cast iron, brass, copper, or aluminum casting.

Direct expansion, volatile refrigerant coils shall have copper or brass headers with necessary control connections.

Steam and water coil headers shall be fitted with 1/4-inch DN8 ips spring-loaded plug drains and vent petcocks. Automatic vents shall be provided where needed.

2.12.4 Coil Tubing

Coils shall be constructed of copper tubing with aluminum or copper fins. Helical coil fins shall be wound tight to the tubes and solder-coated. Plate fins shall have spacer collars in metallic contact with the adjacent fin, and fins shall be mechanically bonded to the tube. No bare tube surface shall be visible within the finned portion of the coil.

Cooling coils of helical wound copper design shall be solder-coated.

Coil tubes in water and volatile refrigerant service shall be parallel and shall have sufficient intermediate full coil depth supports to prevent sagging of unsupported span due to working fluid pressures and temperatures and summer and winter coil-ambient conditions. Sagging shall be unacceptable if tube centerline is displaced by more than 3/16 inch 5 millimeter from centerline of tube connection at outlet header when coils are more than two rows deep and when installed in accordance with the manufacturer's instructions. Provisions for expansion and contraction shall be adequate to preclude sagging and distortion under thermal loads applied in indicated or specified service. Tubes shall be sloped to be free draining.

Heating-coil face tube spacing shall be a maximum of 3 inches 75 millimeter on center for 1-inch DN25 tubes, 2 inches 50 millimeter for 3/4-inch DN20 tubes, and 1-1/2 inches 38 millimeter for 5/8-inch DN18 tubes.

Coil face tube spacing for cooling coils and for helically wound heating coils immediately followed by water-cooling coils shall not exceed 1-1/2 inches 38 millimeter on center.

Tubes shall be straight, turns shall be made through headers or return U-bends, and connections and joints shall be brazed.

Coil tube material shall be seamless deoxidized copper.

Coil tube material for superheated-steam service to 350 psi 2400 kilopascal at 500 degrees F 260 degrees C shall be seamless 90-10 copper-nickel with 0.035-inch 0.89 millimeter wall thickness.

Raw coil tube stock wall minimum thickness shall be 0.035 inch 0.89 millimeter.

Where mechanical insert devices are used to increase liquid turbulence within tubes, the wall thickness of these tubes shall be increased by 0.010 inch 0.25 millimeter over the minimum raw coil tube stock specified for the service.

Tube minimum outside diameter shall be 5/8 inch 18 millimeter.

2.12.5 Coil Circuiting

Standard or full-circuited water coils shall have as many full-length tubes in each circuit as the number of tubes in the depth of the coil face; double-circuit water coils shall have twice as many as standard coils; and half-circuit water coils shall have half as many as standard coils and to the next larger whole number where odd numbers are involved.

Coils more than two rows deep shall be counterflow type; however double- or half-circuit coils, with a reasonable deviation from counterflow arrangement may be used, provided the pressure drop and capacity requirements are met.

2.12.6 Drainable Coils

Drainable coils shall be capable of being purged free of water with compressed air.

Self-draining coils shall have a drain point at the end of every tube and shall be pitched to that point. Drain provisions shall include: drained headers; U-bends with integral plugs; or nonferrous plugs in cast-iron headers. Each tube shall drain substantially dry by gravity alone when drains and vents are open.

Coil pitch and leveling shall be field checked for drainability in the presence of the Contract Administrator.

2.12.7 Testing

Coils shall be factory pressure tested, dehydrated, vacuum tested, purged with inert gas, and sealed, prior to shipment to job site.

2.13 UNIT HEATERS

Unit heaters shall be suspended type and arranged for discharge of air as indicated on the construction drawings. Unit shall comply with applicable American Gas Association standards.

2.13.1 Casing

Casing shall be manufactured of not less than 20-gage 1 millimeter steel. Casing inside and outside shall be given a phosphate pretreatment, primer, and baked enamel finish. Horizontal louvers shall be provided and shall be completely recessed inside of the casing frame.

2.13.2 Heat Exchangers

Heat exchangers shall be welded construction, heavy aluminized steel. Each exchanger shall be formed in a clam-shell design to completely surround the burner. Individual combustion chambers shall be provided for each burner.

2.13.3 Burners

Burners shall be die-formed, aluminum-painted, heavy thickness mild steel with long slot ports for even supply of gas. Burner assembly shall be of unitized construction with integral crossover for positive burner ignition. A draft diverter shall be an integral part of each heat exchanger section

to allow backdrafts to bypass burner assembly without affecting normal operation.

2.13.4 Fans

Fans shall be propeller type, designed and manufactured for unit heater application. Fans shall have a minimum of three aluminum blades.

2.13.5 Motors

Motors shall conform to NEMA MG 1, be totally enclosed, with sleeve bearings and built-in overload protection. Motors shall be mounted to back panel by a fan guard motor mount constructed of spring steel wire.

2.13.6 Controls

Controls shall include high limit switch, fan controls, a 24-volt automatic gas valve with 100 percent safety pilot shutoff, a pressure regulator with leak limiting device, and manual main and pilot valves. An integral junction box for power and control connections shall be provided.

2.13.7 Propeller Unit Heaters (PUH)

2.13.7.1 Vertical Discharge Units

Vertical discharge units shall operate at speeds not in excess of 1,200 revolutions per minute (rpm), except that units with 50,000 Btu 15 kilowatt per hour output and less shall operate at speeds up to 1,800 rpm. Discharge opening shall be covered with a fanguard.

Louver cone diffusers shall be provided.

2.13.7.2 Horizontal Discharge Units

Maximum volume and face velocity for horizontal discharge units shall be:

CFM	FPM
Up to 1,000	800
1,001 to 3,000	900
3,001 and over	1,000
CUBIC METER PER SECOND	METER PER SECOND
Up to 0.47	4.1
0.48 to 1.42	4.6
1.43 and over	5.1

Adjustable double deflection louvers shall be provided.

2.13.7.3 Heating Elements

Heating elements shall be manufacturer's standard construction, rated for service at not less than 300 degrees F at 75 psi 150 degrees C at 520

kilopascal.

2.13.7.4 Casings

Casings with smoothly contoured propeller orifice rings shall be constructed of 20-gage 1 millimeter or thicker cold-rolled carbon steel. Casing surface finish shall include phosphate pretreatment, prime coating, and baked enamel finish.

2.13.7.5 Propellers and Motors

Propellers shall have not less than four aluminum blades and shall be dynamically balanced to ISO 1940-1-1986, [G6.3] [G2.5] [G1.0] [_____].

Horizontal-discharge units shall be provided with fan inlet safety guard.

Motors shall be mounted on elastomer vibration isolators.

2.13.7.6 Sound Rating

Unit heater shall be tested and sound rated in accordance with AMCA 300and AMCA 301.

2.13.7.7 Control

Unit heaters shall be controlled by line-voltage thermostats.

2.13.8 Cabinet Unit Heaters (CUH)

Cabinet unit heaters shall be quiet-operating type, complete with heating elements, fans and drives, filters, baffles and division walls, control provisions, and enclosures with access panels as necessary.

Cabinet shall be sized not larger than indicated in the detail drawings.

Unit pressure components shall be rated for service at not less than 150 psi 1050 kilopascal at system working temperature.

2.13.8.1 Heating Element (CUH)

Heating element shall be manufacturer's standard aluminum fin or serpentine copper-type tube and shall be drainable and ventable.

Cataloged capacity of the heating element shall be constant and permanent.

Tube material shall be seamless deoxidized copper.

Fins shall be mechanically connected to the tubes. Loose fins at operating temperatures will be regarded as causing a reduction in capacity, and the Contractor shall replace such material at no additional cost to the Government. Elements with bent fins are not acceptable.

Expansion provisions and supports shall be such that element movement is strainfree and noiseless.

Face area of the coil shall be not less than that indicated in the detail drawings.

2.13.8.2 Fan and Drive Assembly (CUH)

Fan shall be centrifugal, forward-curved, double-width, double-inlet type, and shall be statically and dynamically balanced to ISO 1940-1-1986, [G6.3] [G2.5] [G1.0] [_____].

Fan drives shall be direct.

Fan drives shall be direct, except where belt drives are indicated in detail drawings. Belt-drive motors shall be fitted with adjustable rails and an adjustable sheave to permit 20 percent adjustment to fan speed. Independent fan shafts shall be elastomer mounted in self-aligning antifriction or sleeve-type bearings, with essentially lifetime lubrication.

Drives shall be two-, three-, or four-speed and switch positions shall include an off position.

Rotating elements shall be statically and dynamically balance to ISO 1940-1 -1986, [G6.3] [G2.5] [G1.0] [_____]d, and fan and drive assembly shall be vibration isolated.

Direct-drive motors shall not exceed 1,200 rpm.

2.13.8.3 Filters (CUH)

Filters shall be installed in a bypass-proof frame to ensure filtering of all moving air before entry into heating element and shall be removable without tools.

2.13.8.4 Enclosures (CUH)

Enclosure configuration shall be as indicated in the detail drawings.

Enclosure surface finish shall include manufacturer's standard phosphate pretreatment, prime coat, and baked enamel finish in color as selected by the Contracting Officer.

2.13.8.5 Insulation (CUH)

Backs of recessed units shall be insulated with not less than 1/2 inch 13 millimeter of 3-pound per cubic foot 48 kilogram per cubic meter density fibrous-glass insulation conforming to NFPA 90A.

2.13.8.6 Control Cycle (CUH)

Sequence of operation shall be as indicated in the Control Diagrams.

Control components shall conform to requirements specified under paragraph entitled, "Controls."

2.13.9 Unit Ventilators (UV)

Unit ventilators shall be quiet-operating modular type, complete with heating elements, fans and drives, filters, baffles and division walls, dampers, control provisions, and enclosures with access panels as necessary.

Unit pressure components shall be rated for service at not less than 150 psi 1050 kilopascal at system working temperature.

Intercomponent wiring shall conform to NFPA 70, and components of unit assembly shall be UL listed and approved.

Heating, fan, and control modules shall have polarized, color-coded, plug-in connections.

2.13.9.1 Heating Element (UV)

Heating element shall be the manufacturer's standard aluminum fin or serpentine copper-tube type and shall be drainable and ventable.

Cataloged capacity of the heating element shall be constant and permanent.

Tube material shall be seamless deoxidized copper.

Fins shall be mechanically connected to the tubes. Loose fins at operating temperatures will be regarded as causing a reduction in capacity, and the Contractor shall replace such material at no additional cost to the Government. Elements with bent fins are not acceptable.

Expansion provisions and supports shall be such that element movement is strainfree and noiseless.

Face area of the coil shall be not less than that indicated in the detail drawings.

2.13.9.2 Fan and Drive Assembly (UV)

Fan shall be centrifugal, forward-curved, double-width, double-inlet type, and shall be statically and dynamically balanced.

Fans shall be belt driven, mounted on a common shaft. Shaft shall be supported by independent, elastomer-mounted, self-aligning, antifriction or sleeve-type bearings with lifetime lubrication. Motor sheave shall be adjustable to provide not less than 20 percent speed variation either way from capacity point. Belt tension shall be adjustable.

Motor shall be manually controlled by two-position on/off switch.

Motor shall be manually controlled by three-position, high/low/off switch.

Motors shall be elastomer vibration-isolation mounted, permanent split-capacitor type with adjustable rail mounting.

2.13.9.3 Filters (UV)

Filters shall be installed in a bypass-proof frame to ensure filtering of all moving air before entry into the heating element and shall be removable without tools.

2.13.9.4 Dampers (UV)

Dampers shall be opposed-blade type constructed to resist salt air. Blades shall be galvanized steel with mechanically attached or secure sealing provisions not dependent upon adhesives. Bearings shall be high-grade commercial quality flanged-type with extended race and corrosion-resistant steel balls and plated races with factory-applied grease conforming to MS DOD-G-24508.

Face and bypass damper shall be provided with external bypass duct if required by the Unit Ventilator.

Mixing dampers shall be provided as an assembly within a mixing box. Dampers shall be capable of varying the proportion of mixed air from 100 percent room air to 100 percent outside air.

2.13.9.5 Enclosure (UV)

Enclosure surface finish shall include manufacturer's standard phosphate pretreatment, prime coat, and baked enamel finish, except as otherwise provided. Color shall be as selected by the Contracting Officer.

2.13.9.6 Wall Sleeve (UV)

Wall sleeve shall be constructed of not less than 18-gage 1.3 millimeter galvanized carbon steel. Finish shall consist of manufacturer's standard galvanized surface preparation and not less than two finish coats of baked enamel or one finish coat of high-build epoxy. Color shall be as selected by the Contracting Officer.

2.14 FAN COIL UNITS

Units shall include an enclosure for cabinet models and casing for concealed models.

Unit color shall be [_____], or approved by the Contracting Officer.

2.14.1 Enclosure

Enclosure shall be constructed of not lighter than 18-gage 1.3 millimeter steel, properly reinforced and braced. Discharge louvers shall be four-way adjustable and shall be designed for proper air distribution throughout the conditioned space. Ferrous-metal surfaces shall be galvanized or treated with a rust-inhibiting finish. Exposed-to-view enclosure corners and edges shall be rounded. Access doors shall be hinged and shall be provided for piping and control compartments.

2.14.2 Casing

Casing shall be acoustically and thermally insulated internally with not less than 1/2-inch 13 millimeter thick insulation.

2.14.3 Coils

Water coils shall be constructed of not less than 1/2-inch DN15 od seamless copper tubing with copper or aluminum plate fins mechanically bonded or soldered to the tubes and shall be provided with not less than 5/8-inch 18 millimeter od control valve.

2.15 AIR HANDLING UNITS (FACTORY ASSEMBLED)

Air handling unit shall be central-station type, factory fabricated, and sectionally or fully assembled. Performance shall be in accordance with values on [equipment schedule] [drawings].

Fan wheels shall be statically and dynamically balanced to ISO 1940-1-1986, [G6.3] [G2.5] [G1.0] [_____].

Dynamic balancing shall be in two planes.

2.15.1 Air-Handling System Balancing Provisions

Facilities shall be provided for the adjustment of fan speed for each air-handling system during air-quantity balancing operations, when required. Facilities provided shall be one of the following:

A variable-pitch drive with variable range to produce the fan speed necessary for proper air balance

A continuously variable drive or power unit to produce the fan speed necessary for proper air balance

Fixed-pitch pulleys providing the proper fan speed.

2.15.2 Motor Requirements

Hermetically sealed compressor motors shall conform to requirements for motors specified herein and to NEMA MG 1, and ARI 520, except that two manually resettable thermal overload protective devices shall be located within motor windings.

2.15.3 Unit Cabinet

Exterior surfaces of cabinets constructed of mill-galvanized steel shall be prepared by a phosphatizing treatment, and painted with two coats of manufacturer's standard enamel finish in color selected by the Contracting Officer.

2.15.4 Multizone Units

Multizone unit delivery dampers shall be part of the manufacturer's standard unit construction.

Face and bypass dampers and multizone unit delivery dampers shall be part of the manufacturer's standard unit construction.

A balancing plate shall be added to the heating coil when required to equalize resistance in airstreams of multizone units.

2.16 AIR HANDLING UNITS (FIELD ASSEMBLED)

Air handling unit shall be central station type of indicated configuration and shall include enclosure, centrifugal fans, guarded V-belt drives, motors, heating and cooling coils, filters, dampers, vibration isolation provisions, and indicated and specified accessories.

In addition to scheduled maximum system operating pressure and system testing pressure, the ceiling shall be capable of sustaining 35 pounds per square foot 1675 pascal load without permanent deformation or damage. Material shall be hot-dip galvanized.

2.16.1 Enclosure

Enclosure surfaces shall consist of self-supporting ceiling and wall panels mounted on, and fastened to, a concrete curbing. Self-supporting shall be defined as free of building construction, except building floor.

2.16.2 Coil Supports

Coil supports shall be fabricated structural steel not less than 1/4 inch 6 millimeter thick, hot-dip galvanized after fabrication. Hot-dip galvanizing shall conform to ASTM A 123/A 123M except that the amount of deposited zinc shall be not less than 2.3 ounces per square foot 700 gram per square meter of single-side surface when tested in accordance with ASTM A 90/A 90M.

2.16.3 Access Doors and Panels

Access doors shall be not less than 24 by 60 inches 6000 by 1525 millimeter and shall be constructed of 16-gage 1.6 millimeter galvanized metal. Doors shall be provided with two heavy-duty hinges with removable pins and a like number of heavy-duty latch sets operable from either side. Latch sets shall be of cast iron or wrought steel construction with provisions for wear adjustment. Doors shall seal against mechanically retained expanded chloroprene elastomer gaskets.

2.16.4 Drain Pans

Intermediate-coil, 3-inch 75 millimeter deep drip pans shall be provided for each tiered coil bank. Bottom pans shall be provided below the lowest coil. For tiered cooling coils, top pan shall extend 12 inches 300 millimeter beyond face of coil, and bottom pan shall extend not less than 24 inches 600 millimeter beyond base of coil. Where more than two pans are used, pan extension shall be proportional. Adequate supports shall be provided, made from the same type material as pans or hot-dip galvanized angle iron with isolation at interface. Pan material shall be 22-gage 0.85 millimeter, Type 304 corrosion-resistant steel with silver-soldered joints. To preclude standing water, drain pan shall be piped and sloped to drain. Drain shall be located at the lowest point. Exterior of pan shall be insulated to prevent condensation.

2.16.5 Eliminators

Eliminators shall be SMACNA three-break, hooked-edge design, constructed of reinforced 16-gage 1.6 millimeter galvanized steel with assembled brazed joints. Eliminator sections shall be easily removable for cleaning.

2.17 PACKAGED AIR-CONDITIONING UNITS

Air-cooled single package and split system units shall have efficiencies in accordance with the recommended levels specified in DOE CE-3.

2.17.1 Window-Type, Packaged, Self-Contained

Unit shall be a packaged self-contained assemblage that includes hermetic compressor, fan(s), motor drives, coils and controls for fully automatic operation, intercomponent piping and wiring, totally enclosed weatherproof casing, and frame mounting ready for power connection.

Refrigerant shall be R-22 or R-134a. Units shall be shipped with a refrigerant holding charge.

2.17.1.1 Construction

Controls shall be located on front face of unit or with remote thermostat with on/off/fan selector, or at a remote panel. Conditioned-air

circulating fan control shall be two- or three-speed, gradually adjustable, or solid-state.

Unit shall have provisions for admitting controlled amounts of outside air as makeup and for exhausting internal air.

Unit shall meet or exceed an Energy Efficiency Ratio (EER) rating as specified in DOE RA-1.

2.17.2 Console-Type, Packaged, Self-Contained

Unit shall be packaged, self-contained, floor-mounted assemblage which includes compressors, fans, motor(s), drives, coils, water-cooled condenser, controls for fully automatic operation, intercomponent piping and wiring, and a single casing suitable for exposed-to-view office locations ready for field terminal connections. Unit shall meet or exceed a 7.5 EER.

Units over 65,000 Btu 70 Megajoule shall meet or exceed 8.2 EER.

2.17.3 Remote-Split-Type, Packaged, Self-Contained

Air-conditioner shall consist of matched assemblies. Each unit shall be provided complete with frame and enclosure, interconnecting piping and wiring, necessary controls and safety devices, and operating charge of oil. Unit shall be ready for full-capacity operation after removal of shipping protection, connection to remote compressor/condenser or condenser, charging, and connection to utilities. Units shall be shipped with a refrigerant holding charge. Performance shall be in accordance with values shown on the [drawings] [equipment schedule].

Unit shall exceed a rating of 8.2 EER.

2.17.3.1 Air-Cooled Condenser

Air-cooled condenser with vertical/horizontal discharge, in a weather-protected casing, shall be suitable for installation remote from air-conditioning unit. Air inlet and discharge grilles shall be provided with galvanized wire-mesh birdscreens.

2.17.3.2 Water-Cooled Condenser

Water-cooled condensers shall include openings, water and refrigerant connections, purge valves, relief devices, refrigerant valves, liquid-level indicating device, and support provisions.

2.17.3.3 Vibration Isolation

Vibration isolation provisions shall conform to requirements specified in paragraph entitled, "Vibration Isolators."

2.18 DUCTWORK

2.18.1 Galvanized Steel Ductwork Materials

Galvanized steel ductwork sheet metal shall be carbon steel, of lock-forming quality, hot-dip galvanized, with regular spangle-type zinc coating, conforming to ASTM A 527/A 527M, G90. Duct surfaces to be painted shall be treated by phosphatizing.

Sheet metal thickness and reinforcement thickness shall conform to ASHRAE-05, ASHRAE-Hdbk SE-SI and SMACNA 1481.

2.18.1.1 Duct Hangers

Duct hangers in contact with galvanized duct surfaces shall be galvanized steel.

2.18.1.2 Mill-Rolled Reinforcing and Supporting Materials

Mill-rolled structural steel shall conform to ASTM A 36/A 36M and, whenever in contact with sheet metal ducting, shall be galvanized to commercial weight of zinc.

2.18.2 Rigid Fibrous-Glass Ductwork Materials

Rigid fibrous-glass duct system, including tapes, adhesives, vapor barriers, and joint sealers, shall conform to requirements of NFPA 90Aand shall have FM P7825 approval and UL 181, Class 1 airduct listing, and be so labeled. Duct system shall have a thermal-conductivity K-value of 0.26 Btu foot per hour per square foot per degrees F 0.45 watt per meter degrees K for flat and 0.23 Btu foot per hour per square foot per degrees F 0.40 watt per meter degrees K for round duct at 75 degrees F 24 degrees C mean temperature. Duct system shall have a noise-reduction coefficient of 0.070 and a vapor-transmission rate of less than 0.02 perm 0.011 nanogram per pascal second square meter for flat board and 0.10 perm 0.06 nanogram per pascal second square meter for round duct. Minimum density shall be 5 pounds per cubic foot 80 kilogram per cubic meter for flat board and 3.25 pounds per cubic foot 52 kilogram per cubic meter for round duct. Vapor barrier shall be factory applied. Materials shall be odorless and nonallergenic when in service.

2.18.3 Flexible Duct Materials

Flexible duct connectors shall be in accordance with UL 181, Class 1 material and shall comply with NFPA 90A.

Metal duct shall be bendable through 180 degrees without damage, with an inside bend radius not greater than one-half the diameter of duct. Metal shall be aluminum or carbon steel protectively zinc-coated with materials conforming of ASTM A 123/A 123M or MS MIL-P-26915.

Wire-reinforced cloth duct shall consist of a chloroprene or vinyl-impregnated and coated fibrous-glass cloth bonded to and supported by a corrosion-protected spring steel helix. Fabric may be a laminate of metallic film and fibrous glass. Working pressure rating of ducting shall not be less than three times maximum system pressure, and temperature range shall be within minus 20 to plus 175 degrees F minus 27 to 75 degrees C.

Wire-reinforced fibrous-glass duct shall consist of a minimum 1-pound per cubic foot 16 kilogram per cubic meter density fibrous glass bonded to and supported by corrosion-protected spring helix. Vapor barrier shall be a 4-mil 0.102 millimeter minimum, pigmented polyvinylchloride film. Duct shall be bendable without damage through 180 degrees with an inside bend radius not greater than two duct diameters. Minimum wall thickness shall be 1 inch 25 millimeter. Thermal conductivity shall be not greater than 0.23 Btu foot per hour per square foot per degrees F 0.40 watt per meter degrees K at 75 degrees F 24 degrees C mean. Permeance shall be not greater than

0.10 perm 0.06 nanogram per pascal second square meter. Working pressure range shall be from minus 1/2-inch water gage (wg) 125 pascal to plus 1-1/2 inches wg 375 pascal; working temperature shall range from minus 20 to plus 250 degrees F minus 29 to 121 degrees C. Minimum sustained velocity without delamination shall be 2,400 fpm 12.2 meter per second. Materials shall conform to NFPA 90A. Acoustic properties shall be submitted for approval.

2.18.4 Manual Volume Dampers

Volume damper construction shall conform to ASHRAE-05, ASHRAE-Hdbk SE-SIand SMACNA 1481.

Dampers shall be equipped with an indicating quadrant regulator having a locking feature externally located and easily accessible for adjustment. Where damper rod lengths exceed 30 inches 760 millimeter, a regulator shall be provided at each end of damper shaft.

Damper shafts shall have two-end bearings.

Splitter damper shall be 22-gage 0.85 millimeter sheet metal, or 2 gages 0.8 millimeter (2 gages) heavier than duct in which installed; i.e., 20-gage 1.0 millimeter splitter in 22-gage 0.85 millimeter duct, up to 16-gage 1.6 millimeter maximum. Hinges shall be full length piano-type or 1/8-inch 3 millimeter thick door type.

Damper shaft shall be full length and shall extend beyond damper blade. A 3/8-inch 10 millimeter square shaft shall be used for damper lengths up to 20 inches 500 millimeter and a 1/2-inch 13 millimeter square shaft shall be used for damper lengths 20 inches 500 millimeter and larger. Where necessary to prevent damper vibration or slippage, adjustable support rods with locking provisions external to duct shall be provided at damper blade end.

Dampers in ducts having a width perpendicular to the axis of the damper that is greater than 12 inches 300 millimeter shall be multiblade type having a substantial frame with blades fabricated of 16-gage 1.6 millimeter metal. Blades shall not exceed 10 inches 250 millimeter in width and 48 inches 1200 millimeter in length and shall be pinned or welded to 1/2-inch 13 millimeter diameter shafts. Dampers greater than 48 inches 1200 millimeter in width shall be made in two or more sections with intermediate mullions, each section being mechanically interlocked with the adjoining section or sections. Blades shall have graphite-impregnated nylon or oil-impregnated sintered bronze bearings and shall be connected so that adjoining blades rotate in opposite directions.

2.18.4.1 Gravity Backdraft and Relief Dampers

Frame shall be constructed of not less than 1-1/2- by 4-inch 40 by 100 millimeter, adequately reinforced, 16-gage 1.6 millimetergalvanized carbon steel. Frames and mullions shall be solidly secured in place and sealed with elastomer calking against air bypass.

Maximum blade width shall be 9 inches 225 millimeter; maximum blade length shall be 36 inches 900 millimeter. Blade material shall be 16-gage 1.6 millimeter galvanized steel, 14-gage 2.0 millimeter 6063 or 5052 alloy aluminum, or 18-gage 1.3 millimeter AISI 18-8 corrosion-resistant steel. Blades shall be provided with mechanically retained seals and 90-degree limit stops.

Dampers used for relief service shall have blades linked together to open not less than 30 degrees on 0.05-inch wg 12.5 pascal differential pressure.

Shaft bearings shall be graphite-impregnated nylon or oil-impregnated bronze.

2.18.4.2 Power-Operated Dampers

Dampers shall conform to applicable requirements specified under paragraph entitled, "Controls and Instrumentation."

2.18.4.3 Flexible Connectors for Sheet Metal

Connectors shall be UL-listed, 20-ounce per square foot 6 kilogram per square meter, fire-retardant, airtight, woven fibrous-glass cloth impregnated with chloroprene. Clear width, not including clamping section, shall be within 3 to 5 inches 75 to 125 millimeter.

2.18.4.4 Fire Dampers

Fire dampers in ductwork shall be provided at firewall barriers.

Fire dampers shall be constructed and labeled in accordance with UL.

2.19 AIR DIFFUSERS

Supply diffusers shall be provided with combination damper and equalizing grid; damper shall be extracting-splitter type, except where otherwise specified.

Gaskets shall be provided for supply-terminal air devices mounted in finished surfaces.

Color selection shall be from manufacturer's standard color chips and approved by the Contracting Officer.

Low-velocity systems shall encompass ductwork and plenums where maximum air velocity is 2,500 fpm 13 meter per second and maximum static pressure is 2 inches wg 500 pascal, positive or negative.

2.19.1 Type Air-Diffusion Devices

Construction of air-diffusion devices shall be aluminum.

2.19.1.1 Type DRA

Type DRA supply diffuser shall be round with five or more expanding cones with beaded edges to provide hemispherically diffused discharge air. Cones shall be arranged to provide a minimum of four air paths that simultaneously diffuse air at 20 to 50 fpm 0.10 to 0.25 meter per second and aspirate room air at 25 to 35 percent of discharge volume.

Antismudge ring shall be provided.

Extended cones shall be provided.

2.19.1.2 Type DRB

Type DRB supply diffuser shall be round with four or more expanding cones to provide hemispherically diffused discharge air. Cones shall be arranged to provide a minimum of three air paths that simultaneously diffuse air at 20 to 50 fpm 0.10 to 0.25 meter per second. Pattern adjustment shall range from horizontal to downward projection, and any intermediate point, when mounted on exposed ductwork.

Integral or separate antismudge ring shall be provided.

Extended ceiling cone shall be provided.

2.19.1.3 Type DRC

Type DRC combination supply and return diffuser shall be round with four expanding cones; cones shall be arranged to provide one return air path and two supply air paths. A butterfly supply-air damper and an annular return-air damper shall be provided.

Antismudge ring shall be provided.

2.19.1.4 Type DRE

Type DRE supply diffuser shall be round with three or more expanding cones to provide discharge air paths that shall be, minimally, two-position adjustable for horizontal or vertical discharge.

Antismudge ring shall be provided.

2.19.1.5 Type DRH

Type DRH supply diffuser shall be half-round with four or more semiconical expanding members to discharge diffused air in a 180-degree pattern. Cones shall be arranged to provide a minimum of three air paths that shall simultaneously diffuse air at 20 to 50 fpm 0.10 to 0.25 meter per second. Opposed-blade volume control damper shall be provided.

2.19.1.6 Type DP Series

Type DP series supply diffuser shall have a square or rectangular, perforated face plate with opposed blade or splitter-damper volume control, white baked enamel exterior finish, and black matte finish on exposed-to-view interior surface. (Type DP series diffusers fit a hung ceiling grid system.)

Type DPA shall provide [one-way deflection.] [two-way opposed deflection.] [two-way diagonal deflection.] [three-way deflection.] [four-way deflection.]

2.19.1.7 Type DLB

Type DLB supply diffuser shall be linear bar type, frame mounted, with extruded-aluminum bar and frame.

Bars shall be 1/4-inch thick by 3/4-inch high, 1/2 inch 6 millimeter thick by 20 millimeter high, 13 millimeter on center. Bar spacing shall be pencil-proof. Bar deflection angle shall be zero degrees.

Floor- and sill-mounted diffusers shall be heavy-duty reinforced construction to carry loads of not less than 100 pounds per square foot 4800 pascal.

Diffusers shall be continuous length with hairline butt joints.

Mitered end caps shall be provided where diffuser run terminates.

Dampers shall be opposed-blade type.

An integral, pivoted, bar-type access door shall be provided.

Straightening grids shall be provided.

2.19.1.8 Type DLS

Type DLS supply diffuser shall be linear slot type, extruded aluminum construction, with fully adjustable integral air pattern and volume control vanes that deflect air pattern from horizontal along ceiling to straight down, or any intermediate setting. Pattern control element shall permit complete blanking-off of slot.

Slot width shall be 3/4 inch 20 millimeter.

Number of slots per unit run shall be as indicated in the manufacturer's catalog data.

Butts in continuous runs shall be aligned for hairline joints.

Ends of diffuser shall butt against walls without mitered end caps. End caps shall be provided where slot terminates.

Exposed-to-view part of frame shall be anodized aluminum; interior exposed-to-view components shall have a black matte finish.

2.19.1.9 Type DSA

Type DSA supply diffuser shall be square with four or more expanding flared members to provide radially diffused discharge air. Flared members shall be arranged to provide a minimum of four air paths that simultaneously diffuse air at 20 to 50 fpm 0.10 to 0.25 meter per second. Pattern adjustments shall include horizontal, vertical projection, and an intermediate position or range.

Integral extended surface to fit into module of lay-in ceiling shall be provided.

2.19.1.10 Type GS

Type GS supply grille shall be double deflection type with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension.

Integral extended surface to fit into module of lay-in ceiling shall be provided.

2.19.1.11 Type GR

Type GR return grilles shall be single deflection type with fixed face bars.

Grilles installed in vertical surfaces shall have horizontal face bars set downward at approximately 35 degrees from vertical.

Grilles installed in horizontal surfaces shall have face bars straight and parallel to short dimension.

Integral extended surface to fit into module of lay-in ceiling shall be provided.

2.19.1.12 Type GCA

Type GCA shall have an individually adjustable, horizontal, curved-blade grille and a one-way pattern.

2.19.1.13 Type GCB

Type GCB shall have an individually adjustable, vertical, curved-blade grille and a one-way pattern.

2.19.1.14 Type GCD

Type GCD shall have an individually adjustable, vertical, curved-blade grille and a two-way pattern.

2.19.1.15 Type GCE

Type GCE shall have an individually adjustable, vertical and horizontal, curved-blade grille and a three-way pattern.

2.19.1.16 Type GCF

Type GCF shall have an individually adjustable, vertical and horizontal, curved-blade grille and a four-way pattern.

2.19.1.17 Type RS

Type RS shall be supply register, double-deflection type, with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension. Dampers shall be opposed-blade type.

Integral extended surface to fit into module of lay-in ceiling shall be provided.

2.19.1.18 Type RR

Type RR shall be return register, single-deflection type, and shall have fixed face bars with opposed-blade dampers.

Registers installed in vertical surfaces shall have horizontal face bars set downward at approximately 35 degrees from vertical.

Registers installed in horizontal surfaces shall have face bars set straight and parallel to short dimension.

2.19.1.19 Type RCA

Type RCA shall have an individually adjustable, horizontal, curved-blade register and a one-way pattern with opposed-blade damper.

2.19.1.20 Type RCB

Type RCB shall have individually adjustable, vertical, curved-blade register and a one-way pattern with opposed blade damper.

2.19.1.21 Type RCC

Type RCC shall have an individually adjustable, horizontal, curved-blade register and a two-way pattern with opposed blade damper.

2.19.1.22 Type RCD

Type RCD shall have an individually adjustable, vertical, curved-blade register and a two-way pattern with opposed blade damper.

2.19.1.23 Type RCE

Type RCE shall have an individually adjustable, vertical and horizontal, curved-blade register and a three-way pattern with opposed-blade damper.

2.19.1.24 Type RCF

Type RCF shall have an individually adjustable, vertical and horizontal, curved-blade register and a four-way pattern with opposed-blade damper.

2.19.1.25 Type TS

Type TS supply troffer complete assembly shall be provided as indicated in the manufacturer's catalog data. Air handling section of unit shall be installed under this section.

2.19.1.26 Type TR

Type TR return troffer shall conform to requirements for Type TS supply troffer.

2.19.1.27 Type TSR

Type TSR combination supply and return troffer assembly shall be provided as indicated in the manufacturer's catalog data.

2.19.2 Rigid Fibrous-Glass Ductwork

[Rigid fibrous-glass ductwork is not allowed.]

2.20 MIXING BOXES

2.20.1 Dual-Duct Mixing Boxes

Units shall be mechanical constant-volume control type with a mechanical controller that is operated by the entering mixed-airstream and maintains a constant airflow through the unit.

Units shall be manual-damper volume control type. A calibration chart shall be provided with each unit. Each unit shall be labeled with capacity minimum/maximum range to facilitate field adjustment.

2.20.1.1 Construction

Unit shall be factory assembled, complete with casing, air mixing valve assembly, single air mixing valve operator, and mechanical constant-volume control, ready for field mounting and connection to control.

Components subject to friction shall have oil-impregnated bronze bearings, graphite-impregnated or lubricant-impregnated nylon bearings; and lubricant-impregnated elastomers, corrosion-resistant steel, and [_____] .

Casing shall be fitted with rigid, airtight access panels, easily removable and of sufficient size to give free access to interior parts. Closure shall be achieved by spring-retained, quarter-turn, slotted-cam captive devices, or similar operating devices that permits unobstructed closure.

2.20.2 Single Duct, Constant Volume, Terminal Reheat Units

Units shall include a casing, volume regulators, sound attenuating thermal insulation, and heating coils.

2.20.2.1 Casing

Unit casings shall be constructed of 0.040-inch aluminum or 20-gage mill-galvanized steel 1 millimeter aluminum or mill galvanized steel and shall contain removable panels for access to interior parts. Units shall be insulated internally with 1/2-inch 13 millimeter thick mineral-fiber thermal and acoustic insulation, conforming to NFPA 90A.

2.20.2.2 Coils

Water coils shall be constructed of not less than 3/8-inch 10 millimeter outside diameter seamless copper tubing with or aluminum-plate fins mechanically bonded or soldered to the tubes, and with not less than 5/8-inch 16 millimeter outside diameter female solder connectors and manual air vent on return. Coils shall be tested at 150 percent of the working pressure.

2.20.2.3 Controls

Reheat output shall be controlled by a room thermostat designed to modulate the water flow in the coil by positioning a three-way valve.

2.20.3 Variable Constant-Volume Boxes

Casing shall be fabricated from galvanized steel and shall have internal thermal and acoustic insulation. Insulation shall be coated to prevent erosion and shall conform to NFPA 90A.

Casing internal leakage shall be limited to 2 percent of nominal box capacity when the internal pressure is 1 inch wg 250 pascal.

Casing shall be fitted with rigid, airtight access panels, easily removable, and of sufficient size to give unobstructed access to interior parts.

2.21 FILTERS

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NOTE: Filters shall be in accordance with Section

15665 FILTERS.
****

2.21.1 Filter Gages and Manometers

Air filter gages or manometers shall be provided for each type filter assembly. Gages shall be the dial-indicator type, graduated to read 0 to 2 inches wg 0 to 500 pascal, except that gages for HEPA filters shall read 0 to 3 inches wg 0 to 750 pascal. Manometers shall measure from minus 0.5 to 3 inches wg 125 to 750 pascal and be equipped with a built-in indicator bubble. Connect gage or manometer to static-pressure ports and install in a location so that resistance to airflow will be correctly indicated.

Static-submit pressure ports prior to installation and fabrication.

PART 3 EXECUTION

3.1 INSTALLATION

Install materials and equipment in accordance with the requirements of the contract drawings and recommendations of the manufacturer. Installation shall be accomplished by workers skilled in this type of work. Installation shall be so made that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors. Emergency switches and alarms shall be installed in conspicuous locations.

Manufacturer's Installation Instructions shall be submitted indicating the manufacturer's recommended method and sequence of installation for HVAC systems.

Installation drawings shall be installed in accordance with referenced standards in this section. Drawings shall show details of equipment room layout and design.

Pipe valves and specialties shall be installed in accordance with manufacturer's recommendations and in accordance with paragraphs entitled, "Steel Pipe," "Valves," and "Refrigeration Specialties."

3.2 CLEANING

Exposed surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction shall be thoroughly cleaned before such surfaces are prepared for final finish painting or are enclosed within the building structure.

Before final acceptance, mechanical equipment, including piping, ducting, and fixtures, shall be clean and free from dirt, grease, and fingermarks.

3.3 INSULATION SYSTEMS

Insulation and system components shall be installed per the manufacture's instructions.

Workmanship shall reflect the best current practices in the trade. Contours on exposed work shall be smooth and continuous.

3.3.1 Refrigerant and Cold Water Suction Piping

Insulation shall be cellular-elastomer (Type T-3). Thickness shall be

nominal 3/4 inch 19 millimeter. Surfaces, including valve, fittings, unions, and flanges, shall be insulated.

3.3.2 Chilled Water, Hot-Water, and Condensate-Return Piping

Insulation shall be cellular glass with PVC jacket. Thickness shall be not less than that given in the following list. Aboveground pipes, valve bodies, fittings, unions, flanges, and miscellaneous surfaces shall be insulated.

PIPE SIZES (INCHES)	INSULATION THICKNESS (INCHES)
Up to 4	1-1/2
4 to 8	2
8 and over	2-1/2

PIPE SIZES (DN) DIAMETER NOMINAL	INSULATION THICKNESS MILLIMETER
Up to 100	40
100 to 200	50
200 and over	65

3.3.3 Chilled-Water and Dual-Temperature Pumps

Insulation shall be cellular elastomer Type T-9. Thickness shall be 1 inch 25 millimeter. Surfaces subject to condensation shall be covered, and a vapor-barrier coating shall be supplied.

3.4 BOILERS

Boilers shall be installed and tested in accordance with manufacturer's recommendations.

3.5 AIR HANDLING UNITS

3.5.1 Installation

Coils shall be installed in accordance with the manufacturer's recommendations. Dampers shall be set in a fixed position to provide the outside air quantity scheduled.

Floor drains shall be provided where indicated in the equipment room layout drawings. Drain line shall be not less than 2 inches DN50.

3.5.2 Enclosure Test

Services of a competent, factory-trained manufacturer's representative shall be provided to supervise assembly, inspection, and testing of the enclosure.

Enclosure rigidity shall be tested by starting and stopping fans. No audible enclosure popping noise, deflection, or deformation in excess of specified limits shall result.

3.6 DUCTWORK

3.6.1 Installation

Sheetmetal construction shall be provided in accordance with the recommendations for best practices in ASHRAE-05, ASHRAE-Hdbk SE-SI, SMACNA 1481 and NFPA 90A.

Where construction methods for certain items are not indicated or described in the referenced standards or herein, the work shall be performed in accordance with ASHRAE-04.

Supplementary steel shall be designed and fabricated in accordance with AISI SG-913 and AISC 317.

3.6.2 Openings in Roofs and Walls

Building openings are fixed as indicated in the equipment room layout drawings and equipment shall be provided to suit. Contractor may propose to alter these openings upon prior approval by the Contracting Officer and at his expense.

Openings indicated in outside walls and roof are approximate. Within [_____] calendar days after the award of contract, detail drawings showing exact opening dimensions and location of the equipment shall be submitted to the Contracting Officer for approval.

3.6.3 Ductwork Cleaning Provisions

Open ducting shall be protected from construction dust and debris in a manner approved by the Contracting Officer. Dirty assembled ducting shall be cleaned by subjecting main and branch interior surfaces to air streams moving at velocities two times the specified working velocities, at static pressures within maximum ratings. This may done with filter-equipped, wheel mounted, portable blowers; compressed-air operated perimeter lances that direct the compressed air and which are pulled in the direction of normal air flow; or other means approved by the Contracting Officer. Compressed air used for cleaning ducting shall be water- and oil-free. Prior to acceptance, dust and debris shall be removed from exterior surfaces.

3.6.4 Fire Damper Tests

Operation tests shall be performed on each fire damper in the presence of the Contracting Officer by activating fusible link with localized heat. New links shall be provided and installed after successful testing.

3.7 FILTERS

Filter supports and retention elements shall be coordinated to provide a substantial, structurally sound, leakproof installation. Filter arrangements shall be as indicated in the manufacturer's catalog data.

Holding frames shall be gasketed on perimeter, or calked to each other, to supplementary steel, or to closures with elastomeric compounds recommended by the filter manufacturer. Substrate shall be prepared in accordance with the elastomer manufacturer's instructions, including the priming of surfaces in areas where the elastomer is not confined.

3.8 CONTROLS

3.8.1 Installation

Installation of control components shall be done by Contractor-certified control and instrumentation specialists or factory representatives.

Installation shall conform to the published or written instructions of the manufacturer.

Tubing shall be concealed, except in mechanical rooms or areas where other piping is exposed.

Multiple tube runs shall be neatly nested.

3.8.2 Mechanical Refrigeration Air Dryer Installation

Wall mounting shall be through rubber-in-shear mounts. Dryer shall be connected to air compressor outlet with pressure regulator installed downstream of dryer.

To prevent vibration, controllers shall be isolated by location or by mounting devices.

3.8.3 Testing, Calibration, and Acceptance

After completion of control and instrument piping, control equipment shall be tested and adjusted in terms of design, function, systems balance, and performance, and shall otherwise be made ready for air handling systems acceptance tests. Data showing set points and final adjustments of controls shall be provided.

3.8.4 Operating Instructions and Operator Training

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NOTE: Insert required number of hours.

****

Six copies of written operating maintenance instructions and not less than [_____] hours of operator training shall be provided.

3.9 AIR-HANDLING SYSTEMS TESTING

****

NOTE: The Systems Engineer/Condition Monitoring Office/Predictive Testing Group should inspect the installation during acceptance testing using advanced monitoring technologies such as Infrared Imaging or Ultrasonic Listening. These technologies can identify insulation voids, insulation settling, and system/pressure/vacuum leaks.

****

Pressure tests shall be performed prior to insulation of surfaces, painting, and concealment of work.

3.9.1 Low-Velocity Duct Systems

Portions of systems as selected shall be inspected by the Contracting Officer and tested to positive or negative pressures, or both, whichever is normal to the portion of system under test, to verify the following:

There are no visible mechanical defects.

There is no audible leakage at any point when area ambient noise is at normal-occupancy level.

No leakage is perceptible to the hand, when placed within 6 inches 150 millimeter of a joint.

3.9.2 High-Velocity Duct Systems

High-velocity, high, and medium pressure systems shall be structurally tested at static pressures 50 percent in excess of total fan pressure. Leakage testing shall be at a pressure 25 percent higher than normal operating pressure, and in dual duct systems at maximum pressure at mixing box, when inlet valve is shut off. System will be acceptable provided:

There are no visible mechanical defects.

Measured total system leakage does not exceed 0.5 percent of total system cfm cubic meter per second capacity.

There is no audible leakage at any point when area ambient noise is at normal-occupancy level.

3.9.3 Test Apparatus and Procedures

Test apparatus and procedures shall be similar in all respects to that defined in ASHRAE-05, ASHRAE-Hdbk SE-SI and SMACNA TAB HVAC SYSTEMS. Filtered blower inlet and automatic safety relief device shall be provided to protect system. Accuracy of measurement of leakage flow rate shall be certified to be within 2 percent of total leakage flow.

3.10 REFRIGERATION SYSTEMS TESTING

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NOTE: The Systems Engineer/Condition Monitoring Office/Predictive Testing Group should inspect the installation during acceptance testing using advanced monitoring technologies such as Infrared Imaging or Ultrasonic Listening. These technologies can identify insulation voids, insulation settling, and system/pressure/vacuum leaks.

****

Pressure, vacuum, structural-integrity, and leakage tests shall be applied to all systems and shall be conducted in accordance with the provisions of Paragraph 537 of ASHRAE-04, Chapter 35, ASHRAE-08 and ASME B31.5 except Subparagraphs 537.5, and as modified and supplemented herein.

Systems shall be tested in the presence of the Contracting Officer.

Tests shall be performed prior to insulation of surfaces, painting, and concealment of work.

Factory-sealed refrigeration equipment assemblies shall be kept isolated from field-installed piping until final acceptance of high-vacuum test.

Brazed and mechanical joints that fail structural or leakage tests shall be disassembled, cleaned, and remade.

After repairs have been made, tests shall be repeated until satisfactory results are obtained.

3.10.1 Pressure Testing

Pressure tests shall be conducted with a composite gas consisting of dry nitrogen and the refrigerant that will be used in the system being tested. One-quarter pound per ton 0.6 kilogram per watt of refrigerant shall be used for R-22 systems.

Final test pressure shall be held for not less than 12 hours. There shall be no readable drop in pressure at the end of the test period. Correction of 0.3 psi 2.1 kilopascal will be allowed for each degree of change between initial and final temperature, plus for an increase in temperature and minus for a decrease.

3.10.2 Vacuum Testing

After a successful pressure test, each system shall be connected to a high-vacuum pump capable of reducing absolute pressure in the system to a point where any water present will vaporize at a temperature appreciably below ambient temperature, and will be withdrawn from the system. The system shall be evacuated twice to a vacuum of 2.5 millimeters of mercury (mm Hg), absolute. First vacuum shall be held for not less than 1 hour and then broken with dry nitrogen. Second vacuum shall be held for not less than 6 hours at an ambient temperature of 40 degrees F 4 degrees C or more. With the system isolated at 2.5 mm Hg vacuum, the pressure shall not increase noticeably.

3.10.3 Operating Test

After repairs have been made and tests completed, sealed equipment valves shall be opened, and system shall be charged with refrigerant and lubricant, if necessary. Compressor may then be operated per manufacturers instructions.

For the first 8 hours of operation under load, each system shall be operated with the refrigerant dryers in the circuit. If the sight glass or moisture indicator reveals moisture in the system, dryer cartridges shall be replaced and the operation shall be repeated. This procedure shall be followed until there is no indication of moisture in the system. Dryer cartridges shall be replaced and the dryers shall be bypassed. Oil levels shall be checked frequently and oil added only from sealed cans furnished by the compressor manufacturer.

If there is excessive hot-gas pulsation during operation, mufflers with not more than 1 psi 7 kilopascal drop at design conditions shall be provided. After installation of mufflers, steps necessary to bring system to specified operating condition shall be repeated.

3.11 AIR AND HYDRONIC SYSTEMS TESTING, AND ADJUSTMENT

****
NOTE: The Systems Engineer/Condition Monitoring Office/Predictive Testing Group should inspect the installation during acceptance testing using advanced monitoring technologies such as Infrared Imaging or Ultrasonic Listening. These technologies can identify insulation voids, insulation settling, and system/pressure/vacuum leaks.
****

****
NOTE: Variable pitch sheaves should only be used for system balance and adjustment purposes. After balance is determined they should be replaced with fixed sheaves.
****

[Operational balancing and adjustment of air-handling and hydronic systems shall be performed under the direction of an independent balancing agency whose field representative is a registered professional engineer. Work shall be done in accordance with ASHRAE-06, Chapter 1 ASHRAE-Hdbk SE-SI, ASHRAE-05, Chapter 12 and Chapter 50, AABC MN-1or SMACNA TAB HVAC SYSTEMS, where applicable, the requirements of the contract documents, and in the presence of the Contracting Officer.]

[Operational balancing and adjustment of air-handling and hydronic systems shall be done in accordance with ASHRAE-05, ASHRAE-Hdbk SE-SI andSMACNA TAB HVAC SYSTEMS, the requirements of the contract documents, and in the presence of the Contracting Officer.]

3.11.1 Air-Handling Systems

Final volume conditions for all systems shall be within plus or minus 5 percent of the conditions indicated on contract drawings.

Balancing and adjustment apparatus, procedures and test report shall be in accordance with Section II of ASHRAE-06, Chapter 1 ASHRAE-Hdbk SE-SI, ASHRAE-05, Chapter 12 and Chapter 50, AABC MN-1or SMACNA TAB HVAC SYSTEMS.

3.11.2 Hydronic Systems

3.11.2.1 Balancing, Adjustment, and Acceptance

Systems final flow conditions shall be within plus or minus 5 percent of conditions indicated on contract drawings.

Complete air balance shall have been accomplished before water balance begins.

3.11.2.2 Hydronic Systems Preparation

Hydronic systems shall be tested at 125 percent of rated pressure.

All valves shall be opened to full-open position, including coil-stop valves, bypass valves, and return-line balancing cocks.

Check rotation of pumps after obtaining approval by the Contracting

Officer.

Expansion tanks shall be checked to determine that they are not air-bound and that system is full of water.

3.11.3 Adjustment and Acceptance Criteria

After balance and adjustment operations have been completed, the system shall be tested as a whole to verify that all items perform as an integral part of the system and that temperature and conditions are evenly controlled. Corrections and adjustment shall be made as necessary to produce the required specifications.

3.11.4 Test Report

Operational test reports shall be provided on systems tested. Test report format shall be approved by the Contracting Officer.

3.12 STEAM AND CONDENSATE SYSTEMS TESTING

****
NOTE: The Systems Engineer/Condition Monitoring Office/Predictive Testing Group should inspect the installation during acceptance testing using advanced monitoring technologies such as Infrared Imaging or Ultrasonic Listening. These technologies can identify insulation voids, insulation settling, and system/pressure/vacuum leaks.
****

Prior to acceptance of the work, completed systems shall be tested in the presence of the Contracting Officer.

System shall be subjected to pressure tests to determine structural integrity, and to operational and cyclic tests, as necessary, to determine that system functions and operates as required.

After pressure tests and cleaning operations have been satisfactorily completed, system components shall be adjusted for proper operation within the design and operating characteristics published by the component manufacturer. In addition to requiring the services of an authorized representative of the manufacturer, the Government reserves the right to require the services of an authorized representative of a component manufacturer if the Contractor is unable to adjust a component. The Contractor shall arrange for such services at no additional cost to the Government.

3.12.1 Test Duration

Duration of a test will be determined by the Contracting Officer.

A pressure test shall be held for a minimum of 2 hours and a maximum of 24 hours.

Test may be terminated by the Contracting Officer at any time after it has been determined that the system meets specified requirements.

3.12.2 Test Gages

Contractor's test gages shall conform to ASME B40.100 and shall have a current calibration certification.

3.12.3 Acceptance Pressure Testing

Testing shall take place during steady-state ambient temperature conditions.

Tests shall be hydrostatic unless otherwise specified or approved by the Contracting Officer.

Systems shall be tested at 1-1/2 times primary wsp rating of system components, and the applied pressure shall be maintained. System shall be monitored for a minimum of 1 hour in the presence of the Contracting Officer to detect any leakage.

Components that could be damaged by shock or test pressure shall be removed from piping systems prior to hydrostatic testing.

Movement limiting provisions shall be used to protect expansion joints against overextension from system pressures.

Piping system components, such as valves, shall be checked for functional operation under system test pressure.

3.12.4 Operational Testing

System shall be cycled three times, from start to operating thermal conditions, to verify adequacy of construction, system controls, and component performance.

3.12.5 Test Records

Contractor shall prepare and maintain test records of systems tests. Records shall show test-personnel responsibilities, dates, test gage identification numbers, ambient and test temperatures, pressure ranges, rates of pressure drop, leakage rates, and other system Characteristics.

3.13 ROTATING MACHINERY

3.13.1 Alignment

Before attempting alignment, the contractor will demonstrate that the pump/compressor/fan does not have any load/force imposed by the piping/duct system. Minimum alignment values (below) are for pump and driver at normal running temperatures. Values must be compensated for thermal growth. Limited movement of the pump compressor/fan or driver (commonly known as bolt-bound) must be corrected to ensure alignment capability. Hold down bolts shall not be undercut in order to perform adjustment.

Shims shall be commercially die-cut, without seams or folds, and be made of corrosion resistant stainless steel. No more than four shims shall be used at any single point.

Units with drive motor over [7.5][10][15][20][25] ph shall have alignment jack bolts installed.

Direct drive pumps/compressors may have an intermediate shaft, spacer, or

spool piece (sometimes called a jackshaft) Based on the motor nominal operating speed, the Pump/compressor and driver shall be aligned to the following minimum specifications:

Speed(RPM)	close-coupled offset (mils)	close-coupled angle(mils/in.)	spool piece angle (mils/in. @ coupling apt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

[Pump alignment shall be performed under the direction of the manufacturer's representative.]

Final alignment settings shall be provided as part of the final test data.

3.13.2 Vibration Analyzer

Contractor shall use an Fast Fourier Transformer (FFT) analyzer to measure vibration levels. It shall have the following characteristics: A dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz-10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

An accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk(or finished surface) shall be used with the Fast Fourier Transformer (FFT)analyzer to collect data. The mass of the accelerometer and its mounting shall have minimal influence on the frequency response of the system over the selected measurement range.

3.13.3 Acceptance Tests

Prior to final acceptance, dial indicator gages shall be used to demonstrate that pump/compressor/fan and motor are aligned as specified and that the pump/compressor casings are entirely free of any piping loads.

Prior to final acceptance, vibration analysis shall verify pump/compressor/fan conformance to specifications. Vibration levels shall not be more than .075 in/sec at 1 times run speed and at pump frequency, and .04 in/sec at other multiples of run speed. Vibration data shall be provided as part of the final test data.

3.13.4 Test Records

Contractor shall prepare and maintain test records of systems tests. Records shall show test-personnel responsibilities, dates, test gage identification numbers, ambient and test temperatures, pressure ranges, rates of pressure drop, leakage rates, and other system Characteristics.

Final test reports shall be provided to the Contracting Officer. Reports shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.14 OPERATION AND MAINTENANCE

Contractor shall submit [6] [_____] copies of the Operation and Maintenance Manuals 30 calendar days prior to testing the system involved. Data shall be updated and resubmitted for final approval no later than 30 calendar days prior to contract completion.

Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions. Test data shall be legible and of good quality.

-- End of Section --