REFERENCES

PART 1 GENERAL

SECTION 2A 11 5

FACILITY GAS PIPING

A.S.M.E. B16.3

A.S.M.E. B16.21

A.S.M.E. B16.11

A.S.M.E. B16.1

A.S.M.E. B1.20.1

A.S.M.E. A13.1

A.S.M.E. INTERNATIONAL (A.S.M.E.

API RP 607

API RP 599

API RP 2009

A.MERICAN NATIONAll STANDAlDS INSTITUTE (A.NSI)

A.MERICAN GAS ASSOCIATION (A.G.A.)

A.MERICAN NATIONAll STANDAlDS INSTITUTE (A.NSI)

basc declassification only. the publications referenced to within the text by the

external references. the publications are referenced to a part of this specification to the

The publications listed below form a part of this specification to the

1.1 REFERENCES

FACILITY GAS PIPING
1.3 Submit data package No. 3.

Supplement data package No. 3, if necessary. Submit data if requested to be submitted. Submit data for each valve and piece of equipment and preventive maintenance (replacement). See section 1.2, "Materials, MANUFACTURER'S VENDOR INFORMATION AND LOCATION.

1.2 Gas Facility System Maintenance

1.2.1 Gas Facility System and Equipment Operation

Separate packages.

In accordance with Section 01 30 00, OPERATION AND MAINTENANCE DATA, in three separate packages. Each valve and piece of equipment within the facility. Submit operation and maintenance data in three separate packages. Each valve and piece of equipment within the facility. Submit operation and maintenance data in three separate packages.

1.2 System Description

Gas Facility System and Equipment Data

(C) 2009, (C) 2007, (C) 2004

SSPC-SP 6, (C) 2009

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

2008 EDITION

NFPA 70

UL 610, (C) 2007

(UL) UNDERWRITERS LABORATORIES (UL)
1.4.1 \textbf{Welding Qualifications}

In accordance with MSS SP-25, materials and for installing joints, mark all valves, flanges, and fittings approved for compression-type mechanical joints used in joining downstream Serbian manufacturer's descriptive data and installation instructions for.

1.4 \textbf{QUALITY ASSURANCE}

Data packages, as specified:

- Gas facility equipment maintenance; G, AE
- Gas facility system maintenance; G, AE
- Gas facility system equipment operation; G, AE

SD-10 Operations and Maintenance Data

Pipe coating materials and application procedures; G, AE

SD-08 Manufacturer's Instructions

- Welders procedures and qualifications; G, AE
- SD-07 Certificates

Test with gas; G, AE

Pressure tests; G, AE

Testing; G, AE

SD-06 Test Reports

Warning and identification tape; G, AE

Valves: G, AE

Translation flanges; G, AE

Reservoirs: G, AE

Pipe coating materials and application procedures; G, AE

Gas equipment connectors; G, AE

Gas piping systems; G, AE

SD-03 Product Data

Gas piping systems; G, AE

SD-2 Shop Drawings
2.1 Steel pipe, joints, and fittings

2.2 GAS PIPING SYSTEM AND FITTINGS

Paragraphs on materials, equipment, and handling are provided.

1.5 DELIVERY, STORAGE, AND HANDLING

1.4.3 Shop drawings for complete gas piping system, within 30 days of contract award.

1.4.2 Jointing Thermoplastic and Preformed Seals

1.4.1 Material, joint appearance chart.
2.2.8 Insulating joint material

2.2.8.1 Insulating joint preserves

2.2.8.2 Threaded pipe joints

2.2.7 Gas transmission fittings

2.2.6.2 Screws

2.2.6.5 Pipe threads

2.2.4 Flange gaskets

2.2.3.3 Flanged pipe joints

2.2.2.8 Insulating joint materials

2.2.2.6 Insulating joint material

2.2.5.1 Insulation joint material

2.2.3.1 Insulation joint material

2.2.2.3 Insulation joint material

2.2.2.1 Insulation joint material

2.2.1 Insulatation joint material

2.2.0.1 Insulation joint material
3.3 GAS PIPING SYSTEM

Provide required excavation, backfilling, and compaction as specified in Section 31-00-00. Earthwork.

3.2 EXCAVATION AND BACKFILLING

Provide required excavation, backfilling, and compaction as specified in Section 31-00-00. Earthwork.

After becoming familiar with all details of the work, verify all dimensions.

3.1 EXAMINATION

PART 3 EXECUTION

Provide pipe hangers and supports conforming to MSS SP-28 and MSS SP-69.

2.5 PIPE HANApplication and SUPPORTS

Provide pipe hangers and supports as indicated on the drawing. Provide bolt-on or bracket or wall-mounted hanger supports as indicated on the drawing. Provide brackets, metal hangers, and protective sleeves. Provide remote control with 0 to 10 VDC output. Provide remote control with 0 to 10 VDC output. Provide remote control with 0 to 10 VDC output. Provide remote control with 0 to 10 VDC output.

Provide manufacturer's standard hanger, transition from plastic to steel pipe.

2.4 RISERS

and manufacture compatible with system materials used.

Provide valves 2 inches and smaller conforming to ANSI B16.33 of materials.

2.3.2 VALVES

Provide service or service installation valves conforming to the drawing.

2.3.1 VALVES

In an external connection port, if necessary, provide an external connection port, except when application is provided within the cabinet. Provide rigid metallic pipe and fittings to extend the external face. Provide rigid metallic pipe and fittings to extend the external face. Do not install the flexible connector through the application cabinet.

2.2.9 FLEXIBLE CONNECTORS

Provide pipe ends conforming to ASME F2015.

Provide cap joint flanges, and insulating washers for flange nuts. Provide cap joint flanges, and insulating washers for flange nuts.
3. Installation

3.4.2.2 Nonporous Surfaces

3.4.2.1 Porous Surfaces

Aground Metallic piping System

Distribution. When distributing metals are jointed underground, use gas tight fittings. Select in Section 3 15 NATURAL-GAS / LIQUID Petroleum GAS.

3.4. Protecting Covering

3.3.2 Workmanship and Defects

3.3.1 Protection and cleaning of Materials and Components
Under ground, and with approved transposition fittings. Connections between metallic and plastic piping are only allowed outside.

3.5.2 Metallic Piping Installation

Use aluminum alloy pipe in accordance with ASA X806. Corrugated pipe and bell-and-spigot may be used. Cut thermoplastic and gas cutting and beveling machine may be used.
3.7 Pipe sleeves

Pipes sleeves or collars are not used and do not protrude above the coating, do not use electrodes that have been preheated or exposed to weather conditions. Do not use heat treatment of welding or cutting. Prepare the pipe sleeve to form a smooth surface on the pipe sleeve. Check sleeve fit, and make sure the sleeve is positioned correctly and securely. Examine sleeves in preparation for welding. If sleeves are reused, check all connections and secure connections as needed. Examine sleeves in preparation for welding.

3.6.2 Welded metal joints

Secure all parts, including the threaded joints to stop or prevent leaks. After cutting and before threading, clean and remove all burrs. After cutting, clean the threaded connections up to 1/2 inch in diameter may be made with approved metal cleaning compound or gas welding compound for gas welding only. Threaded joints may be made with the approved gas welding compound or gas welding compound for gas welding only. Provide the threaded joints in metallic pipe with threads cut from threaded pipe. Provide the threaded joints in metallic pipe with threads cut from threaded pipe.

3.6.1 Threaded metal joints

Overstress caused by corrosion of the pipe or failure of the weld or welder. Do not weld or install pipe joints to effectively sustain the longitudinal pull.

3.6 Pipe joints

3.5.6 Final gas connections

Check the final gas connections for each gas equipment item. Place equipment on the piping, secure the equipment to the piping, and make sure the equipment is properly positioned and secured. Make detailed connections to the equipment using high-quality pipe. Unless otherwise specified, make detailed connections with high-quality pipe. Ensure that there is no excessive pressure on the equipment.

3.5.5 Aboveground piping

Run aboveground piping as straight as practicable along the alignment and provide suitable support where necessary. Ensure that the piping is properly supported and secured. Use high-quality materials for the aboveground piping. Ensure that the aboveground piping is properly supported and secured.
3.14 ELECTRICAL BONDING AND GROUNDING

3.13 PIPING SYSTEM SUPPORTS

3.12 BUILDING STRUCTURE

3.11 SPECIAL REQUIREMENTS

3.10 ESCUTCHEONS

3.9 PIPE SEAL

3.8 PIPES PENETRATING WATERPROOFING MEMBRANES

3.7 INSTALLATION OF STEEL PARTITIONS, WALLS AND FLOORS

Provide satisfactory drainage of the floor, basement, cellars, etc., in the basement. Provide suitable drainage for the installation of any gas piping.
3.15 SHUT-OFF VALVE

Inlet the main gas shut-off valve controlling the gas piping system to be easily accessible for operation, as indicated, protected from physical damage, and marked with a metal tag to clearly identify the piping system controlled.

3.16 TESTING

Submit test reports in booklet form tabulating test and measurement performed, date and time, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements as stated in the specifications. Test entire piping system to ensure that it is gas tight, and has all foreign material, test each joint with an approved test material, soap and water, or an equivalent nonflammable solution. Inspect each valve in accordance with ASME B31.3 and API Std 590. Complete test before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install full size, anchorages, and as directed and approved by the Contracting Officer. Do not use oxygen as a testing medium.

3.16.1 Pressure Tests

Submit test reports in booklet form tabulating test and measurement performed, date and time, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements as stated in the specifications. Test entire piping system to ensure that it is gas tight, and has all foreign material, test each joint with an approved test material, soap and water, or an equivalent nonflammable solution. Inspect each valve in accordance with ASME B31.3 and API Std 590. Complete test before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install full size, anchorages, and as directed and approved by the Contracting Officer. Do not use oxygen as a testing medium.

3.16.2 Test with Gas

Before turning on gas under pressure into any piping system for which gas can escape, immediately after turning on the gas, check the piping system for leakage using a laboratory equipment. Confirm all testing to the requirements of NFPA 54, if leakage is recorded shut off the gas supply, repair the leak, and repeat the tests until all leaks have been stopped.

3.16.3 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. Do not purge the open end of piping systems into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54 are followed.
3.17 PIPE COLOR CODE MARKING

Testing and purging.

Furnish all labor, materials and equipment necessary for conducting the

3.16.4 Labor, Materials and Equipment
PART 1   GENERAL

1.1   REFERENCES

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.4 (1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)

AMERICAN WELDING SOCIETY (AWS)

AWS 249.1 (2005) Safety in Welding, Cutting and Allied Processes

ASME INTERNATIONAL (ASME)

ASME B1.1 (2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B1.20.1 (1983; R 2006) Pipe Threads, General Purpose (Inch)


ASME B16.18 (2001; R 2005) Cast Copper Alloy Solder Joint Pressure Fittings

ASME B16.21 (2005) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.22 (2001; R 2005) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings


ASME B16.34 (2009) Valves - Flanged, Threaded and Welding End


ASME B18.2.2 (1987; R 2005) Standard for Square and Hex Nuts

ASME B31.9 (2008) Building Services Piping

ASME B40.100 (2005) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A 194/A 194M (2009) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both

ASTM A 307 (2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength


ASTM F 1007 (1986; R 2007) Pipeline Expansion Joints of the Packed Slip Type for Marine Application


COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015 (1994; R 1995) Copper Tube Handbook

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

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

Except as specified otherwise, equipment and piping components shall be suitable for use in low temperature water heating system. Except as modified herein, the pressure temperature limitations shall be as specified in the referenced standards and specifications. Pressures in this specification are pressures in pounds per square inch above atmospheric pressure, and temperatures are in degrees Fahrenheit (°F).
1.3.1 Hot Water Heating System

Submit plan, elevations, dimensions, capacities, and ratings. Include the following:

d. Pumps
e. Valves
f. Expansion tanks

h. Backflow preventer
i. Air separating tank
j. Boilers

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
   Hot water heating system

SD-03 Product Data

Pumps

Include pump speed and characteristic curve for performance of impeller selected for each pump. Curves shall indicate capacity vs head, efficiency, and brake power for full range, from shut-off to free delivery.

Expansion tanks
Backflow preventers
External air separation tanks
Hot water heating pipe

SD-06 Test Reports
Hydrostatic test of piping system
Auxiliary equipment and accessory tests

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

SD-07 Certificates
Backflow preventer certification
Report of prior installations
Welding procedures
Welder's qualifications

SD-10 Operation and Maintenance Data

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit a list of qualified service organizations which includes addresses and qualifications.

1.5 QUALITY ASSURANCE

1.5.1 Welding

1.5.1.1 Report of Prior Installations

Submit a Certificate of Full Approval or a current Certificate of Approval for each design, size, and make of backflow preventer being provided for the project. Certificate shall be from the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, and shall attest that this design, size, and make of backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. A Certificate of Provisional Approval is not acceptable in lieu of the above.

1.5.1.2 Welding Procedures
Before performing welding, submit three copies of welding procedure specification for all metals to be used in the work, together with proof of welder's qualification as outlines in ASME B31.9.

1.5.1.3 Welder's Qualifications

Before welder or operator performs welding, submit three copies of Welder's Performance Qualification Record in conformance with ASME B31.9 showing that the welder was tested under the approved procedure specification submitted by the Contractor. In addition, submit each welder's assigned number, letter, or symbol used to identify the work of the welder.

1.5.1.4 Identification of Welder's Work

Ensure that each welder's assigned number, letter or symbol is affixed immediately upon completion of the weld. To welders making defective welds after passing a qualification test, give a requalification test. Upon failing to pass the test, do not permit welder to work in this contract.

1.5.1.5 Previous Qualifications

Welding procedures, welders, and welding operators previously qualified by test may be accepted for this contract without requalification subject to the approval and provided that all the conditions specified in ASME B31.9 are met before a procedure can be used.

1.5.2 Brazing and Soldering

1.5.2.1 Brazing Procedure

ASME B31.9. Brazing procedure for joints shall be as outlined in CDA A4015.

1.5.2.2 Soldering, Soldering Preparation, and Procedures for Joints

ASME B31.9 and as outlined in CDA A4015.

1.5.3 Backflow Preventer Certification

Submit a Certificate of Full Approval or a current Certificate of Approval for backflow preventers.

1.6 SAFETY STANDARDS

1.6.1 Welding

Safety in welding and cutting of pipe shall conform to AWS Z49.1.

1.6.2 Guards

Couplings, motor shafts, gears and other moving parts shall be guarded, in accordance with OSHA 29 CFR 1910.219. Guards shall be cast iron or expanded metal. Guard parts shall be rigid and removable without disassembling the guarded unit.

PART 2 PRODUCTS
2.1 PIPE AND FITTINGS

2.1.1 Hot Water Heating Pipe (Supply and Return)

ASTM A 53/A 53M electric resistance welded or seamless Schedule 40 steel pipe or ASTM B 88 Type hard drawn Copper tubing.

2.1.2 Fittings

Provide fittings compatible with the pipe being provided and shall conform to the following requirements.

2.1.2.1 Steel or Malleable Iron Pipe

Sizes 1/8 to 2 inches. ASME B16.11 steel socket welding or screwed type or ASME B16.3 for screwed type malleable iron fittings.

2.1.2.2 Steel, Cast Iron, or Bronze

Sizes 2 1/2 inches and above. Steel fitting butt welding type ASME B16.9 or ASME B16.5 flanged type. Cast iron fittings flanged type ASME B16.1. Bronze fittings up to 8 inch size flanged type ASME B16.24.

2.1.2.3 Fittings for Copper Tubing

ASME B16.18 cast bronze solder joint type or ASME B16.22 wrought copper solder joint type. Fittings may be flared or compression joint type.

2.1.3 Unions

2.1.3.1 Steel Pipe

Provide ASME B16.39, malleable iron unions, threaded connections.

2.1.3.2 Copper Tubing

Provide CID A-A-59617, bronze unions, solder joint end.

2.1.3.3 Dielectric Union

Provide insulated union with galvanized steel female pipe-threaded end and a copper solder joint end conforming with ASME B16.39, Class 1, dimensional, strength and pressure requirements. Union shall have a water-impervious insulation barrier capable of limiting galvanic current to one percent of the short-circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test.

2.1.4 Flanges

Remove raised faces when used with flanges having a flat face.

2.1.4.1 Steel Flanges

ASME B16.5 forged steel, welding type.
2.1.4.2 Cast Iron Screwed Flanges

ASME B16.1.

2.1.4.3 Bronze Screwed Flanges


2.1.5 Drains and Overflows

2.1.5.1 Steel Pipe

ASTM A 53/A 53M, Seamless Schedule 40, Malleable iron or forged steel fittings, screwed or welded joints.

2.1.5.2 Copper Tubing

ASTM B 88, Type L, hard drawn, cast brass or wrought copper fittings, Grade Sb5 solder joints.

2.1.5.3 PVC Pipe

ASTM D 1785, Schedule 40, and Schedule 80 for sizes 8 inch and larger, solvent weld joints.

2.1.6 Valves

Valves shall have rising stems and shall open when turned counterclockwise.

2.1.6.1 Gate Valves

a. Bronze Gate Valves: MSS SP-80, 2 inches and smaller, wedge disc, inside screw type not less than Class 150. Use solder joint ends with copper tubing.

b. Steel Gate Valves: ASME B16.34, provide with open stem and yoke type with solid wedge or flexible wedge disc and heat and corrosion-resistant steel trim.

c. Cast Iron Gate Valves: MSS SP-70, 2 1/2 inches and larger, open stem and yoke type with bronze trim.

2.1.6.2 Globe and Angle Valves

a. Bronze Globe and Angle Valves: MSS SP-80, 2 inches and smaller, Class 200, except use Class 150 with solder ends for copper tubing. Valves shall have renewable seat and discs except solder end valves which shall have integral seats.

b. Steel Globe and Angle Valves: ASME B16.34, provide with heat and corrosion-resistant trim.

c. Cast Iron Globe and Angle Valves: MSS SP-85, 2 1/2 inches and larger, with bronze trim, tapped drains and brass plug.
2.1.6.3 Check Valves

a. Bronze Check Valves: MSS SP-80, 2 inches and smaller, regrinding swing check type, Class 200.

b. Steel Swing Check Valves: ASME B16.34, regrinding swing check type, Class 200.
   
   (1) Swing check valves shall have bolted caps.

   (2) Steel Lift check valves 2 inches and smaller shall have bolted caps. Lift check valves 2 1/2 inches and larger shall have pressure seal caps.

c. Cast Iron Check Valves: ASME B16.34, 2 1/2 inches and larger, bronze trim, non-slam, eccentric disc type for centrifugal pump discharge service.

2.1.6.4 Ball Valves

Flanged or butt-welding ends ball valve shall conform to MSS SP-72, bronze. Threaded, socket-welding, solder joint, grooved and flared ends shall conform to MSS SP-110.

2.1.6.5 Butterfly Valves

Conform with MSS SP-67, Type I - Tight shut off valve, and flanged valve ends. Valve body material shall be steel and shall be bubble tight for shutoff at 150 psig. Flanged and flangeless type valves shall have Type 300 series corrosion resistant steel stems and corrosion resistant or bronze discs with molded elastomer disc seals. Flow conditions shall be for the regulation from maximum flow to complete shutoff by way of throttling effect. Valves shall be provided in closed system. Valves smaller than 8 inches shall have throttling handles. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and indicators. Valves shall have a minimum of 7 locking positions and shall be suitable for water temperatures up to 200 degrees F.

2.1.6.6 Butterfly Valves 2 Inches and Smaller

Valves shall be one-piece and three-piece design with male or female threaded or soldered end connections and shall be bubble tight for shutoff at 150 psig. Stem and disc assembly shall be of 300 series corrosion resistant steel. Disc seal assembly shall be of 300 series corrosion resistant steel. Disc seal shall be suitable for the liquid being used in the system in which the valve is to be installed. Valves shall be suitable for water temperature up to 200 degrees F and shall be capable of operating at the rated pressure of 150 psig. Valves shall be designed for throttling service use by valve lever and indicator adjustment.
2.1.6.7  Relief Valves

Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

2.1.6.8  Valve Operating Mechanisms

Provide chainwheels and extension stems where indicated and as specified.

b. Chainwheel Operator: Shall be fabricated of cast iron or steel and shall include a wheel, endless chain and a guide to keep the chain on the wheel. Provide galvanized steel endless chain extending to within 3 feet of the floor.

d. Extension Stem: Corrosion resisting steel designed for rising and non-rising stems. Provide in length required to connect the valve stem and the handwheel and of sufficient cross section to transfer the torque required to operate the valve.

2.1.6.9  Balancing Valves

Balancing valves shall be calibrated bronze body balancing valves with integral ball valve and venturi or valve orifice and valve body pressure taps for flow measurement based on differential pressure readings. Valve pressure taps and meter connections shall have seals and built-in check valves with threaded connections for a portable meter. Meter shall be provided by the same manufacturer and be capable of reading system pressures and shall meet the requirements of the paragraph entitled "Flow Measuring Equipment." Valves shall have internal seals to prevent leakage around rotating element and be suitable for full shut-off rated pressure. Valves shall have an operator with integral pointer and memory stop. Balancing valves shall be selected for the required flows as indicated on the plans.

2.1.7  End Connections

2.1.7.1  Flexible Connectors

Provide flexible pipe connectors on piping connected to equipment. Flexible section shall consist of rubber, tetrafluoroethylene resin, corrosion-resistant steel, bronze, monel, or galvanized steel. Material provided and configuration shall be suitable for pressure, and circulating medium. Flexible section shall have flanged ends and shall be suitable for service intended. Flexible section may be reinforced with metal retaining rings, with built-in braided wire reinforcement and restriction bolts or with wire braid cover suitable for service intended.

2.1.7.2  Steel Piping

Screwed or socket welded for 2 inches and smaller and flanged or butt welded for 2 1/2 inches and larger.

b. Flanged Joints: Bolting and gaskets shall be as follows:

(1) Bolting: Bolt and stud material ASTM A 307, Grade B, and nut material ASTM A 194/A 194M, Grade 2. Bolt, stud, and nut dimensions ASME B18.2.2 threads ASME B1.1coarse type with Class 2A fit for bolts and studs, and Class 2B fit for nuts. Bolts or bolt studs shall extend completely through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Carbon steel bolts shall have American Standard regular square or heavy hexagon heads and shall have American Standard heavy semifinished hexagonal nuts conforming to ASME B18.2.2.

(2) Gaskets: ASME B16.21, Nonasbestos compressed material 1/16 inch thickness full face or self-centering flat ring type and suitable for pressure and temperature of the piping system.

c. Butt Weld Joints: ASME B31.9. Backing rings shall conform to ASME B31.9. Ferrous rings shall not exceed 0.05 percent sulfur; for alloy pipe, backing rings shall be of material compatible with the chemical composition of the parts to be welded and preferably of the same composition. Provide continuous machined or split band backing rings.


2.1.7.3 Joints for Copper Tubing

a. Solder conforming to ASTM B 32 alloy grade Sb5 or Sn96. Solder and flux shall be lead free (less than 0.2 percent of lead).

b. Copper Tube Extracted Joint: An extracted mechanical tee joint may be made in copper tube. Make joint with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, provide dimpled depth stops. Notch the branch tube for proper penetration into fitting to assure a free flow joint. Braze extracted joints using a copper phosphorous classification brazing filler metal. Soldered joints shall not be permitted.

2.1.8 Expansion Joints

2.1.8.1 Packless Type

Provide ASTM F 1120, Type III with fabricated corrosion-resistant steel bellows.

2.1.8.2 Guided Slip-Tube Type

Provide ASTM F 1007, Type IV internally-externally guided, injected semiplastic type packing.

2.1.9 Instrumentation
2.1.9.1  Pressure and Vacuum Gauges

Provide ASME B40.100 with restrictor.

2.1.9.2  Indicating Thermometers

Thermometers shall be dial type with an adjustable angle suitable for the service. Provide thermowell sized for each thermometer in accordance with the thermowell specification. Fluid-filled thermometers (mercury is not acceptable) shall have a nominal scale diameter of 5 inches. Construction shall be stainless-steel case with molded glass cover, stainless-steel stem and bulb. Stem shall be straight, length as required to fit well. Bimetal thermometers shall have a scale diameter of 3 1/2 inches. Case shall be hermetic. Case and stem shall be constructed of stainless steel. Bimetal stem shall be straight and of a length as required to fit the well.

2.1.9.3  Pressure/Temperature Test Ports

Pressure/Temperature Test Ports shall have brass body and EPDM and/or Neoprene valve seals. Ports shall be rated for service between 35 and 275 degrees F and up to 500 psig. Ports shall be provided in lengths appropriate for the insulation thickness specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and installed to allow a minimum of 12 inches of access for probe insertion. Provide with screw-on cap attached with a strap or chain to prevent loss when removed. Ports shall be 1/4 inch NPT and accept 1/8 inch diameter probes.

2.1.10  Miscellaneous Pipeline Components

2.1.10.1  Air Vent

Provide float type air vent in hydronic systems. Vent shall be constructed of brass or semi-steel body, copper float, and stainless steel valve and valve seat. Design air vent to suit system operating temperature and pressure. Provide isolating valve to permit service without draining the system. Pipe discharge of vent to a drain.

2.1.10.2  Strainers

Strainers for classes 125 and 250 piping in IPS 1/2 to 8 inches, inclusive, FS WW-S-2739 and locate as indicated.

2.1.10.3  Hangers and Supports

Design and fabrication of pipe hangers, supports, and welding attachments shall conform to MSS SP-58 and ASME B31.9. Hanger types and supports for bare and covered pipe shall conform to MSS SP-69 for the temperature range.

2.1.10.4  Pipe Sleeves

Sleeves in masonry and concrete walls, floors, and roof slabs shall be ASTM A 53/A 53M, Schedule 40 or Standard Weight, hot-dip galvanized steel ductile-iron or cast-iron pipe. Sleeves in partitions shall be zinc-coated sheet steel having a nominal weight of not less than 0.906 pound per square foot.
2.1.10.5 Escutcheon Plates

Provide one piece or split hinge metal plates for piping passing through floors, walls, and ceilings in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces and paint finish on metal plates in unfinished spaces.

2.2 ELECTRICAL EQUIPMENT

Provide complete with motors, motor starters, thermal overload protection, and controls. Equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3 CONTROLS

Provide controls as specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

2.4 INSULATION

Provide shop and field applied insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.5 ASBESTOS PROHIBITION

Asbestos and asbestos containing products are prohibited.

PART 3 EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

Piping fabrication, assembly, welding, soldering, and brazing shall conform to ASME B31.9. Piping shall follow the general arrangement shown. Route piping and equipment within buildings out of the way of lighting fixtures and doors, windows, and other openings. Run overhead piping in buildings in inconspicuous positions. Provide adequate clearances from walls, ceilings, and floors to permit welding of joints and application of insulation. Make provision for expansion and contraction of pipe lines. Make changes in size of water lines with reducing fittings. Do not bury, conceal, or insulate until piping has been inspected, tested, and approved. Do not run piping concealed in walls, partitions, underground, or under the floor except as otherwise indicated. Where pipe passes through building structure, locate pipe joints and expansion joints where they may be inspected. Provide flanged joints where necessary for normal maintenance and where required to match valves and equipment. Furnish gaskets, packing, and thread compounds suitable for the service. Provide long radius ells where possible to reduce pressure drops. Pipe bends in lieu of welding fittings may be used where
space permits. Pipe bends shall have a uniform radius of at least five times the pipe diameter and shall be free from appreciable flattening, wrinkling, or thinning of the pipe. Do not use mitering of pipe to form elbows, notching straight runs to form full sized tees, or any similar construction. Make branch connections over 2 inches with welding tees except factory made forged welding branch outlets or nozzles having integral reinforcements conforming to ASME B31.9 may be used, provided the nominal diameter of the branch is at least one pipe size less than the nominal diameter of the run. Branch connections 2 inches and under can be threaded or welded. Run vertical piping plumb and straight and parallel to walls. Provide sleeves for lines passing through building structure. Provide a fire seal where pipes pass through fire wall, fire partitions, fire rated pipe chase walls, or floors above grade. Install piping connected to equipment with flexibility for thermal stresses and for vibration, and support and anchor so that strain from weight and thermal movement of piping is not imposed on the equipment.

3.2.1 Hangers and Supports

Unless otherwise indicated, horizontal and vertical piping attachments shall conform to MSS SP-58. Band and secure insulation protection shields without damaging pipe insulation. Continuous inserts and expansion bolts may be used.

3.2.2 Grading of Pipe Lines

Unless otherwise indicated, install horizontal lines of hot water piping to grade down in the direction of flow with a pitch of not less than one inch in 30 feet, except in loop mains and main headers where the flow may be in either direction.

3.2.3 Pipe Sleeves

Provide sleeves where pipes and tubing pass through masonry or concrete walls, floors, roof, and partitions. Annular space between pipe, tubing, or insulation and the sleeve shall not be less than 1/4 inch. Hold sleeves securely in proper position and location before and during construction. Sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs shall extend 2 inches above finished floor. Firmly pack space between pipe or tubing and sleeve with oakum and caulk on both ends of the sleeve with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. Seal both ends of penetrations through fire walls and fire floors to maintain fire resistive integrity with UL listed fill, void, or cavity material.

3.2.4 Flashing for Buildings

Provide flashing where pipes pass through building roofs, and make outside walls tight and waterproof.

3.2.5 Unions and Flanges

Provide unions and flanges to permit easy disconnection of piping and apparatus. Each connection having a screwed-end valve shall have a union. Place unions and flanges no farther apart than 100 feet. Install unions
downstream of valves and at equipment or apparatus connections. Provide unions on piping under 2 inches in diameter, and provide flanges on piping 2 inches and over in diameter. Provide dielectric unions or flanges between ferrous and non-ferrous piping, equipment, and fittings; except that bronze valves and fittings may be used without dielectric couplings for ferrous-to-ferrous or non-ferrous-to-non-ferrous connections.

3.2.6 Connections for Future Equipment

Locate capped or plugged outlets for connections to future equipment as indicated.

3.2.7 Changes in Pipe Size

Provide reducing fittings for changes in pipe size; reducing bushings are not permitted. In horizontal lines, provide eccentric reducing fittings to maintain the top of the lines in the same plane.

3.2.8 Cleaning of Pipe

Thoroughly clean each section of pipe, fittings, and valves free of foreign matter before erection. Prior to erection, hold each piece of pipe in an inclined position and tap along its full length to loosen sand, mill scale and other foreign matter. For pipe 2 inches and larger, draw wire brush, of a diameter larger than that of the inside of the pipe, several times through the entire length of pipe. Before making final connections to apparatus, wash out interior of piping thoroughly with water. Plug or cap open ends of mains during shutdown periods. Do not leave lines open where foreign matter might enter the pipe.

3.2.9 Valves

Install valves in conformance with ASME B31.9. Provide gate valves unless otherwise directed. Install valves with stems horizontal or above. Locate or equip stop valves to permit operation from floor level, or provide with safe access in the form of walkways or ladders. Install valves in positions accessible for operation and repair.

3.2.9.1 Globe Valves

Install globe valves so that the pressure is below the disk and the stem horizontal.

3.2.9.2 Relief Valves

Provide valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks. Select system relief valve so that capacity is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment. Pipe relief valve outlet to the nearest floor drain.

3.2.10 Pressure Gage

Provide a shut-off valve or pet cock between pressure gages and the line.
3.2.11 Thermometers

Provide thermometers and thermal sensing elements of control valves with a separable socket. Install separable sockets in pipe lines in such a manner to sense the temperature of flowing the fluid and minimize obstruction to flow.

3.2.12 Strainers

Provide strainers, with meshes suitable for the services, where indicated, or where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

3.2.13 Pumps

Select pumps for specified fluid temperatures, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve. Support piping adjacent to pump such that no weight is carried on pump casings. Install close coupled and base mounted pumps on concrete base, with anchor bolts, set and level, and grout in place and provide supports under elbows on pump suction and discharge line sizes 4 inches and over. Lubricate pump before start-up.

3.2.14 Equipment Foundations

Locate equipment foundations as shown on the drawings. Size, weight, and design shall preclude shifting of equipment under operating conditions. Foundations shall meet the requirements of the equipment manufacturer. Concrete shall conform to Section 03 30 00 CAST-IN-PLACE CONCRETE, and grout shall be approved non-shrinking.

3.2.15 Equipment Installation

Install equipment in accordance with installation instructions of the manufacturers. Grout equipment mounted on concrete foundations before installing piping. Install piping in such a manner as not to place a strain on the equipment. Do not bolt flanged joints tight unless they match. Grade, anchor, guide, and support piping without low pockets.

3.2.16 Cleaning of Systems

As installation of the various system components is completed, fill, start, and vent prior to cleaning. Place terminal control valves in open position. Add cleaner to closed system at concentration as recommended by manufacturer. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water. Circulate for 6 hours at design temperatures, then drain. Refill with clean water and repeat until system cleaner is removed. Use neutralizer agents on recommendation of system cleaner supplier and approval of Contracting Officer. Remove, clean, and replace strainer screens. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required. Preliminary or final tests are not permitted until cleaning is approved.
3.2.17 Painting of Piping and Equipment

Provide in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.2.18 Identification of Piping

Identify piping in accordance with OSHA 29 CFR 1910.144, except that labels or tapes may be used in lieu of painting or stencilling. Spacing of identification marking on runs shall not exceed 50 feet. Materials for labels and tapes shall conform to FS A-A-1689, and shall be general purpose type and color class. Painting and stencilling shall conform to Section 09 90 00 PAINTS AND COATINGS.

3.3 FIELD QUALITY CONTROL

Perform inspections and tests as specified herein to demonstrate that piping and equipment, as installed, is in compliance with contract requirements. Start up and operate the system. During this time, periodically clean the various strainers until no further accumulation of foreign material occurs. Exercise care so that minimum loss of water occurs when strainers are cleaned. Adjust safety and automatic control instruments to place them in proper operation and sequence.

3.3.1 Hydrostatic Test of Piping System

Test piping system hydrostatically using water not exceeding 100 degrees F. Conduct tests in accordance with the requirements of ASME B31.9 and as follows. Test piping system after all lines have been cleaned and before applying insulation covering. Remove or valve off from the system, gages, and other apparatus which may be damaged by the test before the tests are made. Install calibrated test pressure gage in the system to observe any loss in pressure. Maintain test pressure for a sufficient length of time to enable an inspection of each joint and connection. Perform tests after installation and prior to acceptance. Notify the Contracting Officer in writing 2 days prior to the time scheduled for the tests.

3.3.2 Auxiliary Equipment and Accessory Tests

Observe and check pumps, accessories, and equipment during operational and capacity tests for leakage, malfunctions, defects, noncompliance with referenced standards, or overloading.

3.3.2.1 Backflow Preventers

Backflow preventers shall be tested by locally approved and certified backflow assembly testers. A copy of the test report shall be provided to the Contracting Officer prior to placing the domestic water system into operation, or no later than 5 days after the test.

3.4 TESTING, ADJUSTING, AND BALANCING

Test, adjust, and balance the hydronic system in accordance with Section 23 05 93 TESTING, ADJUSTING AND BALANCING.

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

3.4.2 Sound Level Tests

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

a. Background sound level (systems off);

b. Total sound level corrected for background; and

c. Sound power rating by manufacturer of the respective outlet.

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

-- End of Section --
1.1 REFERENCES

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 720 (2002) Refrigerant Access Valves and Hose Connectors
AHRI 750 (2007) Thermostatic Refrigerant Expansion Valves
AHRI 760 (2007) Solenoid Valves for Use With Volatile Refrigerants

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


AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M (2004; Errata 2004) Specification for Filler Metals for Brazing and Braze Welding
AWS Z49.1 (2005) Safety in Welding, Cutting and Allied Processes

ASME INTERNATIONAL (ASME)
ASME B16.22  (2001; R 2005) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings


ASME BPVC SEC IX  (2007; Addenda 2008) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)


ASTM A 653/A 653M  (2009) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process


ASTM D 520  (2000; R 2005) Zinc Dust Pigment

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

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigerant Piping System; G, AE

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Piping layouts which identify all valves and fittings.

b. Plans and elevations which identify clearances required for maintenance and operation.

SD-03 Product Data

Refrigerant Piping System

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Include in the data manufacturer's recommended installation instructions and procedures. Provide data for the following components as a minimum:

a. Piping and Fittings

b. Valves

c. Piping Accessories

d. Pipe Hangers, Inserts, and Supports

Spare Parts

Spare parts data for each different item of equipment specified in Army projects only.

Qualifications; G, _AE___ six copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.

Refrigerant Piping Tests; G, _AE___
A schedule, at least 2 weeks prior to the start of related testing, for each test. Identify the proposed date, time, and location for each test.

Demonstrations; G, __AE__

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

Refrigerant Piping Tests

Six copies of the report in bound 8 1/2 by 11 inch booklets documenting all phases of the tests performed. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

SD-07 Certificates

Service Organization; G, __AE__

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Maintenance
Operation and Maintenance Manuals

Data Package 2 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

Six complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Six complete copies of maintenance manual in bound 8 1/2 x 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals
shall include piping layouts and simplified wiring and control diagrams of the system as installed.

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site, if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made, as a permanent record. Structural members shall be welded in accordance with Section 05 05 23 WELDING, STRUCTURAL.

1.3.2 Contract Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation is the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

1.5 MAINTENANCE

1.5.1 General

Operation and maintenance data shall comply with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

1.5.2 Extra Materials

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than one months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS
a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

b. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown.

c. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

d. Exposed equipment moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS 249.1.

2.2 ELECTRICAL WORK

Electrical equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Field wiring shall be in accordance with manufacturer's instructions.

2.3 REFRIGERANT PIPING SYSTEM

Refrigerant piping, valves, fittings, and accessories shall be in accordance with ASHRAE 15 & 34 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories shall be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service shall be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant.

2.4 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

2.4.1 Copper Tubing

Copper tubing shall conform to ASTM B 280 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 1-3/8 inches. Joints shall be brazed except that joints on lines 7/8 inch and smaller may be flared. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Wrought copper and bronze solder-joint pressure fittings shall
conform to ASME B16.22 and ASTM B 75. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings shall not be allowed for brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

2.4.2 Solder

Solder shall conform to ASTM B 32, grade Sb5, tin-antimony alloy for service pressures up to 150 psig. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

2.4.3 Brazing Filler Metal

Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.5 VALVES

Valves shall be designed, manufactured, and tested specifically for refrigerant service. Valve bodies shall be of brass, bronze, steel, or ductile iron construction. Valves 1 inch and smaller shall have brazed or socket welded connections. Valves larger than 1 inch shall have butt welded end connections. Threaded end connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections. Valve stems exposed to the atmosphere shall be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow shall be legibly and permanently indicated on the valve body. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.5.1 Refrigerant Stop Valves

Valve shall be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing shall be replaceable under line pressure. Valve shall be provided with a handwheel or wrench operator and a seal cap. Valve shall be the straight or angle pattern design as indicated.

2.5.2 Check Valves

Valve shall be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve shall be provide with resilient seat.

2.5.3 Liquid Solenoid Valves

Valves shall comply with AHRI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions
shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 400 psi and a maximum operating pressure differential of at least 200 psi at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.5.4 Expansion Valves

Valve shall conform to AHRI 750 and ASHRAE 17. Valve shall be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 2 degrees F of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicated or for constant evaporator loads.

2.5.5 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 2 degrees F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.5.6 Refrigerant Access Valves

Refrigerant access valves and hose connections shall be in accordance with AHRI 720.

2.6 PIPING ACCESSORIES

2.6.1 Filter Driers

Driers shall conform to AHRI 710. Sizes 5/8 inch and larger shall be the full flow, replaceable core type. Sizes 1/2 inch and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that
none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 1,500 psi.

2.6.2 Sight Glass and Liquid Level Indicator

2.6.2.1 Assembly and Components

Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

2.6.2.2 Gauge Glass

Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.6.2.3 Moisture Indicator

Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

2.6.3 Flexible Pipe Connectors

Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 300 degrees F. Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.6.4 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports shall conform to MSS SP-58 and MSS SP-69.

2.6.5 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's
standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.2.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.2.2 Functional Requirements

Piping shall be installed 1/2 inch/10 feet of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

3.2.3 Fittings and End Connections
3.2.3.1 Brazed Connections

Brazing shall be performed in accordance with AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Joints in steel tubing shall be painted with the same material as the baked-on coating within 8 hours after joints are made. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and not be sprung or forced.

3.2.3.2 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.2.4 Valves

3.2.4.1 General

Refrigerant stop valves shall be installed on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Stop valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated noncondensible gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved.

3.2.4.2 Expansion Valves

Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 2-1/8 inches in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 2-1/8 inches. The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing shall be facing up.

3.2.4.3 Valve Identification
Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 1-3/8 inch diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14 gauge annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

3.2.5 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturer's recommendations for the system in which it is installed. Dryers shall be installed such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.2.6 Sight Glass

A moisture indicating sight glass shall be installed in all refrigerant circuits down stream of all filter dryers and where indicated. Site glasses shall be full line size.

3.2.7 Discharge Line Oil Separator

Discharge line oil separator shall be provided in the discharge line from each compressor. Oil return line shall be connected to the compressor as recommended by the compressor manufacturer.

3.2.8 Accumulator

Accumulators shall be provided in the suction line to each compressor.

3.2.9 Flexible Pipe Connectors

Connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required.

3.2.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating
temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.2.10.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.2.10.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.2.10.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.2.10.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.2.10.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 40 shields shall be used on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 2 inches and larger.

3.2.10.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds shall have the excess hanger loads suspended from panel points.

3.2.10.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet not more than 8 feet from end of risers, and at vent terminations.

3.2.10.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide
materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.2.10.9 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.2.10.10 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.2.11 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 feet on each side of each expansion joint, and in lines 4 inches or smaller not more than 2 feet on each side of the joint.

3.2.12 Pipe Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.2.13 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A 653/A 653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A 53/A 53M, Standard weight. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Sleeves shall not be installed in structural members.
3.2.13.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed with not less than 4 inches of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 4 inches of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.2.13.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 00 JOINT SEALANTS.

3.2.13.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 17 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8 inches from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 2 inches above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.
3.2.13.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.2.13.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.2.14 Access Panels

Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

3.2.15 Field Applied Insulation

Field installed insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.16 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.16.1 Color Coding

Color coding for piping identification is specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.16.2 Color Coding Scheme

A color coding scheme for locating hidden piping shall be in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.3 CLEANING AND ADJUSTING

Clean uncontaminated system(s) by evacuation and purging procedures currently recommended by refrigerant and refrigerant equipment manufacturers, and as specified herein, to remove small amounts of air and moisture. Systems containing moderate amounts of air, moisture, contaminated refrigerant, or any foreign matter shall be considered contaminated systems. Restoring contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, shall be performed using currently approved refrigerant and refrigeration manufacturer's procedures. Restoring contaminated systems
shall be at no additional cost to the Government as determined by the Contracting Officer. Water shall not be used in any procedure or test.

3.4 TRAINING COURSE

Conduct a training course for 2 members of the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

3.5 REFRIGERANT PIPING TESTS

After all components of the refrigerant system have been installed and connected, subject the entire refrigeration system to pneumatic, evacuation, and startup tests as described herein. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test. Provide the services of a qualified technician, as required, to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.5.1 Preliminary Procedures

Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

3.5.2 Pneumatic Test

Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 70 degree F dewpoint and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 10 psi with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ASHRAE 15 & 34 with a maximum test pressure 25 percent greater. Pressure above 100 psig shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure will be recorded along with the ambient temperature to which the system is exposed. A correction factor of 0.3 psi will be allowed for each degree F change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, then the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken
apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing shall not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

3.5.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 micrometers. During evacuation of the system, the ambient temperature shall be higher than 35 degrees F. No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, then the system shall be evacuated again down to 300 micrometers and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 500 micrometers is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure continues to rise, check the system for leaks, repair as required, and repeat the evacuation procedure. During evacuation, pressures shall be recorded by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

3.5.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

3.5.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

3.5.6 Contractor's Responsibility

At all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.
PART 1   GENERAL

1.1   REFERENCES

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

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360 (2005) Specification for Structural Steel Buildings, with Commentary

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


AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M (2004; Errata 2004) Specification for Filler Metals for Brazing and Braze Welding

ASTM INTERNATIONAL (ASTM)

ASTM A 653/A 653M (2009) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
1.2 DESIGN REQUIREMENTS

Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS apply to work specified in this section.

1.3 SCOPE OF WORK

Encompass low-pressure systems ductwork and plenums where maximum air velocity is 2,000 feet per minute (fpm) and maximum static pressure is 2 inches water gage (wg), positive or negative.

Submit Connection Diagrams for low pressure ductwork systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit Design Analysis and Calculations for low pressure ductwork systems indicating the manufacturer's recommended air velocities, maximum static pressures, temperature calculations and acoustic levels.
Do not use rigid fibrous-glass ductwork.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Submit Material, Equipment, and Fixture Lists and Records of Existing Conditions in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

Submit the following in accordance with paragraph entitled, "Drawings," of this section.

Connection Diagrams
Record Drawings

SD-03 Product Data

Submit manufacturer's catalog data for the following items:

Galvanized Steel Ductwork Materials
Brazing Materials
Mill-Rolled Reinforcing and Supporting Materials
Round Sheet Metal Duct Fittings

Turning Vanes

Flexible Connectors

Power Operated Dampers

Fire Dampers and Wall Collars
Gravity Backdraft and Relief Dampers
Manual Volume Dampers

SD-05 Design Data
SD-06 Test Reports

Ductwork Leakage Tests
Operational Tests

SD-07 Certificates

Submit certificates, showing conformance with the referenced standards contained in this section for:

Galvanized Steel Ductwork Materials
Brazing Materials
Mill-Rolled Reinforcing and Supporting Materials
Round Sheet Metal Duct Fittings

Turning Vanes
Dampers

Flexible Connectors

SD-10 Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with paragraph entitled, "Operation and Maintenance," of this section.

Power Operated Dampers
Fire Dampers and Wall Collars

1.5 DRAWINGS

Submit Connection Diagrams for low pressure ductwork systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Provide Record Drawings with current factual information including deviations from, and amendments to, the drawings and concealed or visible changes in the work, for low pressure ductwork systems. Label drawings "As-Built".

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 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 924/A 924M and ASTM A 653/A 653M, Designation G90. Treat duct surfaces to be painted by phosphatizing.
Conform to ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966 for sheet metal gages and reinforcement thickness.

Low pressure ductwork minimum standards are as follows:

MINIMUM SHEET METAL GAGE

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<tr>
<th>DUCT WIDTH</th>
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<tr>
<td>0 - 12</td>
<td>26</td>
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<td>13 - 30</td>
<td>24</td>
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<td>31 - 60</td>
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2.1.2 Brazing Materials

Brazing materials shall be silicon bronze conforming to AWS A5.8/A5.8M.

2.1.3 Mill-Rolled Reinforcing And Supporting Materials

Conform to ASTM A 36/A 36M for mill-rolled structural steel and, wherever in contact with sheet metal ducting galvanize to commercial weight of zinc or coated with materials conforming to ASTM A 123/A 123M SSPC A.

Equivalent strength, proprietary design, rolled-steel structural support systems may be submitted for approval in lieu of mill-rolled structural steel.

2.2 COMPONENTS

2.2.1 Round Sheet Metal Duct Fittings

Shop fabricate fittings.

Manufacture as separate fittings, not as tap collars welded or brazed into duct sections.

Submit for approval offset configurations.

Miter elbows shall be two-piece type for angles less than 31 degrees, three-piece type for angles 31 through 60 degrees, and five-piece type for angles 61 through 90 degrees. Centerline radius of elbows shall be 1-1/2 times fitting cross section diameter.

Crosses, increasers, reducers, reducing tees, and 90-degree tees shall be conical type.

Cutouts in fitting body shall be equal to branch tap dimension or, where smaller, excess material shall be flared and rolled into smooth radius nozzle configuration.

2.2.2 Reinforcement
Support inner liners of both duct and fittings by metal spacers welded in position to maintain spacing and concentricity.

2.2.3 Fittings

Make divided flow fittings as separate fittings, not tap collars into duct sections, with the following construction requirements:

- Sound, airtight, continuous welds at intersection of fitting body and tap
- Tap liner securely welded to inner liner, with weld spacing not to exceed 3 inches
- Pack insulation around the branch tap area for complete cavity filling.
- Carefully fit branch connection to cutout openings in inner liner without spaces for air erosion of insulation and without sharp projections that cause noise and airflow disturbance.

Continuously braze seams in the pressure shell of fittings. Protect galvanized areas that have been damaged by welding with manufacturer's standard corrosion-resistant coating.

Submit for approval offset configurations.

Elbows shall be two-piece type for angles through 35 degrees, three-piece type for angles 36 through 71 degrees, and five-piece type for angles 72 through 90 degrees.

Crosses, increasers, reducers, reducing tees, and 90-degree tees shall be conical type.

2.2.4 Turning Vanes

Turning vanes shall be double-wall type, commercially manufactured for high-velocity system service.

2.2.5 Dampers

Low pressure drop, high-velocity manual volume dampers, and high-velocity fire dampers shall be constructed in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

2.2.6 Flexible Connectors For Sheet Metal

Connectors shall be UL listed, 30-ounce per square foot, waterproof, fire-retardant, airtight, woven fibrous-glass cloth, double coated with chloroprene. Clear width, not including clamping section, shall be 6 to 8 inches.

Leaded vinyl sheet shall be provided as a second layer for sound attenuation. Leaded vinyl shall be not less than 0.055 inch thick, shall weigh not less than 0.87 pound per square foot, and shall be capable of approximately 10-decibel attenuation in the 10- to 10,000-hertz range.
2.2.7 Duct Hangers

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

2.2.8 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 in accordance with ASTM A 123/A 123M.

Equivalent strength, proprietary-design, rolled-steel structural support systems may be submitted for approval in lieu of mill-rolled structural steel.

2.2.9 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 zinc-coated ASTM A 123/A 123M.

2.2.10 Manual Volume Dampers

Conform to SMACNA 1966 for volume damper construction.

Equip dampers with an indicating quadrant regulator with a locking feature externally located and easily accessible for adjustment and standoff brackets to allow mounting outside external insulation. Where damper rod lengths exceed 30 inches, provide a regulator at each end of damper shaft.

All damper shafts shall have two-end bearings.

Splitter damper shall be 22-gage sheet metal 2 gages heavier than duct in which installed. Hinges shall be full length piano-type.

Damper shaft shall be full length and shall extend beyond damper blade. A 3/8 inch square shaft shall be used for damper lengths up to 20 inches and a 1/2 inch square shaft shall be used for damper lengths 20 inches 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 shall be multiblade type having a substantial frame with blades fabricated of 16-gage metal. Blades shall not exceed 10 inches in width and 48 inches in length and shall be pinned to 1/2 inch diameter shafts. Dampers greater than 48 inches in width shall be made in two or more sections with intermediate mullions, each section being mechanically interlocked with the adjoining section or sections.
shall have graphite-impregnated nylon bearings and shall be connected so that adjoining blades rotate in opposite directions.

2.2.11 Gravity Backdraft And Relief Dampers

Frame shall be constructed of not less than 1-1/2" by 4 inch reinforced 16-gage galvanized 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, and maximum blade length shall be 36 inches. Blade material shall be 16-gage galvanized 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 differential pressure.

Shaft bearings shall be graphite-impregnated nylon.

Gravity backdraft dampers in sizes 18 by 18 inches or smaller, when furnished integral with air moving equipment, may be equipment manufacturer's standard construction.

2.2.12 Power-Operated Dampers

Dampers shall conform to applicable requirements specified under Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC.

2.2.13 Fire Dampers And Wall Collars

Fire damper locations shall be in accordance with NFPA 90A.

Fire dampers in ductwork shall be provided at firewall barriers.

Fire dampers shall be constructed and labeled in accordance with UL 555 to provide damper and mounting fire-resistance that equals or exceeds fire-resistance of the construction in which installed. For link loads in excess of 20 pounds, UL-approved quartzoid links shall be provided.

Wall collars shall be constructed in accordance with UL 555.

PART 3 EXECUTION

3.1 PREPARATION

Provide sheet metal construction in accordance with the recommendations for best practices in ASHRAE EQUIP IP HDBK, Chapter 16, SMACNA 1966, NFPA 90A, and ASHRAE FUN IP, Chapter 32.

Where construction methods for certain items are not described in the referenced standards or herein, perform the work in accordance with recommendations for best practice defined in ASHRAE EQUIP IP HDBK.

Clean free of oil, grease, and deleterious substances sheet metal surfaces to be painted and surfaces to which adhesives are to be applied.
Duct strength shall be adequate to prevent failure under service pressure or vacuum created by fast closure of duct devices. Provide leaktight, automatic relief devices.

Supplementary steel shall be designed and fabricated in accordance with AISC 360 and AISC 325.

3.2 INSTALLATION

Fabricate airtight and include reinforcements, bracing, supports, framing, gasketing, sealing, and fastening to provide rigid construction and freedom from vibration, airflow-induced motion and noise, and excessive deflection at specified maximum system air pressure and velocity.

Enclose dampers located behind architectural intake or exhaust louvers by a rigid sheet metal collar and sealed to building construction with elastomers for complete air tightness.

Provide outside air-intake ducts and plenums made from sheet metal with soldered watertight joints.

Provide offsets and transformations as required to avoid interference with the building construction, piping, or equipment.

Wherever ducts pass through firewalls or through walls or floors dividing conditioned spaces from unconditioned spaces, provide a flanged segment in that surface during surface construction.

Clean free of oil, grease, and deleterious substances sheet metal surfaces to be painted or surfaces to which adhesives will be applied.

Where interiors of ducting may be viewed through air diffusion devices, construct the viewed interior with sheet metal and paint flat black.

Make plenum anchorage provisions, sheet metal joints, and other areas airtight and watertight by calking mating galvanized steel and concrete surfaces with a two-component elastomer.

3.3 APPLICATION

3.3.1 Low Pressure Sheet Metal Ducts

Weld angle iron frames at corners and ends, whenever possible. Angle iron reinforcements shall be riveted or welded to ducts not more than 6 inches on center, with not less than two points of attachment. Spot welding, where used, shall be 3 inches on center.

Standard seam joints shall be sealed with an elastomer compound to comply with SMACNA 1966 Seal Class A, B or C as applicable.

Crossbreaking shall be limited to 4 feet and shall be provided on all ducts 8 inches wide and wider. Bead reinforcement shall be provided in lieu of
crossbreaking where panel popping may occur. Where rigid insulation will be applied, crossbreaking is not required.

3.3.1.1 Longitudinal Duct Seams

Corner seams shall be Pittsburg lock.

3.3.1.2 Joints and Gaskets

Companion angle flanges shall be bolted together with 1/4 inch diameter bolts and nuts spaced 6 inches on center. Flanged joints shall be gasketed with chloroprene full-face gaskets 1/8 inch thick, with Shore A 40 durometer hardness. Gaskets shall be one piece and vulcanized at joints.

3.3.1.3 Flexible Duct Joints

Joints between flexible duct without sheet metal collars and round metal ductwork connections shall be made by trimming the ends, coating the inside of the flexible duct for a distance equal to depth of insertion with elastomer calk, and by securing with sheet metal screws or binding with a strap clamp.

3.3.1.4 Square Elbows

Provide double-vane duct turns in accordance with SMACNA 1966.

3.3.1.5 Radius Elbows

Conform to SMACNA 1966 for radius elbows. Provide an inside radius equal to the width of the duct. Where installation conditions preclude use of standard elbows, the inside radius may be reduced to a minimum of 0.25 times duct width and install turning vanes in accordance with the following schedule.

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<thead>
<tr>
<th>WIDTH OF ELBOWS INCHES</th>
<th>RADIUS OF TURNING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VANES IN PERCENT OF DUCT WIDTH</td>
</tr>
<tr>
<td></td>
<td>VANE NO. 1</td>
</tr>
<tr>
<td>Up to 16</td>
<td>56</td>
</tr>
<tr>
<td>17 to 48</td>
<td>43</td>
</tr>
<tr>
<td>49 and over</td>
<td>37</td>
</tr>
</tbody>
</table>

Where two elbows are placed together in the same plane in ducts 30 inches wide and larger, the guide vanes shall be continuous through both elbows rather than spaced in accordance with above schedule.

3.3.1.6 Outlets, Inlets, And Duct Branches

Install branches, inlets, and outlets so that air turbulence will be reduced to a minimum and air volume properly apportioned. Install adjustable splitter dampers at all supply junctions to permit adjustment of the amount of air entering the branch. Wherever an air-diffusion device is shown as being installed on the side, top, or bottom of a duct, and whenever a branch
takeoff is not of the splitter type, a commercially manufactured 45 degree side-take-off (STO) fitting with manua; provide volume damper to allow adjustment of the air quantity and to provide an even flow of air across the device or duct it services.

Where a duct branch is to handle more than 25 percent of the air handled by the duct main, use a complete 90-degree increasing elbow with an inside radius of 0.75 times branch duct width. Size of the leading end of the increasing elbow within the main duct shall have the same ratio to the main duct size as the ratio of the related air quantities handled.

Where a duct branch is to handle 25 percent or less of the air handled by the duct main, the branch connection shall have a 45 degree side take-off entry in accordance with SMACNA 1966.

3.3.1.7 Duct Transitions

Where the shape of a duct changes, the angle of the side of the transition piece shall not exceed 15 degrees from the straight run of duct connected thereto.

Where equipment is installed in ductwork, the angle of the side of the transition piece from the straight run of duct connected thereto shall not exceed 15 degrees on the upstream side of the equipment and 22-1/2 degrees on the downstream side of the equipment.

3.3.1.8 Branch Connections

Construct radius tap-ins in accordance with SMACNA 1966.

3.3.1.9 Access Openings

Install access doors and panels in ductwork upstream and downstream from coils adjacent to fire dampers at controls or at any item requiring periodic inspection, adjustment, maintenance, or cleaning, and every 20 feet 6.1M for indoor air quality housekeeping purposes.

Minimum size of access opening shall be 12 by 18 inches, unless precluded by duct dimensions or otherwise indicated.

Construct access door in accordance with SMACNA 1966, except that sliding doors may be used only for special conditions upon prior approval. Insulated doors shall be double-panel type.

Access doors that leak shall be made airtight by adding or replacing hinges and latches or by construction of new doors adequately reinforced, hinged, and latched.

Duct access shall be particularly suitable for commercial duct cleaning methods utilizing vacuum devices. Space access openings with a frequency and at points which will permit ready access to duct internals with essentially no duct or insulation cutting. Where access through an air-diffusion device or through access doors specified herein is not available at a specific point, 8 inch diameter, 16-gage provide access plates not more than 10 feet on center. Where duct is insulated and vapor-sealed,
provide mastic seals around circumference of access. When access plate is in place and insulated, externally identify the location.

3.3.1.10 Plenum Construction

Intake and discharge plenums shall have companion angle joints with the following minimum thickness of materials:

<table>
<thead>
<tr>
<th>LONGEST SIDE</th>
<th>SHEET METAL</th>
<th>COMPANION ANGLES</th>
<th>REINFORCEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCHES</td>
<td>ALL SIDES</td>
<td>INCHES</td>
<td>INCHES, 24 INCHES ON CENTER MAXIMUM</td>
</tr>
<tr>
<td>20</td>
<td>1-1/2 by 1-1/2 by 1/8</td>
<td>1-1/2 by 1-1/2 by 1/8</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>2 by 2 by 1/8</td>
<td>2 by 2 by 3/16</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>2 by 2 by 1/8</td>
<td>2 by 2 by 1/8</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>2 by 2 by 3/16</td>
<td>2 by 2 by 3/16</td>
<td></td>
</tr>
</tbody>
</table>

At the floor line and other points where plenums join masonry construction, panels shall be bolted 12 inches on center to 2- by 2- by 3/16 inch thick hot-dip galvanized steel angle that has been secured to the masonry with masonry anchors and bolts 24 inches on center and caulked tight to the masonry.

Panels shall be anchored to curbing by not less than 2- by 2- by 3/16 inch thick hot-dip galvanized steel angle iron. Concrete curbing shall include angle iron nosing with welded studs for the anchoring of panels. Nosing shall be level at curb height within plus or minus 1/16 inch.

Plenum access doors shall be constructed in accordance with SMACNA 1966 except that access doors smaller than man-access doors shall have door openings framed with angle iron that is one commercial size smaller than specified panel reinforcement.

Man-access door size shall be per SMACNA 1966 and paragraph entitled, "Access Openings," of this section. Insulated and uninsulated construction shall be per SMACNA 1966. Door openings shall be framed with channel iron. Doors shall be framed with angle iron. Channel iron and angle iron shall be approximately the same size as specified panel reinforcement. Exterior door skin shall be 16 gage. Latches shall be fabricated steel, hinges shall be at least 4 inches long, and bolting shall be at least 3/8 inch diameter.

Angle iron and channel iron shall have welded and ground miter corners.

3.3.1.11 Manual Volume Dampers

Balancing dampers of the splitter, butterfly, or multilouver type, shall be provided to balance each respective main and branch duct.

Dampers regulated through ceilings shall have regulator concealed in box mounted in the ceiling, with a cover finish aesthetically compatible with
ceiling surface. Where ceiling is of removable construction, regulators shall be above ceiling, and location shall be marked on ceiling in a manner acceptable to the Contracting Officer.

3.3.1.12 Flexible Connectors For Sheet Metal

Air handling equipment, ducts crossing building expansion joints, and fan inlets and outlets shall be connected to upstream and downstream components by treated woven-cloth connectors.

Connectors shall be installed only after system fans are operative, and vibration isolation mountings have been adjusted. When system fans are operating, connectors shall be free of wrinkle caused by misalignment or fan reaction. Width of surface shall be curvilinear.

3.3.2 Rectangular Sheet Metal Ducts

3.3.3 Round Sheet Metal Ducts

3.3.3.1 Duct Gages, Joints, And Reinforcement

Sheet metal minimum thickness, joints, and reinforcement between joints shall be in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

Longitudinal duct joint shall be manufactured by machine, with spiral lockseams to and including 60 inch diameters, and to dimensional tolerances compatible with fittings provided.

Ducts shall have supplemental girth angle supports, riveted with solid rivets 6 inches on center to duct. Girth angles shall be located as follows:

<table>
<thead>
<tr>
<th>DIAMETER, INCHES</th>
<th>REINFORCEMENT-MAXIMUM SPACING, INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 to 36</td>
<td>1-1/4 by 1-1/4, 1/8 thick, 72 inches on center</td>
</tr>
<tr>
<td>37 to 50</td>
<td>1-1/4 by 1-1/4, 1/8 thick, 60 inches on center</td>
</tr>
<tr>
<td>51 to 60</td>
<td>1-1/2 by 1-1/2, 1/8 thick, 48 inches on center</td>
</tr>
</tbody>
</table>

Draw band girth joints are not acceptable.

Slip joints shall be made up by coating the male fitting with elastomer sealing materials, exercising care to prevent mastic from entering fitting bore, leaving only a thin annular mastic line exposed internally. Sheet metal screws shall be used to make assembly rigid, not less than four screws per joint, maximum spacing 6 inches. Pop rivets shall not be used. All joints shall be taped and heat sealed.
Bolt heads and nuts shall be hex-shaped, 5/16 inch diameter for ducts up to 50 inch diameter, and 3/8 inch diameter for 51 inch diameter ducts and larger.

Flanges shall be continuously welded to duct on outside of duct and intermittently welded with 1 inch welds every 4 inches on inside joint face. Excess filler metal shall be removed from inside face. Galvanized areas that have been damaged by welding shall be protected with manufacturer's standard corrosion-resistant coating.

3.3.3.2 Duct Transitions

Where the shape of a duct changes, the angle of the side of the transition piece shall not exceed 15 degrees from the straight run of duct connected thereto.

Where equipment is installed in ductwork, the angle of the side of the transition piece from the straight run of duct connected thereto shall not exceed 15 degrees on the upstream side of the equipment and 22-1/2 degrees on the downstream side of the equipment.

3.3.4 Transverse Reinforcement Joints

Transverse reinforcements shall be riveted with solid rivets to duct sides 6 inches on center. Transverse reinforcement shall be welded at all corners to form continuous frames.

3.3.5 Joint Gaskets

Flanged joints shall be gasketed with chloroprene full-face gaskets 1/8 inch thick, Shore A 40 durometer hardness. Gaskets shall be one piece, vulcanized at joints.

3.3.6 Radius Elbows

Fabricate elbow proportions and radius elbows in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

3.3.7 Plenum Connections

Round duct connections shall be welded joint bellmouth type.

Rectangular duct connections shall be bellmouth type, constructed in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

3.3.8 Access Openings

Install access panels in ductwork adjacent to fire dampers.

Minimum size of access opening shall be 12 by 18 inches, unless precluded by duct dimension.
Access openings shall be framed by welded and ground miter joint, 1/8 inch thick strap steel, with 1/4 inch studs welded to frame. Cover plate shall be not less than 16-gage, reinforced as necessary for larger sizes.

In lieu of access doors, readily accessible flanged duct sections may be provided upon approval. Provide stable hanger supports for disconnected duct termini.

3.3.9 Duct Supports

Install duct support in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966. Duct hangers shall meet the minimum size specified in ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966. Provide two hangers where necessary to eliminate sway. Support attachment to duct surfaces, shall be by solid rivet 4 inches on center.

Selection of hanging system shall be at the Contractor's option, and shall take into account the location and precedence of work under other sections, interferences of various piping and electrical conduit, equipment, building configuration, structural and safety factor requirements, vibration, and imposed loads under normal and abnormal service conditions. Support sizes, configurations, and spacings are given to show the minimal type of supporting components required. If installed loads are excessive for the specified hanger spacing, hangers, and accessories heavier-duty components shall be provided. After system startup, any duct support device which, due to length, configuration, or size, vibrates or causes possible failure of a member, shall be replaced or the condition shall otherwise be alleviated. Special care shall be exercised to preclude cascade-type failures.

Hanger rods, angles, and straps shall be attached to beam clamps. Concrete inserts, masonry anchors, and fasteners shall be approved for the application.

Hardened high-carbon spring-steel fasteners fitted onto beams and miscellaneous structural steel are acceptable upon prior approval of each proposed application and upon field demonstration of conformance to specification requirements. Fasteners shall be made from steel conforming to AISI Type 1055, treated and finished in conformance with SAE AMS 2480, Type Z (zinc phosphate base), Class 2 (supplementary treatment). A 72-hour load-carrying capacity shall be verified by a certified independent laboratory.

Hanger spacing shall provide a 20-to-1 safety factor for supported load.

Maximum load supported by any two fasteners shall be 100 pounds.

Friction rod assemblies are not acceptable.

Where support from metal deck systems is involved, support requirements shall be coordinated with installation of metal deck.
Ductwork and equipment shall not be hung from roof deck, piping, or other ducts or equipment. Maximum span between any two points shall be 10 feet, with lesser spans as required by duct assemblies, interferences, and permitted loads imposed.

There shall be not less than one set of hangers for each point of support. Hangers shall be installed on both sides of all duct turns, branch fittings, and transitions.

Hangers shall be sufficiently cross braced to eliminate sway vertically and laterally.

Rectangular ducts up to 36 inches shall be supported by strap-type hangers attached at not less than three places to not less than two duct surfaces in different planes.

Perforated strap hangers are not acceptable.

Rectangular ducting, 36 inches and larger, shall be supported by trapeze hangers. Ducts situated in unconditioned areas and required to have insulation with a vapor-sealed facing shall be supported on trapeze hangers. Hangers shall be spaced far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside the trapeze. Duct hangers shall not penetrate the vapor-sealed facing.

Where trapeze hangers are used, the bottom of the duct shall be supported on angles sized as follows:

<table>
<thead>
<tr>
<th>WIDTH OF DUCT, INCHES</th>
<th>MINIMUM BOTTOM ANGLE SIZE, INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 and smaller</td>
<td>1-1/4 by 1-1/4 by 1/8</td>
</tr>
<tr>
<td>31 to 48</td>
<td>1-1/2 by 1-1/2 by 1/8</td>
</tr>
<tr>
<td>49 to 72</td>
<td>1-1/2 by 1-1/2 by 3/16</td>
</tr>
<tr>
<td>73 to 96</td>
<td>2 by 2 by 1/4</td>
</tr>
<tr>
<td>97 and wider</td>
<td>3 by 3 by 1/4</td>
</tr>
</tbody>
</table>

Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, such equipment shall be hung independently of the ductwork by means of rods or angles of sizes adequate to support the load.

Ducting, when supported from roof purlins, shall not be supported at points greater than one-sixth of the purlin span from the roof truss. Load per hanger shall not exceed 400 pounds when support is from a single purlin or 800 pounds when hanger load is applied halfway between purlins by means of auxiliary support steel provided under this section. When support is not halfway between purlins, the allowable hanger load shall be the product of 400 times the inverse ratio of the longest distance to purlin-to-purlin spacing.

When the hanger load exceeds the above limits, provide reinforcing of purlin(s) or additional support beam(s). When an additional beam is used,
the beam shall bear on the top chord of the roof trusses, and bearing shall be over gusset plates of top chord. Beam shall be stabilized by connection to roof purlin along bottom flange.

Purlins used for supporting fire-protection sprinkler mains, electrical lighting fixtures, electrical power ducts, or cable trays shall be considered fully loaded, and supplemental reinforcing or auxiliary support steel shall be provided for these purlins.

Provide vibration isolators in discharge ducting system for a distance not less than 50 feet beyond the air handling unit. Deflection of duct and equipment mountings shall be coordinated.

3.3.10 Flexible Connectors For Steel Metal

Air-handling equipment, ducts crossing building expansion joints, and fan inlets and outlets shall be connected to upstream and downstream components by treated woven-cloth connectors.

Install connectors only after system fans are operative and all vibration isolation mountings have been adjusted. When system fans are operating, connectors shall be free of wrinkles caused by misalignment or fan reaction. Width of surface shall be curvilinear.

3.3.11 Insulation Protection Angles

Galvanized 20-gage sheet, formed into an angle with a 2 inch exposed long leg with a 3/8 inch stiffening break at outer edge, and with a variable concealed leg, depending upon insulation thickness, shall be provided.

Install angles over all insulation edges terminating by butting against a wall, floor foundation, frame, and similar construction. Fasten angles in place with blind rivets through the protection angle, insulation, and sheet metal duct or plenum. Install angles after final insulation covering has been applied.

3.3.12 Duct Probe Access

Provide holes with neat patches, threaded plugs, or threaded or twist-on caps for air-balancing pitot tube access. Provide extended-neck fittings where probe access area is insulated.

3.3.13 Openings In Roofs And Walls

Building openings are fixed and provide equipment to suit.

3.4 FIELD QUALITY CONTROL

3.4.1 Fire Damper Tests

Perform Operational tests on each fire damper in the presence of the Contracting Officer by enervating fusible link with localized heat. Provide new links and install after successful testing.
3.4.2 Ductwork Leakage Tests

Contractor shall conduct complete leakage test of new ductwork in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Tests shall be performed prior to installing ductwork insulation.

3.4.3 Inspection

Ductwork shall be inspected in accordance with SMACNA 1987.

3.5 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 all main and branch interior surfaces to airstreams moving at velocities two times specified working velocities, at static pressures within maximum ratings. This may be accomplished by: filter-equipped portable blowers which remain the Contractor's property; wheel-mounted, compressed-air operated perimeter lances which direct the compressed air and which are pulled in the direction of normal airflow; and other means approved by the Contracting Officer. Compressed air used for cleaning ducting shall be water- and oil-free. After construction is complete, and prior to acceptance of the work, construction dust and debris shall be removed from exterior surfaces. SMACNA 1987.

3.6 OPERATION AND MAINTENANCE

Contractor shall submit 6 copies of the Operation and Maintenance Manuals 30 calendar days prior to testing the medium/high pressure ductwork systems. 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.

-- End of Section --
PART 1   GENERAL

1.1   REFERENCES

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

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)


AMCA 300 (2005) Reverberant Room Method for Sound Testing of Fans

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI Guideline D (1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11 (1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings

ABMA 9 (1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M (2004; Errata 2004) Specification for Filler Metals for Brazing and Braze Welding

ASME INTERNATIONAL (ASME)

ASME B16.21 (2005) Nonmetallic Flat Gaskets for Pipe Flanges

ASME BPVC SEC IX (2007; Addenda 2008) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)

1.2 SYSTEM DESCRIPTION

Construct, complete and operational, an exhaust system as specified herein. The exhaust system(s) shall provide adequate air exhaust quantities and velocities. All duct shall be properly sized for pressure loss and adequate velocity including locating intakes, ductwork size, layout, equipment and controls. Construction of the exhaust system shall be based on the referenced publications, and other provisions as specified herein. Furnish ductwork offsets, fittings, and any other accessories required, as specified, to provide a complete exhaust system installation and to eliminate interference with other construction. Controls shall be provided
as specified in Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G, AE

Exhaust System Installation; G, AE

Three copies of the Exhaust System Drawings, no later than 21 days prior to the start of exhaust system installation.

SD-03 Product Data

Related Submittals

A list of the Exhaust System Related Submittals, no later than 7 days after the approval of the Exhaust System Specialist.

Ductwork Components; G, AE

Materials and Equipment

Manufacturer's catalog data included with the Exhaust System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Spare Parts

Spare parts data for each different item of material and equipment specified.

Field Instructions

Final Acceptance Tests

Proposed diagrams, instructions, and other sheets, concurrent with the Final Acceptance Test Procedures, Framed instructions under glass or in laminated plastic shall be posted where directed, including wiring and control diagrams showing the complete layout of the entire system. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted
beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

Proposed procedures for Final Acceptance Tests, no later than 14 days prior to the proposed start of the tests.

Proposed date and time to begin Final Acceptance Tests, submitted with the Final Acceptance Test Procedures. Notification shall be provided at least 14 days prior to the proposed start of the test.

Onsite Training; G, AE

Proposed Onsite Training schedule, at least 14 days prior to the start of related training.

Exhaust System Specialist; G, AE

The name and documentation of certification of the proposed Exhaust System Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the exhaust system drawings and hydraulic calculations.

SD-06 Test Reports

Final Acceptance Tests

Three copies of the completed Final Acceptance Tests Reports, no later than 7 days after the completion of the Final Acceptance Tests. All items in the Final Acceptance Report shall be signed by the Exhaust System Specialist.

SD-07 Certificates

Inspection; G, AE

Concurrent with the Final Acceptance Test Report, certification by the Exhaust System Specialist that the exhaust system is installed in accordance with the contract requirements, including signed approval of the Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Exhaust System
Operation and Maintenance Manuals

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days prior to on-site training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour on-site response to a service call on an emergency basis.
1.4 QUALITY ASSURANCE

1.4.1 Detail Drawings

Submit Detail Drawings consisting of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, installation instructions, complete duct, wiring, and schematic diagrams and any other details to demonstrate that the system has been coordinated and will properly function as a unit. Also show proposed layout and anchorage of equipment and appurtenances, and equipment in relation to other parts of the work including clearances required for maintenance and operation.

1.4.2 Exhaust System Specialist

The Exhaust System Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful installation of the exhaust systems(s). The related submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Exhaust System Specialist when submitted to the Government. The Exhaust System Specialist shall be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.5 DELIVERY, STORAGE, AND HANDLING

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all ductwork, flexible connections and pipes shall either be capped or plugged until installed.

1.6 EXTRA MATERIALS

Submit spare parts data for each item of equipment and material specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

b. Where an integrated, packaged exhaust system is furnished, all items will be the product of the system manufacturer. System component parts may be by other manufacturers. Equipment shall be supported by a service organization that is capable of responding to service calls within four hours.
c. Asbestos and asbestos-containing products are not acceptable.

2.2 NAMEPLATES

All equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.3 EQUIPMENT GUARDS AND ACCESS

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed according to Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

2.4 DUCTWORK COMPONENTS

2.4.1 General

Duct shall be constructed of stainless steel sheets of the minimum gauge thickness for ducts as required in SMACNA 1922. Ducts shall be constructed and sealed in accordance with SMACNA 1922 for a negative pressure of 4 inch water gauge static pressure. Ducts, unless otherwise approved, shall be round with longitudinal lock seam and conform to the dimensions indicated. Ducts shall be straight and smooth on the inside with airtight joints. Where ducts with crimped ends are used to make up joints, the joints shall have crimp and bead. The bead shall provide a rigid stop for the mating open end to seat against. Steel spiral wound duct is not acceptable.

2.4.2 Fittings

Reducing fittings shall have a minimum of 1 inch increase in diameter per 8 inches in length. Elbows shall have a centerline radius of not less than 1.5 times the diameter. Branches shall stub into mains at main expansion points at an angle of not more than 30 degrees with the centerline of the main duct in the direction of air flow, unless otherwise indicated or approved. Where riser ducts with single or multiple inlets are indicated, the riser duct shall connect into the bottom of the main duct at an angle as specified for branches. Where flexible connections connect to the main duct, the duct branch takeoff or stub shall be braced with approved metal straps or members.

2.4.3 Cleanout

Cleanout shall be provided on the end of the main ductwork opposite the end of the fan suction connection. The cleanout opening shall be sized to the approximate inside area of the duct. Removable airtight caps or flange type covers of minimum gauge thickness as the main duct shall be provided. Other cleanout openings shall be provided where indicated.

2.4.4 Apparatus Connections
Where sheet metal connections are made to fan suction and discharge, or where ducts of dissimilar metals are connected, an approved noncombustible flexible connection approximately 6 inches wide shall be installed and securely fastened by zinc-coated steel clinch-type draw bands for round ducts. For rectangular ducts the flexible connections locked to metal collars shall be installed using normal duct construction methods.

2.4.5 Duct Test Holes

Test holes with covers shall be provided where indicated, directed, or where necessary in ducts and plenums for using Pitot tubes for taking air measurements to balance the air systems.

2.4.6 Duct Sleeves and Framed Openings

Duct sleeves shall be provided for all round ducts 15 inch diameter or less passing through floors, walls, ceilings, or roofs. Sleeves in non-load bearing walls shall be fabricated of 20 gauge steel sheets conforming to ASTM A 924/A 924M. Sleeves in load-bearing walls shall be fabricated of standard-weight galvanized steel pipe conforming to ASTM A 53/A 53M. Round ducts larger than 15 inch diameter and all square and rectangular ducts passing through floors, walls, ceilings, or roofs shall be installed through framed openings. Structural steel members for framed openings shall conform to ASTM A 36/A 36M. Framed openings shall provide 1 inch clearance between the duct and the opening. Closure collars of galvanized steel not less than 4 inches wide shall be provided on each side of walls or floors where sleeves or framed openings are provided. Collars for round ducts 15 inch diameter or less shall be fabricated from 20 gauge galvanized steel. Collars for round, square or rectangular ducts with minimum dimension over 15 inches shall be fabricated from 18 gauge galvanized steel.

2.5 EXHAUST HOSE SYSTEM

2.5.1 Tailpipe Adapters

Adapters shall be of the tapered-cone type with spring clips or other suitable devices for exhaust pipe attachment. The adapter shall fit 6 inch nominal diameter exhaust pipe.

2.5.2 Welding Fume Receptors

Welding fume receptors shall be constructed of not less than 20 gauge thick aluminum and shall be equipped with 1/2 inch mesh receptor screens; shall have swivel connections, and magnets on receptor base.

2.5.3 Flexible Exhaust Hose

Flexible exhaust hose shall be 0.012 inch minimum strip thickness of stainless steel. Wye connectors shall be provided where shown. Flexible tubing inside diameter and length shall be as shown. The tubing shall be connected to the bottom of the ductwork. A flanged connection shall be provided where the flexible tubing and overhead ductwork are joined. The flanged connection shall consist of steel flanges not less than 0.078 inch thick, 1/8 inch gasket. The gasket shall be suitable for the system design temperature shown, in accordance with ASME B16.21, full face or self-centering flat ring type. It shall contain aramid fibers Bonded with
styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). The flange shall be sized or designed to suit the hose as approved. The connection of the neoprene hose may be installed with an approved hose clamp or as recommended by the manufacturer.

2.5.4 Exhaust Hose Suspension System

The exhaust hose suspension system shall suspend the flexible tubing overhead when not in use; allowing it to be lowered to the operating level, when required. The suspension system shall be furnished complete with cable, and operating mechanism. The suspension system shall be counter-weighted type.

2.6 DAMPERS

Dampers shall be of the type indicated and installed where shown. Dampers shall be of the circular disk type with quadrant locking device or blast gate type. Damper blades shall be not less than 16 gauge thickness of stainless steel. Blast gate dampers shall be two piece construction with adjustable sliding gate and setscrew.

2.7 MATERIALS

Materials shall conform to the following requirements.

2.7.1 Screen

ASTM E 2016, type and class as required for the application.

2.7.2 Iron and Steel Sheets

2.7.2.1 Galvanized Iron and Steel

ASTM A 924/A 924M, Coating Designation G90.

2.7.2.2 Uncoated Steel

ASTM A 1011/A 1011M, condition, and type best suited to intended use.

2.7.2.3 Stainless Steel

ASTM A 167, Type 304.

2.7.3 Steel Structural Shapes

ASTM A 36/A 36M.

2.7.4 Solder Silver

AWS A5.8/A5.8M, brazing alloy; grade to suit application.

2.7.5 Solder

ASTM B 32, composition to suit application.
2.7.6 Bolts and Nuts

Bolts and nuts, except as required for high temperature exhaust applications, shall be in accordance with ASTM A 307. Bolts and nuts used for exhaust applications where the temperature of the bolt may rise above 400 degrees F or used as flange bolts in corrosion resistant material shall be in accordance with ASTM A 193/A 193M Class 2. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A 307 or ASTM A 193/A 193M as applicable.

2.8 ELECTRICAL WORK

Electrical motor-driven equipment specified shall be provided complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be according to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 1 hp and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary. Each motor shall be according to NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 10 hp or less. Adjustable frequency drives shall be used for larger motors.

2.9 AIR MOVING DEVICES

2.9.1 General

Fans shall be tested and rated in accordance with the standards of AMCA 210, Type "D" Ducted Inlet, Ducted Outlet Configuration. Where V-belt drives are used, such drives shall be designed for not less than 150 percent of the connected driving capacity, and motor sheaves shall be adjustable to provide not less than an overall 20 percent speed variation. Sheaves shall be selected to drive the fan at such speed as to produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Motors for V-belt drives shall be provided with adjustable rails or bases. Fans shall be provided with personnel screens or guards on both suction and supply ends except where ducts or dampers are connected to the fan. Fans and motors shall be provided with vibration isolation supports or mountings. Vibration isolation units shall be standard products with published load ratings, and shall be single rubber-in-shear, neoprene coated fiberglass, double rubber-in-shear springs, or springs under inertia base. Each fan shall be selected to produce the capacity required at the fan total pressure indicated. Standard AMCA arrangements shall be provided unless otherwise indicated and the rotation and discharge shall be as indicated. Fans shall have nonoverloading characteristics. Fan housing shall be constructed with not less than 16 gauge thickness of steel. Fan impellers shall be constructed to meet AMCA Spark Resistance "B" Classification and accurately balanced both statically and dynamically when installed in the assembled fan unit. Impeller and housing in the air stream shall be coated with neoprene, epoxy,
phenolic resins, or otherwise be suitable to resist the corrosive gases and temperatures produced. Fans shall be free of objectionable vibration or noise. Certified performance curves indicating that the fan supplied will operate in its most efficient operating range will be provided. In addition, "sound power" ratings shall be furnished with each fan. Fans indicated to be mounted on exterior of building shall be provided with weatherproof covers for the motor drive unit or other weatherproofing as recommended by the manufacturer. Each fan shall be selected to produce the capacity required at the fan total pressure indicated. Weather hoods, flashing, and bird screens shall be provided where indicated.

2.9.2 Fans

The sound power level shall be as indicated and values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated. Fans shall be tested and rated according to AMCA 210. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than 150 percent of the connected driving capacity. Motor sheaves shall be variable pitch for 15 hp and below and fixed pitch as defined by AHRI Guideline D. Variable pitch sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance.

2.9.2.1 Protective Devices

Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports or mountings as indicated. Vibration-isolation units shall be standard products with published loading ratings.

2.9.2.2 Centrifugal Fans

Centrifugal fans shall be fully enclosed, single-width single-inlet, or double-width double-inlet, AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Impeller wheels shall be rigidly constructed, accurately balanced both statically and dynamically. Fan blades may be forward curved, backward-inclined or airfoil design in wheel sizes up to 30 inches. Fan blades for wheels over 30 inches in diameter shall be backward-inclined or airfoil design. These fans shall be suitable for the temperatures encountered. The fan shaft shall be provided with a heat slinger to dissipate heat buildup along the shaft. An access (service) door to facilitate maintenance shall be supplied with these fans. Fan wheels over 36 inches in diameter shall have overhung pulleys and a bearing on each side of the wheel. Indirect drive fan wheels 36 inches or less in diameter may have one or more extra long bearings between the fan wheel and the drive. Bearings shall be sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with
accessible grease fittings or permanently lubricated type. Grease fittings shall be connected to tubing and serviceable from a single accessible point. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Fan shafts shall be steel, accurately finished, and shall be provided with key seats and keys for impeller hubs and fan pulleys. Each fan outlet shall be of ample proportions and shall be designed for the attachment of angles and bolts for attaching flexible connections. Motors, unless otherwise indicated, shall not exceed 1800 rpm and shall have totally enclosed enclosures. Motor starters shall be magnetic type with watertight enclosure.

2.9.3 In-Line Centrifugal Fans

In-line centrifugal fans shall have welded tubular casings, centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Air shall enter and leave the fan axially. Inlets shall be streamline with conversion vanes to eliminate turbulence and discharge air flow smoothly. Fan bearings and drive shafts shall be enclosed and isolated from air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated or lubricative type with grease lines extending to the exterior of the housing. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Motors shall have totally enclosed enclosure. Motor starters shall be magnetic across-the-line with explosion-proof enclosure.

2.10 FACTORY COATING

Equipment and component items, when fabricated from ferrous metal as defined by ASTM (or similar) standard, shall be factory finished with the manufacturers standard finish except that items located outside of building shall have weather-resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B 117.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

3.3 INSPECTION

The Exhaust System Specialist shall inspect the exhaust system periodically during the installation to assure that the exhaust system installed in accordance with the contract requirements. The Exhaust System Specialist shall witness the final tests, and shall sign the test results. The Exhaust System Specialist, after completion of the system inspections and successful Final Acceptance Test, shall certify in writing that the system has been installed in accordance with the contract requirements. Any discrepancy
shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.4 EXHAUST SYSTEM INSTALLATION

3.4.1 General Requirements

Welding and brazing shall conform to ASME BPVC SEC IX. Horizontal sections of the main duct shall be installed with the longitudinal lock seam on the top. Slip joints shall be sealed in accordance with SMACNA 1922. Riser duct shall be supported and anchored to the structure as indicated. Main duct shall be attached to the structural members of the building as recommended by SMACNA 1922.

3.4.2 Building Surface Penetrations

Sleeves or framed openings shall be utilized where duct penetrates building surfaces. Penetrations shall be sealed, and fireproofed in accordance with Section 07 84 00 FIRESTOPPING. The space between the sleeve or framed opening and the duct shall be packed with mineral wool or other approved material. Closure collars shall be installed around the duct on both sides of the penetrated surface. Collars shall fit tight against the building surfaces and snugly around the duct.

3.5 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance operations. Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

3.7 FINAL ACCEPTANCE TESTS

Each exhaust system and inlet shall be balanced to produce the indicated air quantities within 10 percent at the conditions shown. Control devices shall be set to control at the points indicated or directed. Bearings shall be lubricated, and the speed, direction or rotation of each fan shall be checked. The running current of each motor shall be checked. Upon completion, and prior to acceptance of the installation, the exhaust system shall be tested at operating conditions to demonstrate satisfactory functional and operating efficiency. Operating tests shall cover a period of not less than 2 hours for each system, and all tests shall be conducted in the presence of the Contracting Officer. If tests do not demonstrate satisfactory operation of the exhaust system, correct deficiencies and retest. Provide all instruments, facilities, and labor required to properly conduct the tests. The electricity required for testing will be furnished by the Government.