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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA-15218 (May 2005)
NASA
Superseding NASA-15218 (October 2004)

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NASA-15218 (May 2005)

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SECTION 15218

VACUUM SYSTEMS

05/05

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

This section covers aboveground low-vacuum systems defined for the purposes of this section as systems at pressures less than atmospheric and ranging to approximately 29.5 inches of mercury vacuum or the approximately absolute; 0.25144 pound per square inch, absolute, 13,000 microns of mercury absolute, or 13 torr 100 kilopascal (29.5 inches of mercury), 1.734 kilopascal (0.25144 psi) or 13 millimeter of mercury.

Drawings shall completely detail anchors, restraining guides, sway braces, and shock absorbing provisions to accommodate reaction forces encountered, as well as other piping support elements not covered by the following specifications.

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PART 1 GENERAL

1.1 REFERENCES

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

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 314 (1990; R 2000) Steel Anchor Bolts

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 350 (1999) Load and Resistance Factor Design

	(LFRD) Specification for Structural Steel Buildings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C207	(2001) Steel Pipe Flanges for Waterworks Service-Sizes 4 in. Through 144 in.
AWWA C208	(2001) Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C504	(2000) Standard for Rubber-Seated Butterfly Valves

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.8	(1991; 8th Ed) Welding Handbook; Volume Two - Welding Processes

ASME INTERNATIONAL (ASME)

ASME B16.1	(1998) Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2002) Forged Steel Fittings, Socket-Welding and Threaded
ASME B16.22	(2002) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.3	(1998) Malleable Iron Threaded Fittings Classes 150 and 300
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B16.5	(2003) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24
ASME B16.9	(2001) Factory-Made Wrought Steel Buttwelding Fittings
ASME B18.2.1M	(1996) Square and Hex Nuts (Metric Series)
ASME B18.2.2	(1987; R 1999) Square and Hex Nuts
ASME B31.1	(2001) Power Piping
ASME B40.100	(1998) Pressure Gauges and Gauge Attachments
ASME B46.1	(2002) Surface Texture (Surface Roughness, Waviness, and Lay)

ASTM INTERNATIONAL (ASTM)

ASTM A 105/A 105M	(2003) Standard Specification for Carbon Steel Forgings for Piping Applications

ASTM A 126/A 126M	(1995) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A 139	(2000) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A 181/A 181M	(2001) Standard Specification for Forgings, Carbon Steel, for General-Purpose Piping
ASTM A 183	(2003) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A 197/A 197M	(2000) Standard Specification for Cupola Malleable Iron
ASTM A 216/A 216M	(1993; R 2003) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A 234/A 234M	(2003) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperatures
ASTM A 307	(2004) Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 351/A 351M	(2003) Standard Specification for Steel Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure Containing Parts
ASTM A 436	(1984; R 2001) Standard Specification for Austenitic Gray Iron Castings
ASTM A 53/A 53M	(2002) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 694/A 694M	(2003) Standard Specification for Forgings, Carbon and Alloy Steel, for Pipe Flanges, Fittings, Valves and Parts for High Pressure Transmission Service
ASTM B 148	(1997; R 2003) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B 164	(2003) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B 280	(2003) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B 370	(2003) Standard Specifications for Copper Sheet and Strip for Building Construction

ASTM B 62	(2002) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 749	(2003) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C 592	(2000) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C 920	(2002) Standard Specification for Elastomeric Joint Sealants
ASTM D 2000	(2003a) Standard Classification System for Rubber Products in Automotive Applications
ASTM E 1	(2003a) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E 621	(1994; R 1999e1) Standard Practice for Use of Metric (SI) Units in Building Design and Construction
ASTM F 1120	(1987; R 1998) Standard Specification for Circular Metallic Bellows-Type Expansion Joints for Piping Applications
ASTM F 147	(1987; R 2003) Standard Test Method for Flexibility of Non-Metallic Gasket Material
ASTM F 568M	(2004) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

FLUID SEALING ASSOCIATION (FSA)

FSA-0017	(1995) Non-Metallic Expansion Joints and Flexible Pipe Connectors Technical Handbook, 6th Edition

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

MSS SP-104	(2003) Wrought Copper LW Solder Joint Pressure Fittings
MSS SP-43	(1991; R 2001) Wrought Stainless Steel Butt - Welding Fittings Including Reference to Other Corrosion Resistant Materials
MSS SP-58	(2002) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-67	(2002) Butterfly Valves
MSS SP-69	(2002) Pipe Hangers and Supports -

	Selection and Application
MSS SP-72	(1999) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2003) Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	(2001) Steel Pipe Unions Socket Welding and Threaded
MSS SP-86	(2002) Guidelines for Metric Data in Standards for Valves, Flanges, Fittings and Actuators

U.S. DEPARTMENT OF DEFENSE (DOD)

MS MIL-C-6183	(1998b) Cork and Rubber Composition Sheet; for Aromatic Fuel- and Oil-Resistant Gaskets

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS FF-S-325	(Int Amd 3) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)

1.2 SUBMITTALS

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

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The following shall be submitted in accordance with Section 01330, "Submittal Procedures," in sufficient detail to show full compliance with the specification:

SD-02 Shop Drawings

Detail Drawings shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

Installation drawings shall be submitted for low-vacuum piping systems in accordance with paragraph entitled, "Aboveground Piping Systems Installation," of this section.

SD-03 Product Data

Manufacturer's catalog data shall be submitted for the following items:

Aboveground Piping Materials

Valves
Miscellaneous Materials
Supporting Elements

SD-06 Test Reports

Test reports shall be submitted for the following items showing Government and Contractor test personnel responsibilities, dates, test gage identification numbers, ambient temperatures, pressure ranges, rates of pressure drop, and leakage rates.

Hydrostatic Tests
Leakage Tests

SD-07 Certificates

Certificates shall be submitted for the following items showing conformance with the referenced standards contained in this section.

Aboveground Piping Materials
Valves
Miscellaneous Materials
Supporting Elements

1.3 GENERAL REQUIREMENTS

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NOTE: If Section 15003, "General Mechanical Provisions," is not included in the project specification, applicable requirements therefrom should be inserted and the first paragraph deleted. If Section 15072, "Vibration Isolation for Air Conditioning Equipment," is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted. If Section 15055, "Welding Mechanical," is not included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.
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[Section 15003, "General Mechanical Provisions," apply to work specified in this section.]

[Section 15072, "Vibration Isolation for Air Conditioning Equipment" applies to work in this section.]

[Section 15055, "Welding Mechanical," applies to work specified in this section.]

Detail Drawings shall include the manufacturer's design and construction calculations, the forces required to obtain rated axial and lateral movements, installation criteria, anchor and guide requirements, and all other pertinent data required for evaluation of proposed equipment. Drawings shall specifically call out the procedures to be followed and provisions required to protect expansion joints during specified testing operations.

In lieu of separate hangers, the Contractor may submit for approval a detail drawing of proposed trapeze hangers with turnbuckles on rods and a solid or split-ring clamp for each pipe.

PART 2 PRODUCTS

2.1 ABOVEGROUND PIPING MATERIALS

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NOTE: Coordinate indicated and specified vacuum and pressure ratings with test criteria.
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2.1.1 Vacuum Systems to 29.5 Inches of Mercury 100 kPa Vacuum

Type BCS: Black carbon steel

Pipe (1/8 inch through 1-1/2 inches): (DN6 through DN30): Schedule 40, furnace butt weld, black carbon steel, conforming to ASTM A 53/A 53M, Type F

Pipe (2 through 8 inches (DN50 through DN200 where indicated): Schedule 40, seamless (Type 5) or electric (Type E) resistance-welded, black carbon steel, conforming to ASTM A 53/A 53M, Grade B, Type [E] [S]. Grade A should be used for permissible field bending.

Fittings (2 inches (DN50 and under): 150-pounds per square inch, gage (psig) 1050 kilopascal working steam-pressure (wsp), banded, black malleable iron, screwed, conforming to ASTM A 197/A 197M, ASTM A 234/A 234M and ASME B16.3

Unions (2 inches (DN50 and under): 250-psig 1724 kilopascal wsp, female, screwed, black malleable iron, with brass to iron seat and ground joint, conforming to ASME B16.39 and MSS SP-83

Couplings (2 inches (DN50 and under): Standard weight, screwed, black carbon steel

Fittings (2-1/2 inches (DN65 and over): Steel, butt weld, conforming to MSS SP-43, ASTM A 234/A 234M and ASME B16.9

Flanges (2-1/2 inches (DN65 and over): 150-psig 1050 kilopascal wsp, forged steel, welding neck, to match pipe wall thickness, conforming to ASME B16.5 and ASTM A 694/A 694M

Grooved pipe couplings and fittings (2-1/2 inches (DN65 and over): Contractor has the option of using malleable iron couplings and fittings conforming to requirements specified under "Grooved Pipe Couplings and Fittings" in this section

Type GCS: Galvanized carbon steel

Pipe (1/8 inch through 1-1/2 inches): (DN6 through DN40): Schedule 40, furnace butt weld, black carbon steel, conforming to ASTM A 53/A 53M, Type F

Pipe (2 through 8 inches (DN50 through DN200 where indicated): Schedule 40, seamless or electric resistance welded, galvanized steel, conforming to ASTM A 53/A 53M, Grade B, Type E or S

Fittings (8 inches and under): 150-psig (DN200 and under): 1050 kilopascal

wsp, banded, galvanized, malleable iron, screwed, conforming to ASTM A 197/A 197M, ASTM A 234/A 234M and ASME B16.3

Unions (2 inches and under): 300-psig (DN50 and under): 2068 kilopascal wsp, female, screwed, galvanized, malleable iron with brass to iron seat and ground joint

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NOTE: Type SWP wall thickness is based on stress values of 12,500 pounds per square inch (psi) 86.2 Megapascal, 85 percent of external average collapse pressure with a safety factor of 4.

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Type SWP: Spiral welded pipe

Pipe [(6 through 36 inches):(DN150 through DN900):] Electric fusion welded, carbon steel, conforming to ASTM A 139, Grade B, with wall thickness as follows:

NOMINAL DIAMETER INCHES	MINIMUM WALL THICKNESS INCH
12.00	0.125
14.00	0.141
16.00	0.172
18.00	0.188
22.00	0.219
24.00	0.250
28.00	0.281
30.00	0.312
36.00	0.375

NOMINAL DIAMETER MILLIMETER	MINIMUM WALL THICKNESS MILLIMETER (INCH)
300	3.18 (0.125)
350	3.58 (0.141)
400	4.37 (0.172)
450	4.78 (0.188)
550	5.56 (0.219)
600	6.35 (0.250)
700	7.14 (0.281)

NOMINAL DIAMETER MILLIMETER	MINIMUM WALL THICKNESS MILLIMETER (INCH)
750	7.92 (0.312)
900	9.53 (0.375)

Refer to "Supporting Elements" in this section for additional requirements.

Fittings (all sizes): Materials and thicknesses shall be as specified for pipe. Fittings configuration and dimensions shall conform to AWWA C208, Tables 1 and 2 and MSS SP-86

Fittings shall be butt weld end type

2,000 pounds per square inch (psi), 13789 kilopascal, forged carbon steel, threaded half coupling, conforming to ASTM A 105/A 105M and ASME B16.11

Threads shall be retapped after welding.

Flanges (all sizes): Forged carbon steel, slip-on type, conforming to ASTM A 181/A 181M, Class 60 or 70, and AWWA C207, Class D, and ASTM A 105/A 105M concentric serrated finish

[Grooved couplings: Refer to "Grooved Pipe Couplings and Fittings" in this section. Pipe ends shall have welded collars grooved to fit couplings, fabricated from ASTM A 53/A 53M pipe.]

2.1.2 Control and Instrumentation System Tubing

Type CPR-C&I: Copper

Tubing

All sizes (1/4-inch (DN8 minimum): Hard drawn or annealed, seamless copper, conforming to ASTM B 280, No. C12200

Fittings

All sizes: Solder joint, wrought copper, conforming toASME B16.22 and MSS SP-104

Ball sleeve compression type, rod or forged brass conforming to SAE A 360 or SAE CA 377, UL-approved, with minimum pressure rating of 200 psi at 100 degrees F 1380 kilopascal at 38 degrees C

Solder

95-5 tin-antimony, alloy Sb5, conforming to AWS WHB-2.8.

2.1.3 Pressure Gages

Pressure gages shall conform to ASME B40.100 and to requirements specified herein. Pressure gages shall be Type II, Class 1 (pressure); Class 2 (vacuum); or Class 3 (pressure-vacuum). Pressure gage size shall be 3-1/2 inches 90 millimeter nominal diameter. Case shall be corrosion-resistant steel conforming to any of the AISI 300 series with an ASM No. 4 standard commercial polish or better. All gages shall be equipped with adjustable red marking pointer and damper screw adjustment in inlet connection.

2.1.4 Thermometers

Thermometers shall conform to ASTM E 1. Thermometers shall be industrial pattern Type I, Class 3. Thermometers installed 6 feet 1830 millimeter or higher above the floor shall have an adjustable angle body. Scale shall be not less than 7 inches 175 millimeter long, and case face shall be manufactured from manufacturer's standard polished aluminum or AISI 300 series polished corrosion-resistant steel. Thermometer range shall be as indicated. Thermometers shall be provided with nonferrous separable wells.

2.1.5 Grooved Pipe Couplings and Fittings

Couplings shall have a housing fabricated in two or more parts of malleable iron castings. Coupling gasket shall be molded synthetic rubber, conforming to requirements of ASTM D 2000. Coupling bolts shall be oval neck track head type with hexagonal heavy nuts, conforming to ASTM A 183.

Pipe fittings used with couplings shall be fabricated of malleable iron castings. Where a manufacturer's standard size malleable iron fitting pattern is not available, fabricated fittings shall be used.

Fittings shall be fabricated from Schedule 40 or 0.375-inch 9.53 millimeter (0.375-inch) wall ASTM A 53/A 53M, seamless steel pipe; long-radius seamless welding fittings with wall thickness to match pipe, conforming to ASTM A 234/A 234M, ASME B16.9 and MSS SP-43.

2.1.6 Metallic Expansion Joints

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NOTE: This specification does not include slip type expansion joints or ball joints.

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Expansion joints shall be packless bellows type conforming to ASTM F 1120, except as otherwise modified or supplemented by requirements.

Expansion joints shall be [Type I, Class 1.] [Type I, Class 2.] [Type II, Class 1.] [Type II, Class 2.] [tied, hinged, or gimbaled.]

Joints shall be designed and constructed to absorb all movement of the pipe sections in which they are installed with no detrimental effect on the pipe or supporting structure.

[Operating pressures and temperatures for each joint shall be as shown.]

[Joints shall be rated, designed, and constructed for service with vacuum

to 2 millimeter of mercury absolute, pressures to 50 psig 345 kilopascal, and temperatures to 250 degrees F 121 degrees C.]

[Joints shall be rated, designed, and constructed for service with vacuum to 2 millimeter of mercury absolute, pressures to 150 psig 1050 kilopascal, and temperatures to 500 degrees F 260 degrees C.]

Joints shall have a designed bursting strength in excess of four times their rated pressure.

Joints shall be capable of withstanding a Hydrostatic Tests of 1.2 times their rated pressure without leakage or distortion while held at their uncompressed length. Life expectancy shall be not less than 10,000 cycles.

Movement capability of each joint shall exceed calculated movement of piping by [33] [_____] percent.

Bellows and internal sleeve material shall be AISI 304[L] corrosion-resistant steel.

End connections shall be as indicated and shall require no field preparation other than maintenance of cleanliness.

[Butt weld end preparation of expansion joints shall conform to the same codes and standards requirements as applicable to the piping system materials at the indicated joint location.]

[Flanges of flanged end expansion joints shall conform to the same codes and standards requirements as are applicable to companion flanges specified for the given piping system at the indicated joint location.]

Van stone flanges shall not be acceptable.

Joints 2-1/2 inches 65 millimeter and smaller shall have internal guides and limit stops.

Joints 3 inches 75 millimeter and larger shall be provided with removable external covers, internal sleeves, and purging connection. Sleeves shall be sized to accommodate lateral clearance required with minimum reduction of flow area, using oversized bellows where necessary. When sleeve requires a gasket as part of locking arrangement, this gasket shall be provided by the manufacturer. Joints without purging connections may be provided; however, these shall be removed from the line or shall not be installed until after cleaning operations have been completed.

[Cylindrical end portion of the reinforced bellows element shall be provided with a thrust sleeve of sufficient thickness to bring this portion within applicable code allowable stress. This sleeve shall provide 360-degree support for the element and end reinforcing ring.]

[Expansion joints shall have four, equidistant, permanent tram points clearly marked on each joint end. Points shall be located to prevent obliteration during installation. Distance between tram points (indicating installed lengths) shall be as noted. Overall dimension shall be subject to approval by the Contracting Officer after joint installation.]

Expansion joints shall have adjustable clamps or yokes provided at quarter points straddling the bellows. Overall joint length shall be set by the manufacturer to maintain joints in manufacturer's recommended position

during installation.

Joints shall be clearly and legibly marked with the manufacturer's name or trademark and serial number and with the size and series or catalogue number, bellows material, and directional flow arrow.

Preservation provisions shall be Level A of ASTM F 1120.

Packing provisions shall be Level B of ASTM F 1120.

2.2 VALVES

2.2.1 Ball Valves, Vacuum (BAVV)

Ball valves shall conform to MSS SP-72 Style [1] [3].

Valves shall be UL approved for certain compressed gases and a pressure rating of not less than 175 psi at 200 degrees F 1210 kilopascal (175 psi) at 93 degrees C; and shall be certified suitable for leaktight service under a vacuum of 2 millimeter of mercury absolute.

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

Valve bodies in sizes 2-1/2-inch DN75 ips and larger shall be flanged-end-connection type constructed of Class [D] [E] [F] material, unless otherwise specified.

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

Balls and stems of valves 2-1/2-inch DN75 ips and larger shall be manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome-plating. In valves 6-inch DN150 ips and larger, balls may be Class D with 900 Brinell hard chrome-plating. Electroless nickel-plating is acceptable.

Valves shall be suitable for flow from either direction and shall seal tightly in either direction.

Valves shall have full pipe size flow areas where noted.

Valves with ball seats kept in place by spring washers are not acceptable. Seats and seals shall be filled tetrafluoroethylene or manufacturer's standard material for the specified service.

Valve body construction shall be such that:

Torque from a pipe with valve installed shall not tend to disassemble the valve by stripping setscrews or by loosening body end inserts or coupling nuts.

Torque from a pipe shall be resisted by a one-piece body between end connections or by bolts in shear where body is of mating flange or surface bolted construction.

2.2.2 Butterfly Valves, Vacuum (BUVV)

****

NOTE: Review service temperature range prior to selection of materials to ensure long elastomer life under nonlubricated conditions.

The following is limited to valve sizes through 42 inches DN1050. Drawings shall show temperature range and negative (vacuum) and positive pressures at which system will operate. Check for sonic velocities. Coordinate with shaft selection. Mass spectrometer tests utilizing helium should be specified only if necessary with leak detector sensitivity of at least 1 times 10 to the minus 6 cubic centimeter per second.

****

Butterfly valves shall conform to MSS SP-67.

Butterfly valves through 20 inches DN500 shall be wafer type; in sizes larger than 20 inches DN500, valves shall be the two-flange type for mounting between specified flanges. Drilled and tapped holes at the valve bearing areas will be acceptable for valves larger than 20 inches DN500.

Valves shall be rated for indicated velocities and shutoff and nonshock working pressure.

Body shall be cast ferrous metal conforming to minimum requirements of ASTM A 126/A 126M, Class B and to ASME B16.1 for body wall thickness.

All sizes of valves shall be certified as tested and suitable for leaktight service under a vacuum of 2 millimeter of mercury absolute.

Laying lengths of wafer valves shall conform to MSS SP-67.

Laying lengths of flanged valves shall conform to AWWA C504, Table 3, and MSS SP-86 short body length.

Disk shall be free of external ribs and shall be streamlined. Disk shall be fabricated from cast ferrous or nonferrous alloys conforming to ASTM A 436, Type 2 copper-free (austenitic cast iron), ASTM A 216/A 216M, Grade WCB (cast steel), ASTM A 351/A 351M, Grade CF8M (corrosion-resistant steel), or ASTM B 148, No. C95500 (aluminum bronze).

[Where vacuum piping systems are corrosion-protected internally, all ferrous valve surfaces exposed to airstream shall be of corrosion-resistant steel or electroplated or flame-sprayed with a corrosion-resistant metal such as aluminum, zinc, tin or cadmium. Protection provided shall be specifically certified as suitable for the intended service.]

Shaft shall be fabricated from AISI 300 series or 17-4 pH corrosion-resistant steel, or nickel-copper alloy conforming to ASTM B 164, and may be one piece or stub-shaft type. Stub shafts shall extend into the disk hub at least 1-1/2 shaft diameters. Connection between the valve shaft and disk shall be designed to transmit shaft torque equivalent to not less than 75 percent of the torsional strength of the minimum required shaft diameter. Minimum nominal shaft diameter for all valves shall be in accordance with the following list:

****

NOTE: Select the following based on AWWA C504, Class 25A, and MSS SP-86 for normal service where dynamic torque is not involved.

****

VALVE SIZE INCHES	SHAFT DIAMETER INCHES	VALVE SIZE INCHES	SHAFT DIAMETER INCHES
3	1/2	16	1-3/8
4	5/8	18	1-1/2
6	3/4	20	1-1/2
8	7/8	24	1-3/4
10	1	30	2
12	1-1/8	36	2-1/2
14	1-1/4	42	2-7/8

VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER	VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER
75	13 (1/2)	400	34 (1-3/8)
100	16 (5/8)	450	38 (1-1/2)
150	19 (3/4)	500	38 (1-1/2)
200	22 (7/8)	600	44 (1-3/4)
250	25 (1)	750	50 (2)
300	28 (1-1/8)	900	63 (2-1/2)
350	31 (1-1/4)	1050	72 (2-7/8)

****

NOTE: Select the following based on AWWA C504, Class 75B, and MSS SP-86 where shaft diameters are suitable for seating and calculated dynamic torque.

****

VALVE SIZE INCHES	SHAFT DIAMETER INCHES	VALVE SIZE INCHES	SHAFT DIAMETER INCHES
3	1/2	16	1-1/2
4	5/8	18	1-5/8
6	3/4	20	1-7/8
8	7/8	24	2-1/4
10	1	30	2-3/4

VALVE SIZE INCHES	SHAFT DIAMETER INCHES	VALVE SIZE INCHES	SHAFT DIAMETER INCHES
12	1-1/8	36	3-1/2
14	1-3/8	42	3-3/4

VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER	VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER
75	13 (1/2)	400	38 (1-1/2)
100	16 (5/8)	450	41 (1-5/8)
150	19 (3/4)	500	48 (1-7/8)
200	22 (7/8)	600	57 (2-1/4)
250	25 (1)	750	70 (2-3/4)
300	28 (1-1/8)	900	89 (3-1/2)
350	35 (1-3/8)	1050	95 (3-3/4)

****

NOTE: Select the following based on AWWA C504, Class 150B, and MSS SP-86 where shaft diameters are suitable for seating and calculated dynamic torque.

****

VALVE SIZE INCHES	SHAFT DIAMETER INCHES	VALVE SIZE INCHES	SHAFT DIAMETER INCHES
3	1/2	16	2
4	5/8	18	2-1/4
6	1	20	2-1/2
8	1-1/8	24	3
10	1-3/8	30	3-5/8
12	1-1/2	36	4-3/8
14	1-3/4	42	5

VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER	VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER
75	13 (1/2)	400	50 (2)
100	16 (5/8)	450	57 (2-1/4)
150	25 (1)	500	63 (2-1/2)
200	28 (1-1/8)	600	76 (3)

VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER	VALVE SIZE MILLIMETER (DN)	SHAFT DIAMETER MILLIMETER
250	35 (1-3/8)	750	92 (3-5/8)
300	38 (1-1/2)	900	111 (4-3/8)
350	44 (1-3/4)	1050	127 (5)

In the sealing areas, shaft shall have a surface finish conforming to ASME B46.1, 0.27 millimeter root mean square or better.

****
NOTE: Cycle life of elastomer is severely reduced in dry service as pressure and temperature increase typically: 4,000 cycles at 75 degrees F at 150 psi 24 degrees C at 1050 kilopascal; 250 cycles at 225 degrees F at 75 psi 107 degrees C at 517.1 kilopascal. Rewrite following paragraph to include cycle life if necessary.
****

Seats and seals shall be resilient elastomer type. Seats shall be mechanically retained type, designed for field removal and replacement unless otherwise specified. Elastomers shall be formulated for continuous nonlubricated service at indicated temperatures and pressures.

[Seats shall be bonded type. Where bonding adhesives are used, these shall comply with elastomer temperature requirements and shall have an effective life equal to or greater than the elastomer.]

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

Shaft seals shall be of the four O-ring type, mounted in a nonferrous metal cage. Two rings shall be used as a shaft seal; the other two rings shall be used as a housing seal. Provisions shall be made to introduce high-vacuum grease to lubricate all four O-rings. High-vacuum grease shall be submitted for Contracting Officer approval.

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

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

Valves larger than 20 inches DN500 shall be provided with thrust bearings set to hold disk firmly in place.

Locking feature shall be provided to make valve tamperproof where indicated.

Manual nonchain-operated valves through 8 inches DN200 shall be provided with not less than nine-position-level lock handles not exceeding 18 inches 450 millimeter in length.

Manual valves 10 inches DN250 and larger, or smaller if the application torque exceeds a pull of 80 foot-pounds 110 newton-meter or if so indicated, shall be provided with gear operators.

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

Gear operators shall be worm-gear type. Gears shall be hob-cut and shall be totally enclosed in a cast-iron housing suitable for grease or oil-flood lubrication. Gears and gear shafts shall be supported on bronze or corrosion-resistant, lubricated bearings. Operators shall be sized to provide the required torque, static or dynamic, with a maximum manual pull of 80 foot-pounds 110 newton-meter on the handwheel or chain wheel.

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

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

2.2.3 Diaphragm Control and Instrument Valves (DCIV)

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

2.2.4 Gage Cocks (GC)

Gage cocks shall be T-head or lever handle ground key type with washer and screw, constructed of polished ASTM B 62 bronze and rated for 125-psi 862 kilopascal (125-psi) saturated steam service. End connections shall suit the service, with or without union and nipple.

2.2.5 Globe and Angle Valves (GLV and ANV)

Globe and angle valves 2 inches DN50 and smaller, shall conform to MSS SP-80 and to requirements specified herein. Valves shall be union-ring bonnet, screwed end type with backseating stem. Disk shall be free to swivel on the stem in all valve sizes and shall have a fiberglass filled, tetrafluoroethylene composition seating surface. Packing shall be woven non-asbestos fiber impregnated with not less than 25 percent, by weight, of tetrafluoroethylene resin.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Bolting

Flange and general purpose bolting shall be hex-bolts and shall conform to ASTM A 307 ASTM F 568M, Grade B. Heavy hex-nuts shall conform to ASME B18.2.2 ASME B18.2.1M. Square-head bolts and nuts shall not be acceptable.

2.3.2 Elastomer Calk

Polysulphide or polyurethane base elastomer calking material shall be two-component conforming to ASTM C 920.

2.3.3 Flashing

Lead

Sheet lead shall conform to ASTM B 749 , Grade [B] [C] [D] and shall weigh not less than 4 pounds per square foot 95 kilogram per square meter.

Copper

Sheet copper shall conform to ASTM B 370 and shall weigh not less than 16 ounces per square foot 5 kilogram per square meter.

2.3.4 Flange Gaskets

****
NOTE: For average vacuum service application use chloroprene, 60 to 65 shore a durometer hardness.
****

Type A: Soft chloroprene sheet, 45 to 60 Shore A durometer hardness, conforming to ASTM F 147 and MS MIL-C-6183, Type II, Class 2, Grade A.

Type B: Medium chloroprene sheet, 60 to 65 Shore A durometer hardness, conforming to ASTM F 147 and MS MIL-C-6183, Type II, Class 2, Grade B.

Type C: Firm chloroprene sheet, 70 to 80 Shore A durometer hardness, conforming to ASTM F 147 and MS MIL-C-6183, Type II, Class 2, Grade C.

2.3.5 Pipe Thread Compounds

Tetrafluoroethylene tape not less than [_____] [2] mils [0.0508] millimeter thick shall be used in compressed air systems for pipe sizes to and including 1-inch DN25 ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval by the Contracting Officer.

2.4 SUPPORTING ELEMENTS

****
NOTE: Type SWP piping horizontal and vertical piping attachments and mill-provided reinforcement of piping should be detailed to suit project conditions. Support spacing should be based on an allowable bending stress of approximately 3,000 pounds per square inch, 20700 kilopascal (3000 psi), desired deflections, and natural frequency of piping when connected to pulsating equipment.
****

2.4.1 Supports

All necessary piping system components and miscellaneous supporting elements shall be provided, including but not limited to, building

structure attachments, supplementary steel, hanger rods, stanchions and fixtures, vertical pipe attachments, pipe attachments, anchors, guides, shock absorbers, and variable and constant supports. All supporting elements shall be suitable for stresses imposed by system pressures and temperatures and natural and other external forces. Refer to Section 15072, "Vibration Isolation for Air Conditioning Equipment," for vibration isolation considerations.

Supporting elements shall be UL approved or listed and shall conform to requirements of ASME B31.1, MSS SP-58, and MSS SP-69.

"Type" devices specified are defined as MSS standards.

[Horizontal and vertical piping attachments and certain other details for piping systems utilizing variable wall thickness, Type SWP spiral welded pipe materials shall be as noted.]

2.4.2 Building Structure Attachments

Anchor devices, concrete and masonry

Anchor devices shall conform to requirements of FS FF-S-325 AASHTO M 314, and FS FF-S-325, [Group I] [Group II, Type 2, Class 2, Style [1] [2]] [Group III] [Group VIII].

Cast-in, floor-mounted equipment anchor devices shall provide adjustable positions.

Masonry anchor devices shall be built-in.

Powder-actuated anchoring devices shall not be used to support any mechanical systems components.

Beam clamps

Beam clamps shall be center loading Type [21] [28] [29] [30], UL listed, catalogued and low rated, commercially manufactured products.

[C-clamps

****

NOTE: C-clamps, as a means of attaching hangers to structural steel, should be avoided. Where used, consider vibration forces and single or accumulated load and resultant moment on structural steel.

****

C-clamps may be used to support piping sizes 1-1/2-inches DN40 and smaller. C-clamps shall be FM approved and UL listed with hardened cup tip, setscrew, locknut, and retaining strap. Retaining strap section shall be not less than 1/8 by 1 inch 3 by 25 millimeter. Beam flange thickness to which clamps are attached shall not exceed 0.60 inch 15.2 millimeter.]

[Inserts, concrete

Concrete inserts shall be constructed in accordance with MSS SP-58 for Type 18 and MSS SP-69. When applied to piping in sizes 2-inch DN50 ips and larger and where otherwise required by imposed loads, a 1-foot

length of 1/2-inch 300 millimeter length of 15 millimeter reinforcing rod shall be inserted and wired through wing slots. Approved proprietary-type continuous inserts may be similarly used.]

2.4.3 Horizontal Pipe Attachments

Single pipes

Piping in sizes to and including 2-inch DN50 ips shall be supported by Type 6 solid malleable iron pipe rings except that split-band-type rings shall be used in sizes up to 1-inch DN25 ips.

Piping in sizes through 8-inch DN200 ips inclusive shall be supported by Types [1] [3] [4] attachments.

Pipe rolls shall be Type 41 or Type 49.

Spring supports shall be provided in accordance with referenced codes and standards. Complete shop drawing data shall be submitted for approval.

Parallel pipes

Trapeze hangers fabricated from approved structural steel shapes, with U-bolts, shall be used in congested areas and where multiple pipe runs occur. Structural steel shapes shall conform to supplementary steel requirements or the support may be commercially available, proprietary design, rolled steel.

2.4.4 Vertical Pipe Attachments

Vertical pipe attachments shall be Type 8, single pipes.

2.4.5 Hanger Rods and Fixtures

Only circular cross section rod hangers shall be used to connect building structure attachments to pipe support devices. Pipe straps, or bars of equivalent strength may be used for hangers only where approved by the Contracting Officer.

Turnbuckles, swing eyes, and clevises shall be provided as required by support system to accommodate pipe accessibility and adjustment for load and pitch.

2.4.6 Supplementary Steel

Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, such supplementary steel shall be designed and fabricated in accordance with AISC 350. and ASTM E 621.

PART 3 EXECUTION

3.1 ABOVEGROUND PIPING SYSTEMS INSTALLATION

3.1.1 Piping Systems

Piping systems shall be fabricated and installed in accordance with ASME B31.1, MSS SP-69 and AWS WHB-2.8.

Installation of piping systems materials shall be in accordance with manufacturer's instructions.

Pipe shall be fabricated to measurements established on the job and shall be carefully worked into place without springing or forcing. Adequate provision shall be made for absorbing all expansion and contraction without undue stress in any part of the system.

Pipe, tubing, fittings, valves, equipment, and accessories shall be clean and free of foreign material before being installed in their respective systems.

Pipe shall be cleaned by hammering, shaking, or swabbing or by a combination of methods.

Lines shall be purged with dry, oil-free compressed air after erection, but purging shall not be relied upon for removing all foreign matter. Purging shall be performed at a velocity greater than maximum normal-flow velocity and be approved by the Contracting Officer.

During the progress of construction, open ends of pipe, fittings, and valves shall be properly protected at all times to prevent the admission of foreign matter. Plugs or caps shall be placed in the ends of all installed work at all times when connections are not actually under way. Plugs shall be commercially manufactured products.

Piping shall be installed straight and true with approved offsets around obstructions and with necessary expansion bends or fitting offsets essential to a satisfactory installation and as may be necessary to increase headroom or to avoid interference with the building construction, electric conduit, or facilities equipment. Installation shall also allow tool space around fittings subject to disassembly.

Standard long-sweep pipe fittings shall be used for changes in direction, unless otherwise specified or approved by the Contracting Officer.

[Mitered joint fittings are not permitted.]

[Mitered joint fittings are not permitted in Schedule 40 wall thickness piping systems but are permitted, as specified, in systems utilizing Type SWP materials.]

Pipe bends in seamless pipe of not less than five pipe diameters radius may be made with hydraulic benders in the field for pipe sizes to 4-inch DN100 ips upon approval of the Contracting Officer.

T-connections shall be made with screwed T-fittings, grooved T-fittings, or where pipe is being welded, with either welding T-fittings or forged branch outlet fittings (without size limitations). Branch outlet fittings, where used, shall be forged, flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full pipe-burst strength requirements.

Short-radius elbows may be used only where specifically authorized by the Contracting Officer.

Horizontal piping shall have a grade and slope direction as noted.

Eccentric reducers shall be used where required to permit proper drainage of pipe lines. Bushings shall not be used for this purpose.

[Drain valves shall be provided in all piping systems at low points and where otherwise indicated. Pipe drains shall consist of 1/2-inch DN15 ball valves with 3/4-inch DN20 hose, gasketed, and capped adapter.]

When piping design permits flange loads on connected equipment, the load shall not exceed 75 percent of maximum allowed by equipment manufacturer.

[Expansion bends shall be made from pipe sections and long-radius welding elbows in sizes 1 inch DN25 and larger. Expansion bends shall be cold sprung and welded into the line, which shall be anchored before removing the spreader from the expansion bend. Amount of cold spring shall be as indicated.]

[Expansion joints shall be provided at points indicated. All expansion joint surfaces shall be protected from mechanical damage, including weld spatter, during installation and testing operations.]

Expansion joint shall be installed with the sealed end of the internal sleeve as leading edge in direction of flow. Lateral stresses shall not be induced by springing pipe during installation. Expansion joints shall be located close to an anchor with the first pipe guide located not more than 4 pipe diameters away from the joint and the second guide located not more than 12 to 14 pipe diameters from the joint. Intermediate pipe guide spacing shall be in accordance with FSA-0017. Contracting Officer will reject any installed joint with nicks, scratches, dents, and other damage, even when otherwise properly installed.

Before acceptance of an expansion joint installation, each joint shall be cycled from "zero" condition to maximum load not less than five times; joint, piping, and equipment alignment shall be checked each time in the presence of the Contracting Officer.

[Guides located in lines with expansion joints shall be lubricated with silicone molybdenum disulfide lubricant.]

3.1.2 Joints

Pipe ends shall be reamed before joint connections are made.

Screwed joints shall be made up with joint compound.

Joint compounds shall be applied to the male thread only, and care shall be exercised to prevent compound from reaching the interior of the pipe.

Threads will be inspected by the Contracting Officer at midpoint of a cut for chaser alignment, proper grinding, thread track, chatter, and for coolant and lubricant effectiveness.

Unions or flanges shall be provided wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system.

Flanged joints shall be assembled with appropriate flanges, gaskets, and bolting. Clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing unaccounted strain on the piping system. Flange faces shall be parallel and the bores concentric; gaskets shall be centered on the flange faces without projecting into the

bore. Bolting shall be lubricated with oil and graphite before assembly to ensure uniform bolt stressing. Flange bolts shall be drawn up and tightened in staggered sequence in order to prevent unequal gasket compression and deformation of the flanges. Wherever a flange with a raised face is joined to a companion flange with a flat face, the raised face shall be machined down to a smooth matching surface and a full face gasket shall be used. After the piping system has been tested, all bolting shall be retightened. Only hex-head nuts and bolts shall be used. Gasket material shall be fresh stock, 1/16 inch 1.6 millimeter thick.

All field-welded joints shall conform to AWS WHB-2.8 and ASME B31.1.

3.1.3 Control and Instrument Air Piping

Hard core tubing shall be used in all exposed areas and either hard drawn or annealed if concealed.

Fittings for supply system copper tubing shall be wrought-copper solder joint type except at connection to apparatus where specified brass mechanical and ips thread adapter fittings may be used. Tool-made bends in lieu of fittings are acceptable. Multiple tube runs shall be neatly nested.

Tubing shall be mechanically attached to supporting surfaces. Supports using adhesives are not acceptable.

Copper tubing horizontal supports for less than three tubes shall be rigid 1- by 3/8-inch 25 by 10 millimeter metal channel. Proprietary metal tube race shall be provided for three or more tubes.

Copper tubing runs embedded in concrete shall be annealed and shall be protected by metallic or plastic electric conduit.

Copper tubing runs in soil shall be jointless and shall be protected by 12-mil 0.3048 millimeter thick bituminous coating or equivalent PVC tape wrapping.

Tubing penetrations of concrete surfaces shall be made with minimum 1-inch DN25 ips, Schedule 40 rigid unplasticized PVC pipe sleeves except that multitube harnesses 1-1/2 inches DN40 od and larger need not have additional protection. Sleeve shall extend 6 inches 150 millimeter above floors and 1 inch 25 millimeter below grade surface of slabs. Where water-or vapor-barrier sealing is required, 1/2-inch 13 millimeter deep elastomer calk shall be applied to surfaces cleaned of oil and other deleterious substances.

Tubing shall be sequentially purged with dry, oil-free compressed air to rid system of impurities generated during joint making and installation and atmospheric moisture before connecting control instruments.

3.1.4 Supporting Elements Installation

Supporting elements shall be provided in accordance with the requirements of referenced codes and standards.

Piping shall be hung from building construction. No piping shall be hung from roof deck or from other pipe.

Welding and cutting of building structural steel is prohibited.

Attachment to building construction concrete shall be by approved cast-in concrete inserts or by built-in anchors. Where attachment by either of above methods is not practical, specified masonry anchor devices may be used upon receipt of written approval from the Contracting Officer.

Fish plates shall be embedded in the concrete to transmit hanger loads to the reinforcing steel where hanger rods exceed 7/8-inch 22 millimeter in diameter.

Masonry anchors selected for overhead applications shall be constructed of ferrous materials only.

Masonry anchors of AASHTO M 314 and FS FF-S-325, Group I; Group II, Type 2, Class 2, Style 1, or Style 2; or Group VIII shall be installed in rotary, nonpercussion, electrically drilled holes. Self-drilling anchors (Group III) may be used provided masonry drilling is done with electric hammers selected and applied in a manner that will preclude concrete spalling or cracking (visible or invisible). Pneumatic tools shall not be allowed.

Percussive action, electric hammers, and combination rotary-electric hammers used for the installation of self-drilling anchors shall be selected in accordance with the following guide:

Tool for anchor devices, nominal sizes 1/4- through 1/2-inch 6 through 13 millimeter, may be hammer type only or combination rotary-hammer type and shall be rated at load to draw not more than 5.0 to 5.5 amperes when operating on 120-volt 60-hertz power.

Tool for anchor devices, nominal sizes 5/8 inch 16 millimeter and larger, hammer-type only, shall be rated at load to draw not more than 8.0 amperes when operating on 120-volt, 60-hertz power. Combination rotary-hammer tools on the same power supply shall have a full load current rating not to exceed 10 amperes.

Inserts and anchors shall be sized for the total stress to be applied with a safety factor as required by applicable codes, but in no case less than 4.

Anchor devices shall be inserted into concrete sections not less than twice the overall length of the device and shall be located not less than the following distance from any side or end edge or centerline of adjacent anchor service:

Anchor Bolt Size (inches)	1/4	5/16	3/8	1/2	5/8	3/4	7/8
Minimum Edge Space (inches)*	3-1/2	3-1/4	4	5	6	7	8
Anchor Bolt Size M Designation	6	8	10	13	16	19	22
Minimum Edge Space (millimeter)*	90	85	105	130	150	180	200

*Except where manufacturer requires greater distance.

In special circumstances, upon prior written approval of the Contracting Officer, center-to-center distance may be reduced to 50 percent of given distance provided the load on the device is reduced in direct proportion to

the reduced distance.

All piping shall run parallel with the lines of the building unless otherwise indicated. Piping and components shall be spaced and installed so that a threaded pipe fitting may be removed between adjacent pipes and so that there will be not less than 1/2 inch 13 millimeter of clear space between the finished surface and adjacent piping. Hangers on different adjacent service lines running parallel with each other shall be arranged in line with each other and parallel to the lines of the building.

Identical service systems piping, where practicable, shall be placed at same elevation and hung on trapeze hangers adjusted for proper pitch.

Spacing of trapeze hangers where piping is grouped in parallel runs shall be the closest interval required for any size pipe supported.

Where it is necessary to avoid any transfer of load from support to support or onto connecting equipment, pipe hangers shall be constant support type.

Anchors and alignment guides incorporated in piping systems shall be welded to the piping and attached to the building structure in accordance with requirements specified herein or as approved by the Contracting Officer.

Piping shall be suitably braced against reaction, sway, and vibration. Bracing shall consist of hydraulic and spring devices, brackets, anchor chairs, rods, or structural steel, or any suitable combination thereof.

Pipe lines, when supported from roof purlins, shall be located not greater than one-sixth of the purlin span from the roof truss. Load per hanger shall not exceed 400 pounds 1780 newton when support is from a single purlin or 800 pounds 3560 newton when hanger load is applied to purlins halfway between purlins by means of auxiliary support steel by supplied by the piping Contractor. 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 service.

When the hanger load exceeds the above limits, reinforcing of the roof purlin(s) or additional support beam(s) shall be furnished and installed. 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 to support fire protection sprinkler lines, electrical lighting fixtures, and electrical power duct or cable tray shall be considered fully loaded, and supplemental reinforcing for these purlins or auxiliary support steel shall be provided.

Hangers and supports for piping shall be installed at specified intervals at locations not more than 3 feet 900 millimeter from the ends of each runout and not over 25 percent of specified interval from each change in direction of piping.

Load rating for all pipe hangers shall be based on weight and forces imposed on all lines. Deflection per span shall not exceed slope gradient of pipe.

[Support provisions and support spacing for Type SWP materials shall be in accordance with the manufacturer's recommendations for the application.]

Schedule 40 and heavier pipe supports shall be in accordance with the following minimum rod size and maximum allowable hanger spacing; concentrated loads will reduce allowable span proportionately:

PIPE SIZE (INCHES)	ROD SIZE (INCHES)	STEEL PIPE (FEET)
Up to 1	3/8	8
1-1/4 to 1-1/2	3/8	10
2	3/8	12
2-1/2 to 3/1/2	1/2	12
4 to 5	5/8	16
6	3/4	16
8	7/8	20

PIPE SIZE MILLIMETER (DN)	ROD SIZE MILLIMETER (INCH)	STEEL PIPE MILLIMETER
Up to 25	10.0 (3/8)	2438
32 to 40	10.0 (3/8)	3048
50	10.0 (3/8)	3658
65 to 90	13.0 (1/2)	3658
100 to 125	16.0 (5/8)	4877
150	19.0 (3/4)	4877
200	22.0 (7/8)	6096

Vertical risers shall be supported independently of connected horizontal piping wherever practicable and shall be guided for lateral stability. Clamps shall be placed under fittings.

[Pipe shall be supported at each floor and at not more than 15-foot 4500 millimeter intervals for pipe 2 inches DN50 and smaller, and at not more than 20-foot 6100 millimeter intervals for pipe 2-1/2 inches DN65 and larger.]

[After the piping systems have been installed, tested, and placed in satisfactory operation, the Contractor shall tighten hanger rod nuts and jam nuts to prevent any loosening.]

3.1.5 Sound Stopping

Effective sound stopping and adequate operating clearance shall be provided to prevent structure contact where pipes penetrate walls, floors, or ceilings. Where penetrations occur from pipe chases into occupied spaces, special acoustic treatment of ceiling shall be provided. Penetrations shall be finished to be compatible with surface being penetrated.

Sound stopping shall be as specified under "Sleeves" in this section.

Leadwool and viscoelastic damping compounds may be proposed for use where other sound-stopping methods are not practicable provided temperature and fire-resistance characteristics of the compound are suitable for the service.

3.1.6 Sleeves

Sleeves shall be supplied and installed where piping passes through roofs, through masonry or concrete walls, and through floors.

Sleeve work shall be laid out before placement of slabs or construction of walls and roof, and all sleeves necessary to complete the work shall be set.

Where pipe sleeves are required after slabs and masonry are installed, holes to accommodate these sleeves shall be made with core drills. Sleeves shall be set in place with a two-component epoxy adhesive system approved by the Contracting Officer. No load shall be carried by such sleeves unless approved by the Contracting Officer.

Sleeves shall be flush with ceilings.

Sleeves shall be flush with the floor in finished spaces and shall extend 2 inches 50 millimeter above the floor in unfinished spaces.

Sleeves passing through steel decks shall be continuously welded or brazed to the deck.

Sleeves extending through floors, roofs, load bearing walls, and fire barriers shall be continuous and shall be fabricated from Schedule 40 steel pipe with welded anchor lugs. All other sleeves shall be formed by molded linear polyethylene liners or similar materials which are removable. Diameter of sleeves shall be large enough to accommodate pipe and sealing materials with a minimum of 3/8-inch 10 millimeter clearance. Sleeve shall accommodate mechanical and thermal motion of pipe to preclude transmission of vibration to walls and the generation of noise.

Space between a pipe and the inside of a pipe sleeve or a construction surface penetration shall be packed solid with a mineral fiber conforming to ASTM C 592, Form B, Class 8 wherever the piping passes through firewalls, equipment room walls, floors, and ceilings connected to occupied spaces, and at other locations where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces. Space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration shall be filled with an elastomer calk to a depth of 1/2 inch 13 millimeter. Surfaces to be calked shall be oil- and grease-free.

3.1.7 Escutcheons

Escutcheons shall be provided at all penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, escutcheons shall be provided on both sides of the partition. Where suspended ceilings are installed, plates shall be provided at the underside only of such ceilings. Escutcheons shall be chrome-plated in occupied spaces and shall be of sufficient size to conceal openings in building construction. Escutcheons shall be firmly attached, preferably with setscrews.

3.1.8 Flashings

Required flashings shall be provided at mechanical systems penetrations of building boundaries.

3.2 VACUUM SYSTEMS TESTING

****
NOTE: Delete paragraph title and following paragraphs when vacuum systems are not applicable to the project.
****

3.2.1 Vacuum Systems

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

****
NOTE: Because of the expansive force of compressed air, pneumatic testing requires special precautions and competent supervision to prevent injury and damage should a failure occur.
****

Pressure tests shall be pneumatic and shall utilize dry, oil-free compressed [air] [carbon dioxide] [nitrogen] for the system under test. Pressure testing shall be done in two stages, preliminary and acceptance.

Personnel not directly involved in pneumatic pressure testing of ferrous piping in excess of 5 psi 34.5 kilopascal shall be evacuated from the area.

Contractor may conduct tests for his purposes, but preliminary tests and acceptance tests shall be conducted as specified herein.

Pressure testing of any system for any purpose shall include preliminary testing by applying internal pressures not in excess of 5 psi 35 kilopascal, swabbing joints under test with standard high film-strength soap solution, and observing for bubbles.

When testing reveals that leakage exceeds specified limits, the leaks shall be isolated, repaired defective materials shall be replaced where necessary, and the system shall be retested until specified requirements are complied with. Leaking gasket joints shall be remade with new gaskets and new flange bolting and used bolting and gaskets shall be discarded. Leaking tubing joints shall be remade with the new fittings and new tube ends.

Only standard piping flanges, plugs, caps, and valves shall be used for sealing off piping for test purposes.

Components that would otherwise sustain damage due to test pressure shall be removed from piping systems during testing. Piping system components such as valves shall be checked for proper operation under system test pressure.

[Expansion joints shall be protected against system pressures by suitable movement-limiting devices.]

No test media shall be added to a system during a test for a period as specified or to be determined by the Contracting Officer.

Duration of a test will be determined by the Contracting Officer. Test may be terminated by direction of the Contracting Officer at any point during a 24-hour period after it has been determined that the permissible leakage rate has not been exceeded.

3.2.2 Test Gages

[Contractor's pressure test gages shall conform to ASME B40.100 and shall have a dial diameter of at least 4-1/2 inches 125 millimeter. Maximum permissible scale range for a given pressure test shall be such that the pointer during a test shall have a starting position at midpoint of the dial or within the middle third of the scale range. Certification of accuracy and correction table shall bear a date within 90 calendar days prior to test use, test gage number, and the project number, unless otherwise approved by the Contracting Officer.]

[Government will furnish vacuum test gages.]

[Government will furnish pressure and vacuum test gages.]

3.2.3 Acceptance Pressure Testing

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

Piping systems shall be tested at 25 psi 175 kilopascal. Test pressure shall be maintained for a period of not less than 2 hours with no pressure drop.

Control and instrumentation tubing systems shall be tested at 30 psi 210 kilopascal. Test pressure shall be maintained for not less than 24 hours with no measurable pressure drop.

3.2.4 Acceptance Vacuum Testing

****
NOTE: Prior to selection of the following test criteria, review provisions to ensure suitability for project application.
****

Piping system shall be evacuated to a pressure of 13 millimeter of mercury, absolute. Each system valve shall be operated at least three times during Leakage Tests. Rate of pressure rise shall not exceed 0.8 millimeter of mercury per hour.

When leakage exceeds the allowable rate, the following methods shall be used to locate leakage source:

Suspected area shall be tested utilizing a helium mass spectrometer in either the detector-probe or tracer-probe configuration.

Detector Probe Method: Test piece shall be internally pressurized with helium gas and a mass spectrometer (tuned for helium) shall be used to probe the exterior surface to spatially isolate the leak. A flexible line shall be employed to scan a capillary tube over the surface to

detect the leak.

Tracer Probe Method: Test piece shall be evacuated and the suspect area flooded in helium gas. Simultaneously, a helium mass spectrometer shall be used to examine the atmosphere within the test piece to determine the extent to which helium is drawn into the evacuated volume. For more accurate measurements, the suspect area can be jacketed and the area between the jacket and the test piece can be filled with 90 to 100-percent pure helium gas as the testing is conducted.

-- End of Section --