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Preparing Activity: NASA Superseding
UFGS-40 18 00.00 40 (May 2014)
UFGS-40 18 00 (February 2011)

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**
**********

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SECTION 40 18 00.00 40

VACUUM SYSTEMS PROCESS PIPING

**05/17**

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**USACE / NAVFAC / AFCEC / NASA** **UFGS-40 18 00.00 40 (May 2017)**

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**Preparing Activity: NASA** **Superseding**
**UFGS-40 18 00.00 40 (May 2014)**
**UFGS-40 18 00 (February 2011)**

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**
**********

SECTION 40 18 00.00 40

VACUUM SYSTEMS PROCESS PIPING
**05/17**

**********
**NOTE: This specification covers the requirements for aboveground low-vacuum systems defined for the purposes of this section as systems at pressures less than atmospheric and ranging to approximately 100 kilopascal (29.5 inches of mercury), 1.734 kilopascal (0.25144 psi) or 13 millimeter of mercury 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.**

**Ensure drawings 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 specification.**

**Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

**Remove information and requirements not required in respective project, whether or not brackets are present.**

**Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).**
**********

PART 1 GENERAL

**********
**NOTE: If Section 23 30 00 HVAC AIR DISTRIBUTION is not included in the project specification, insert**

**applicable requirements therefrom and the first paragraph deleted. If Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT is not included in the project specification, insert applicable requirements therefrom and the second paragraph deleted. If Section 40 17 30.00 40 WELDING GENERAL PIPING is not included in the project specification, insert applicable requirements therefrom and the third paragraph deleted.**
**********

[ Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

][Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT applies to work in this section.

][Section 40 17 30.00 40 WELDING GENERAL PIPING applies to work specified in this section.

]1.1 REFERENCES

**********
**NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.**

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

**References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.**
**********

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO M 314 | (1990; R 2013) Standard Specification for Steel Anchor Bolts |

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

| | |
|---|---|
| AISC 360 | (2016) Specification for Structural Steel Buildings |

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

| | |
|---|---|
| ASME B16.1 | (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250 |
| ASME B16.3 | (2021) Malleable Iron Threaded Fittings, Classes 150 and 300 |
| ASME B16.5 | (2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard |
| ASME B16.9 | (2018) Factory-Made Wrought Buttwelding Fittings |
| ASME B16.11 | (2022) Forged Fittings, Socket-Welding and Threaded |
| ASME B16.22 | (2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings |
| ASME B16.39 | (2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300 |
| ASME B18.2.1 | (2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series) |
| ASME B18.2.2 | (2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series) |
| ASME B31.1 | (2022) Power Piping |
| ASME B31.3 | (2022) Process Piping |
| ASME B40.100 | (2022) Pressure Gauges and Gauge Attachments |
| ASME B46.1 | (2020) Surface Texture, Surface Roughness, Waviness and Lay |

AMERICAN WATER WORKS ASSOCIATION (AWWA)

| | |
|---|---|
| AWWA C207 | (2018) Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm) |
| AWWA C208 | (2022) Dimensions for Fabricated Steel Water Pipe Fittings |
| AWWA C504 | (2015) Standard for Rubber-Seated Butterfly Valves |

AMERICAN WELDING SOCIETY (AWS)

| | |
|---|---|
| AWS WHB-2.9 | (2004) Welding Handbook; Volume 2, Welding Processes, Part 1 |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A53/A53M | (2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless |
| ASTM A105/A105M | (2021) Standard Specification for Carbon Steel Forgings for Piping Applications |
| ASTM A126 | (2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings |
| ASTM A139/A139M | (2022) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over) |
| ASTM A181/A181M | (2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping |
| ASTM A183 | (2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts |
| ASTM A197/A197M | (2000; R 2019) Standard Specification for Cupola Malleable Iron |
| ASTM A216/A216M | (2021) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service |
| ASTM A234/A234M | (2023a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service |
| ASTM A307 | (2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength |
| ASTM A351/A351M | (2018) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts |
| ASTM A436 | (1984; R 2020) Standard Specification for Austenitic Gray Iron Castings |
| ASTM A694/A694M | (2016; R 2022) Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission Service |
| ASTM B62 | (2017) Standard Specification for Composition Bronze or Ounce Metal Castings |
| ASTM B148 | (2014) Standard Specification for Aluminum-Bronze Sand Castings |
| ASTM B164 | (2003; R 2014) Standard Specification for |

| | |
|---|---|
| | Nickel-Copper Alloy Rod, Bar, and Wire |
| ASTM B280 | (2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service |
| ASTM B370 | (2022) Standard Specification for Copper Sheet and Strip for Building Construction |
| ASTM B749 | (2020) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products |
| ASTM C592 | (2022a) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) |
| ASTM C920 | (2018) Standard Specification for Elastomeric Joint Sealants |
| ASTM D2000 | (2018) Standard Classification System for Rubber Products in Automotive Applications |
| ASTM E1 | (2014) Standard Specification for ASTM Liquid-in-Glass Thermometers |
| ASTM F147 | (1987; R 2017) Standard Test Method for Flexibility of Non-Metallic Gasket Materials |
| ASTM F568M | (2007) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners |
| ASTM F1120 | (1987; R 2019) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications |

FLUID SEALING ASSOCIATION (FSA)

| | |
|---|---|
| FSA-0017 | (1995e6) Standard for Non-Metallic Expansion Joints and Flexible Pipe Connectors Technical Handbook |

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)

| | |
|---|---|
| IEST-STD-CC1246 | (2013; Rev E) Product Cleanliness Levels and Contamination Control Program |

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

| | |
|---|---|
| MSS SP-43 | (2019) Wrought Stainless Steel Butt-Welding Fittings |
| MSS SP-58 | (2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation |

| | |
|---|---|
| MSS SP-67 | (2022) Butterfly Valves |
| MSS SP-72 | (2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service |
| MSS SP-80 | (2019) Bronze Gate, Globe, Angle and Check Valves |
| MSS SP-83 | (2014) Class 3000 Steel Pipe Unions Socket Welding and Threaded |
| MSS SP-104 | (2022) Wrought Copper Solder Joint Pressure Fittings |

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

| | |
|---|---|
| RCBEA GUIDE | (2004) NASA Reliability Centered Building and Equipment Acceptance Guide |

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

| | |
|---|---|
| SAE AMS-C-6183 | (2013; Rev A) Cork and Rubber Composition Sheet; for Aromatic Fuel and Oil Resistant Gaskets |

U.S. DEPARTMENT OF DEFENSE (DOD)

| | |
|---|---|
| MIL-PRF-25567 | (1998; Rev E; Notice 1 2005; Notice 2 2010; Notice 3 2015; Notice 4 2020) Leak Detection Compound, Oxygen Systems (Metric) |

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

| | |
|---|---|
| CID A-A-1922 | (Rev A; Notice 1; Notice 2; Notice 3; Notice 4) Shield, Expansion (Caulking Anchors, Single Lead) |
| CID A-A-1923 | (Rev A; Notice 1; Notice 2; Notice 3; Notice 4) Shield, Expansion (Lag, Machine and Externally Threaded Wedge Bolt Anchors) |
| CID A-A-1924 | (Rev A; Notice 3) Shield, Expansion (Self Drilling Tubular Expansion Shell Bolt Anchors |
| CID A-A-55614 | (Basic; Notice 2) Shield, Expansion (Non-Drilling Expansion Anchors) |

## 1.2 SUBMITTALS

**********

**NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other**

**submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.**

**For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.**

**The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.**

**Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.**
**********

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G[, [____]]

SD-03 Product Data

Aboveground Piping Materials; G[, [____]]

Valves; G[, [____]]

Supporting Elements; G[, [____]]

Pressure Gages; G[, [____]]

Thermometers; G[, [____]]

Hex-Bolts; G[, [____]]

SD-06 Test Reports

Leakage Tests; G[, [____]]

SD-07 Certificates

Aboveground Piping Materials

Valves

Supporting Elements

Hydrostatic Tests; G[, [____]]

Pressure Gages

Thermometers

## 1.3 QUALITY CONTROL

### 1.3.1 Predictive Testing and Inspection Technology Requirements

**********
**NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS for additional information regarding cost feasibility of PT&I.**
**********

This section contains systems or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure that building equipment and systems installed by the Contractor have been installed properly and contain no identifiable defects that shorten the design life of a system or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

# PART 2 PRODUCTS

## 2.1 SYSTEM DESCRIPTION

Submit detail drawings. Include the manufacturer's design and construction calculations, the forces necessary to obtain rated axial and lateral movements, installation criteria, anchor and guide requirements, and all other pertinent data necessary for evaluation of the proposed equipment. Ensure that drawings specifically call out the procedures to be followed and provisions necessary to protect expansion joints during specified testing operations.

## 2.2 COMPONENTS

### 2.2.1 Valves

#### 2.2.1.1 Ball Valves, Vacuum (BAVV)

Provide the following:

a. Ball valves conforming to MSS SP-72 Style [1] [3], UL-approved for certain compressed gases and a pressure rating of not less than 1210 kilopascal at 93 degrees C 175 psi at 200 degrees F; and certified suitable for leaktight service under a vacuum of 2 millimeters of mercury absolute.

b. Valve bodies in sizes 50 mm 2 inch iron pipe size (ips) and smaller, screwed-end-connection type, constructed of Class A copper alloy.

c. Valve bodies in sizes 63 mm 2-1/2 inch ips and larger with flanged-end-connection, constructed of Class [D] [E] [F] material, unless otherwise specified.

d. Balls and stems of valves 50 mm 2 inch ips and smaller, made with 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.

e. Balls and stems of valves 63 mm 2-1/2 inch ips and larger made with manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome-plating. In valves 150 mm 6 inch ips and larger, balls may be Class D with 900 Brinell hard chrome-plating. Electroless nickel-plating is acceptable.

Ensure that valves are suitable for flow from either direction and seal tightly in both directions, with full pipe size flow areas where noted. Do not use valves with ball seats kept in place by spring washers.

Ensure that seats and seals are filled tetrafluoroethylene or manufacturer's standard material for the specified service.

Provide valves with body construction such that:

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

b. The valve body resists torque from a pipe by a one-piece body between end connections or by bolts in shear where the body is of mating flange or surface-bolted construction.

#### 2.2.1.2 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 1067 mm 42 inches. Show on drawings, temperature range and negative (vacuum) and positive pressures at**

**which the system will operate. Check for sonic velocities. Coordinate with shaft selection. Specify mass spectrometer tests using helium only if necessary with leak detector sensitivity of at least 1 times 10 to the minus 6 cubic centimeters per second.**

**********

Provide butterfly valves conforming to MSS SP-67 and the following requirements:

a. Butterfly valves through 508 mm 20 inches - wafer type.

b. Valve sizes larger than 508 mm 20 inches - two-flange type for mounting between specified flanges. Drilled and tapped holes at the valve bearing areas are acceptable for valves larger than 508 mm 20 inches.

c. Rated for indicated velocities, shutoff, and nonshock working pressure.

d. Body - cast ferrous metal conforming to minimum requirements of ASTM A126, Class B and to ASME B16.1 for body wall thickness.

Provide certification that:

a. All sizes of valves as tested are suitable for leaktight service under a vacuum of 2 millimeter of mercury absolute.

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

c. Laying lengths of flanged valves conform to AWWA C504, Table 3, short body length.

d. Disk is free of external ribs and streamlined. Verify that the disk is fabricated of cast ferrous or nonferrous alloys conforming to ASTM A436, Type 2 copper-free (austenitic cast iron), ASTM A216/A216M, Grade WCB (cast steel), ASTM A351/A351M, Grade CF8M (corrosion-resistant steel), or ASTM B148, No. C95500 (aluminum bronze).

[ Where vacuum piping systems are corrosion-protected internally, ensure that all ferrous valve surfaces exposed to airstream are [corrosion-resistant steel],[ electroplated][ flame-sprayed with a corrosion-resistant metal such as aluminum, zinc, tin, or cadmium]. Provide certification specifically stating that the coating is suitable for the intended service.

] Provide a shaft fabricated from AISI 300 series or 17-4 pH corrosion-resistant steel, or nickel-copper alloy conforming to ASTM B164, and may be one piece or stub-shaft, with stub shafts extended into the disk hub at least 1-1/2 shaft diameters. Verify that the connection between the valve shaft and disk is designed to transmit shaft torque equivalent to not less than 75 percent of the torsional strength of the minimum required shaft diameter. Ensure that the minimum nominal shaft diameter for all valves is in accordance with the following list:

**********

**NOTE: Select the following based on AWWA C504, Class 25A, for normal service where dynamic torque**

**is not involved.**
**********

| VALVE SIZE MILLIMETER | SHAFT DIAMETER MILLIMETER | VALVE SIZE MILLIMETER | SHAFT DIAMETER MILLIMETER |
|---|---|---|---|
| 75 | 13 | 400 | 34 |
| 100 | 16 | 450 | 38 |
| 150 | 19 | 500 | 38 |
| 200 | 22 | 600 | 44 |
| 250 | 25 | 750 | 50 |
| 300 | 28 | 900 | 63 |
| 350 | 31 | 1050 | 72 |

| 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 |

**********
**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 MILLIMETER | SHAFT DIAMETER MILLIMETER | VALVE SIZE MILLIMETER | SHAFT DIAMETER MILLIMETER |
|---|---|---|---|
| 75 | 13 | 400 | 38 |
| 100 | 16 | 450 | 41 |
| 150 | 19 | 500 | 48 |

| VALVE SIZE MILLIMETER | SHAFT DIAMETER MILLIMETER | VALVE SIZE MILLIMETER | SHAFT DIAMETER MILLIMETER |
|---|---|---|---|
| 200 | 22 | 600 | 57 |
| 250 | 25 | 750 | 70 |
| 300 | 28 | 900 | 89 |
| 350 | 35 | 1050 | 95 |

| 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 |
| 12 | 1-1/8 | 36 | 3-1/2 |
| 14 | 1-3/8 | 42 | 3-3/4 |

**********

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

**********

| VALVE SIZE MILLIMETER | SHAFT DIAMETER MILLIMETER | VALVE SIZE MILLIMETER | SHAFT DIAMETER MILLIMETER |
|---|---|---|---|
| 75 | 13 | 400 | 50 |
| 100 | 16 | 450 | 57 |
| 150 | 25 | 500 | 63 |
| 200 | 28 | 600 | 76 |
| 250 | 35 | 750 | 92 |
| 300 | 38 | 900 | 111 |
| 350 | 44 | 1050 | 127 |

| 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 |

In the sealing areas, ensure that the shaft has a surface finish conforming to ASME B46.1, 0.27 millimeter 0.0106 inches 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 24 degrees C at 1050 kilopascal 75 degrees F at 150 psi; 250 cycles at 107 degrees C at 517.1 kilopascal 225 degrees F at 75 psi. Rewrite the following paragraph to include cycle life if necessary.**

**********

Use resilient elastomer seats and seals. Ensure that seats are mechanically retained and designed for field removal and replacement unless otherwise specified. Formulate elastomers for continuous nonlubricated service at indicated temperatures and pressures.

[ Use bonded seats. Where bonding adhesives are used, ensure that adhesives comply with elastomer temperature requirements and have an effective life equal to or greater than the elastomer.

][Install seats in the valve body or on the disk, except that circular cross-section O-ring construction is not acceptable.

] Use four O-ring seals, mounted in a nonferrous metal cage. Use two rings as a shaft seal; use the other two rings as a housing seal. Make provisions to introduce high-vacuum grease to lubricate all four O-rings. Submit high-vacuum grease for Contracting Officer approval.

Provide seat or disk mating surfaces with corrosion-resistant steel, austenitic gray cast iron, or bronzes specified for the disk or the materials specified for stems. Weld these materials to the substrate, and ground or mechanically retain. Do not use plated or similarly applied surfacing materials.

Use sleeve bearings of the manufacturer's standard corrosion-resistant steel, bronze, nickel-copper alloy, or filled tetrafluoroethylene. Design bearings 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. Provide the operating end of the shaft with dual inboard bearings or a single inboard and an outboard bearing in or beyond the operator.

Provide valves larger than 508 mm 20 inches with thrust bearings set to hold the disk firmly in place.

Provide a locking feature to make the valve tamperproof where indicated.

Provide manual nonchain-operated valves through 200 mm 8 inches with not less than nine-position-level lock handles not exceeding 450 millimeter 18 inches in length.

Provide gear operators to the following: manual valves 250 mm 10 inches and larger, or smaller manual valves if the application torque exceeds a pull of 110 Newton-meter 80 foot-pounds or if so indicated.

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

Use worm-gear operators. Ensure that gears are hob-cut and totally enclosed in a cast-iron housing suitable for grease or oil-flood lubrication. Support gears and gear shafts on bronze or corrosion-resistant, lubricated bearings. Size operators to provide the required torque, static or dynamic, with a maximum manual pull of 110 Newton-meter 80 foot-pounds on the handwheel or chain wheel.

For modulating or remotely actuated two-position service valves, where indicated, provide with pneumatic operators, pilot positioners, valve position indicators, and boosters and relays where necessary. Note the operating air-supply pressure.

Ensure that the maximum load on a pneumatic operator does not exceed 85 percent of rated operator capacity.

2.2.1.3 Diaphragm Control and Instrument Valves (DCIV)

Provide forged brass body diaphragm valves in sizes 8 mm and 10 mm 1/4 and 3/8 inch with reinforced tetrafluoroethylene diaphragm, an AISI 300 series corrosion-resistant steel spring, and a round phenolic handle. Fit the handle with ISA color code disks.

2.2.1.4 Gage Cocks (GC)

Ensure that gage cocks are T-head or lever-handle ground-key with washer and screw, constructed of polished ASTM B62 bronze and rated for 862 kilopascal 125 psi saturated steam service. Ensure that end connections suit the service, with or without union and nipple.

2.2.1.5 Globe and Angle Valves (GLV And ANV)

Ensure that globe and angle valves 50 mm 2 inches and smaller, conform to MSS SP-80 and to requirements specified herein. Provide union ring bonnet valves, screwed-end with backseating stem. Ensure that the disk is free to swivel on the stem in all valve sizes and has a fiberglass-filled, tetrafluoroethylene composition seating surface. Provide woven nonasbestos fiber packing, impregnated with not less than 25 percent by weight, of tetrafluoroethylene resin.

2.2.2 Supporting Elements

**********

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

**********

2.2.2.1 Supports

Provide all necessary piping system components and miscellaneous supporting elements, including building structure attachments, supplementary steel, hanger rods, stanchions and fixtures, vertical pipe attachments, pipe attachments, anchors, guides, shock absorbers, and variable and constant supports. Ensure that all supporting elements are suitable for stresses imposed by system pressures and temperatures and natural and other external forces. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations.

Provide UL-approved or UL-listed supporting elements conforming to the requirements of ASME B31.1, and MSS SP-58.

"Type" devices specified are defined as MSS standards.

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

]2.2.2.2 Building Structure Attachments

a. Anchor Devices, Concrete and Masonry

Ensure that anchor devices conform to the requirements of AASHTO M 314, CID A-A-1922, CID A-A-1923, CID A-A-1924, and CID A-A-55614.

Provide cast-in, floor-mounted equipment anchor devices with adjustable positions.

Ensure that masonry anchor devices are built-in.

Do not use powder-actuated anchoring devices to support any mechanical systems components.

b. Beam Clamps

Use center-loading beam clamps, Type [21] [28] [29] [30], UL-listed, catalogued and low-rated, commercially manufactured products.

[ c. C-Clamps

**********

**NOTE: Avoid using C-clamps, to attach hangers to**

**structural steel if possible. 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 40 mm 1-1/2 inches and smaller. Provide FM-approved and UL-listed C-clamps with hardened cup tip, setscrew, locknut, and retaining strap. Ensure that the retaining-strap section is not less than 3 by 25 millimeter 1/8 by 1 inch. Beam flange thickness to which clamps are attached cannot exceed 15.2 millimeter 0.60 inch.

][d. Concrete Inserts

Construct concrete inserts in accordance with MSS SP-58 for Type 18. When applied to piping in sizes 50 mm 2 inch ips and larger and where otherwise required by imposed loads, insert and wire a 300 millimeter length of 15 millimeter 1 foot length of 1/2 inch reinforcing rod through wing slots. Approved, proprietary, continuous inserts may be similarly used.

]2.2.2.3 Horizontal Pipe Attachments

Instead of separate hangers, a detail drawing of proposed trapeze hangers with turnbuckles on rods and a solid or split-ring clamp for each pipe may be submitted for approval.

Single pipes

a. Support piping in sizes to and including 50 mm 2 inch ips by Type 6 solid malleable iron pipe rings, except use split-band rings in sizes up to 25 mm 1 inch ips.

b. Support piping in sizes through 200 mm 8 inch ips inclusive by Types [1] [3] [4] attachments.

c. Ensure that pipe rolls are Type 41 or Type 49.

d. Provide spring supports in accordance with referenced codes and standards. Submit complete shop drawing data for approval.

Parallel pipes

a. Use trapeze hangers fabricated from approved structural-steel shapes, with U-bolts, in congested areas and where multiple pipe runs occur. Ensure that structural-steel shapes conform to requirements for supplementary steel. Alternatively, use commercially available, proprietary, rolled steel for the supports.

2.2.2.4 Vertical Pipe Attachments

Use Type 8 vertical pipe attachments, single pipes.

2.2.2.5 Hanger Rods and Fixtures

Use only circular cross-section rod hangers 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.

Provide turnbuckles, swing eyes, and clevises as required by the support system to accommodate pipe accessibility and adjustment for load and pitch.

2.2.2.6 Supplementary Steel

Where it is necessary to frame structural members between existing members or where structural members are used instead of commercially rated supports, design and fabricate such supplementary steel in accordance with AISC 360.

2.2.3 Pressure Gages

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

2.2.4 Thermometers

Provide thermometers conforming to ASTM E1; industrial pattern Type I, Class 3. Ensure that thermometers installed 1830 millimeter 6 feet or higher above the floor have an adjustable-angle body. Ensure that the scale is not less than 175 millimeter 7-inches long, and that the case face is manufactured from manufacturer's standard polished aluminum or AISI 300 series polished corrosion-resistant steel. Indicate the thermometer range. Provide thermometers with nonferrous separable wells.

2.2.5 Bolting

Provide flange and general-purpose bolting hex-bolts conforming to ASTM F568M ASTM A307, Grade B; and heavy hex-nuts conforming to ASME B18.2.1 ASME B18.2.2. Do not use square-head bolts or nuts.

2.3 MATERIALS

**********
**NOTE: Coordinate indicated and specified vacuum and pressure ratings with test criteria.**
**********

2.3.1 Aboveground Piping Materials

Piping for Vacuum Systems To 100 Kpa 29.5 Inches Of Mercury Vacuum.

2.3.1.1 Black Carbon Steel

Pipe 3 mm through 37 mm 1/8 inch through 1-1/2 inches: Schedule 40, furnace butt weld, black carbon steel, conforming to ASTM A53/A53M, Type F.

Pipe 50 mm through 200 mm 2 through 8 inches where indicated: Schedule 40, seamless (Type 5) or electric (Type E) resistance-welded, black carbon steel, conforming to ASTM A53/A53M, Grade B, Type [E] [S]. Grade A should be used for permissible field bending.

Fittings 50 mm 2 inches and under: 1050 kilopascal 150 pounds per square inch, gage (psig) working steam-pressure (wsp), banded, black malleable

iron, screwed, conforming to ASTM A197/A197M, ASTM A234/A234M and ASME B16.3.

Unions 50 mm 2 inches and under: 1724 kilopascal 250 psig wsp, female, screwed, black malleable iron, with brass-to-iron seat and ground joint, conforming to ASME B16.39 and MSS SP-83.

Couplings 50 mm 2 inches and under: Standard weight, screwed, black carbon steel.

Fittings 67 mm 2-1/2 inches and over: Steel, butt weld, conforming to MSS SP-43, ASTM A234/A234M and ASME B16.9

Flanges 67 mm 2-1/2 inches and over: 1050 kilopascal 150 psig wsp, forged steel, welding neck, to match pipe wall thickness, conforming to ASME B16.5 and ASTM A694/A694M.

Grooved pipe couplings and fittings 67 mm 2-1/2 inches and over: Use of malleable iron couplings and fittings conforming to requirements specified under "Grooved Pipe Couplings and Fittings" in this section is optional.

2.3.1.2 Galvanized Carbon Steel

Pipe 3 mm through 37 mm 1/8 inch through 1-1/2 inches: Schedule 40, furnace butt weld, black carbon steel, conforming to ASTM A53/A53M, Type F.

Pipe 50 mm through 200 mm 2 through 8 inches where indicated: Schedule 40, seamless or electric-resistance-welded, galvanized steel, conforming to ASTM A53/A53M, Grade B, Type E or S.

Fittings 200 mm and under: 1050 kilopascal 8 inches and under: 150 psig wsp, banded, galvanized, malleable iron, screwed, conforming to ASTM A197/A197M, ASTM A234/A234M and ASME B16.3.

Unions 50 mm and under: 2068 kilopascal 2 inches and under: 300 psig wsp, female, screwed, galvanized, malleable iron with brass-to-iron seat and ground joint conforming to ASME B16.39.

2.3.1.3 Spiral Welded Pipe

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

Pipe[ 150 mm through 914 mm 6 through 36 inches:] Electric-fusion-welded, carbon steel, conforming to ASTM A139/A139M, Grade B, with wall thickness as follows:

| NOMINAL DIAMETER MILLIMETER | MINIMUM WALL THICKNESS MILLIMETER |
|---|---|
| 300 | 3.18 |

| NOMINAL DIAMETER MILLIMETER | MINIMUM WALL THICKNESS MILLIMETER |
|---|---|
| 350 | 3.58 |
| 400 | 4.37 |
| 450 | 4.78 |
| 550 | 5.56 |
| 600 | 6.35 |
| 700 | 7.14 |
| 750 | 7.92 |
| 900 | 9.53 |
| NOMINAL DIAMETER INCHES | MINIMUM WALL THICKNESS INCH |
| 12 | 0.125 |
| 14 | 0.141 |
| 16 | 0.172 |
| 18 | 0.188 |
| 22 | 0.219 |
| 24 | 0.250 |
| 28 | 0.281 |
| 30 | 0.312 |
| 36 | 0.375 |

Refer to paragraph SUPPORTING ELEMENTS INSTALLATION for additional requirements.

a. Fittings (all sizes): Specify materials and thicknesses for pipe. Ensure that fitting configuration and dimensions conform to AWWA C208, Tables 1 and 2.

Ensure fittings are butt weld end, 13789 kilopascal 2,000 pounds per square inch (psi), forged carbon steel, threaded half coupling, conforming to ASTM A105/A105M and ASME B16.11

Retap threads after welding.

b. Flanges (all sizes): Forged carbon steel, slip-on, conforming to ASTM A181/A181M, Class 60 or 70, and AWWA C207, Class D, and

ASTM A105/A105M concentric serrated finish.

[ c. Grooved couplings: See paragraph GROOVED PIPE COUPLINGS AND FITTINGS. Ensure that pipe ends have welded collars grooved to fit couplings, fabricated from ASTM A53/A53M pipe.

]2.3.2 Control and Instrumentation System Tubing

Use copper tubing, Type CPR-C&I.

For all sizes, use 6 mm 1/4 inch minimum: Hard-drawn or annealed, seamless copper, conforming to ASTM B280, No. C12200.

Use copper fittings for all sizes, solder-joint, wrought copper, conforming to ASME B16.22 and MSS SP-104.

Use ball sleeve compression, rod or forged brass, UL-approved, with minimum pressure rating of 1380 kilopascal at 38 degrees C 200 psi at 100 degrees F.

Use solder, 95-5 tin-antimony, alloy Sb5, conforming to AWS WHB-2.9

2.3.3 Grooved Pipe Couplings and Fittings

Provide couplings with a housing fabricated in two or more parts of malleable iron castings; with molded synthetic-rubber coupling gasket, conforming to requirements of ASTM D2000. Ensure that coupling bolts have oval-neck track heads with hexagonal heavy nuts, conforming to ASTM A183.

Provide pipe fittings used with couplings fabricated of malleable iron castings. Where a manufacturer's standard-size malleable iron fitting pattern is not available, use fabricated fittings.

Ensure that fittings are fabricated from Schedule 40 or 9.53 millimeter 0.375-inch wall ASTM A53/A53M, seamless steel pipe; long-radius seamless welding fittings with wall thickness to match pipe, conforming to ASTM A234/A234M and MSS SP-43 ASME B16.9.

2.3.4 Metallic Expansion Joints

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

Provide packless bellows expansion joints conforming to ASTM F1120, except as otherwise modified or supplemented by requirements.

Provide metallic bellows designed in accordance with ASME B31.3, Appendix X, and Standards of the Expansion Joint Manufacturers Association.

Ensure that expansion joints are [Type I, Class 1.] [Type I, Class 2.] [Type II, Class 1.] [Type II, Class 2.] [tied, hinged, or gimbaled.] Verify that joints are 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.

[ Verify that operating pressures and temperatures for each joint are as shown.

][Provide joints that are designed and rated for service with vacuum to 2 millimeter of mercury absolute, pressures to 345 kilopascal 50 psig, and temperatures to 121 degrees C 250 degrees F.

][Provide joints that are designed and rated for service with vacuum to 2 millimeter of mercury absolute, pressures to 1050 kilopascal 150 psig, and temperatures to 260 degrees C 500 degrees F.

] Provide joints that are designed with bursting strength in excess of four times their rated pressure and are capable of withstanding hydrostatic tests of 1.5 times their rated pressure without leakage or distortion while held at their uncompressed length, with a life expectancy of not less than 10,000 cycles.

Ensure that the movement capability of each joint exceeds calculated movement of piping by [33] [_____] percent.

Provider bellows and internal sleeve material made from AISI 304[L] corrosion-resistant steel.[ Use Type C-22 Hastelloy alloy for bellows exposed to highly corrosive environments, such as those found within 1 mile of the ocean or at a launch pad using propellants with corrosive exhaust products.]

Ensure that end connections are as indicated and require no field preparation other than maintenance of cleanliness.

[ Ensure that the butt weld end preparation of the expansion joints conforms to the same codes and standards requirements that apply to the piping system materials at the indicated joint location.

][Ensure that the flanges of flanged end expansion joints conform to the same codes and standards requirements that apply to the companion flanges specified for the given piping system at the indicated joint location.

] Van stone flanges are not acceptable.

Provide joints 65 millimeter 2-1/2 inches and smaller with internal guides and limit stops.

Provide joints 75 millimeter 3 inches and larger with removable external covers, internal sleeves, and purging connection. Size sleeves to accommodate the lateral clearance required with minimum reduction of flow area, using oversized bellows where necessary. When a sleeve requires a gasket as part of the locking arrangement, provide a gasket made by the same manufacturer. Joints without purging connections may be provided; however, remove these from the line or do not install them until after cleaning operations have been completed.

[ Provide the cylindrical end portion of the reinforced bellows element with a thrust sleeve of sufficient thickness to bring this portion within the stress allowed by the applicable code. Ensure sleeve provides 360-degree support for the element and end reinforcing ring.

][Provide four expansion joints, with equidistant, permanent tram points clearly marked on each joint end. Locate points to prevent obliteration during installation. Ensure that the distances between tram points (indicating installed lengths) are as noted. Overall dimension is subject to approval by the Contracting Officer after joint installation.

] Provide expansion joints with adjustable clamps or yokes at quarter points straddling the bellows. Set the overall joint length to maintain the joints in the manufacturer's recommended position during installation.

Clearly and legibly mark joints 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.

Verify that provisions are Level A of ASTM F1120, and that packing provisions are Level 8 of ASTM F1120.

2.3.5 Elastomer Caulk

Use two-component polysulfide or polyurethane base elastomer caulking material conforming to ASTM C920.

2.3.6 Flashing

Provide flashing material meeting the following:

a. Lead - Ensure that sheet lead conforms to ASTM B749, Grade [B] [C] [D] and weighs not less than 95 kilogram per square meter 4 pounds per square foot.

b. Copper - Ensure sheet copper conforms to ASTM B370 and weigh not less than 5 kilogram per square meter 16 ounces per square foot.

2.3.7 Flange Gaskets

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

Provide the following flange gaskets:

Type A: Soft chloroprene sheet, 45 to 60 Shore A durometer hardness, conforming to ASTM F147 and SAE AMS-C-6183, Type II, Class 2, Grade A.

Type B: Medium chloroprene sheet, 60 to 65 Shore A durometer hardness, conforming to ASTM F147 and SAE AMS-C-6183, Type II, Class 2, Grade B.

Type C: Firm chloroprene sheet, 70 to 80 Shore A durometer hardness, conforming to ASTM F147 and SAE AMS-C-6183, Type II, Class 2, Grade C.

2.3.8 Pipe Thread Compounds

Use tetrafluoroethylene tape not less than [_____] [0.0508] millimeter [2] mils thick in compressed-air systems for pipe sizes to and including 25 mm 1 inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval by the Contracting Officer.

## PART 3 EXECUTION

### 3.1 INSTALLATION

#### 3.1.1 Aboveground Piping Systems

**********

**NOTE: Projects with users requiring a high-grade vacuum and high-purity systems such as analytical laboratory or space flight operations should consider precision chemical cleaning for particulate and nonvolatile residue (NVR) removal. The presence of residual hydrocarbons within piping may hamper the ability to pull and sustain high vacuum levels and allow contaminates to migrate to downstream services.**

**********

Fabricate and install systems in accordance with ASME B31.1, MSS SP-58 and AWS WHB-2.9.

Install piping system materials in accordance with the manufacturer's instructions.

Fabricate pipe to measurements established on the job, and work into place without springing or forcing. Make adequate provisions for absorbing all expansion and contraction without undue stress in any part of the system.

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

[Clean pipe by hammering, shaking, or swabbing or by a combination of methods.][ Conduct precision cleaning in accordance with IEST-STD-CC1246 to a cleanliness level of 300A or lower.]

Purge lines with dry, oil-free compressed air after erection, but do not rely on purging for removing all foreign matter. Perform purging at a velocity greater than the maximum normal-flow velocity and at a velocity approved by the Contracting Officer.

During the progress of construction, properly protect open ends of pipe, fittings, and valves at all times to prevent the admission of foreign matter. Place the plugs or caps in the ends of all installed work at all times when connections are not actually under way. Ensure that the plugs are commercially manufactured products.

Install piping straight and true with approved offsets around obstructions with the necessary expansion bends or fitting offsets and as may be necessary to increase headroom or to avoid interference with the building construction, electric conduit, or facility equipment. During installation, allow for tool space around any fittings subject to disassembly.

Use standard long-sweep pipe fittings 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 using Type SWP materials.

] Pipe bends in seamless pipe of at least five pipe diameters radius may be made with hydraulic benders in the field for pipe sizes to 100 mm 4 inch ips upon approval of the Contracting Officer.

Make T-connections 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). Provide forged branch outlet fittings, where used, 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.

Install horizontal piping with the grade and slope direction as noted.

Use eccentric reducers where necessary to permit proper drainage of pipe lines. Do not use bushings for this purpose.

[ Provide drain valves in all piping systems at low points and where otherwise indicated. Ensure pipe drains consist of 13 mm 1/2 inch ball valves with 19 mm 3/4 inch hose, gasketed, and capped adapter.

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

[ Make expansion bends from pipe sections and long-radius welding elbows in sizes 25 mm 1 inch and larger. Ensure that expansion bends are cold-sprung and welded into the line, and anchored before removing the spreader from the expansion bend. Indicate the amount of cold spring.

][Provide expansion joints at points indicated. Protect all expansion joint surfaces from mechanical damage, including weld spatter, during installation and testing operations.

] Install expansion joints with the sealed end of the internal sleeve as the leading edge in the direction of flow. Ensure that the lateral stresses are not induced by springing pipe during installation. Locate the expansion joints close to an anchor, with the first pipe guide, located at least 4 pipe diameters away from the joint and the second guide located at least 12 to 14 pipe diameters from the joint. Ensure that the intermediate pipe guide spacing is in accordance with FSA-0017. The 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, cycle each joint from "zero" condition to maximum load not less than five times; check the joint, piping, and equipment alignment each time in the presence of the Contracting Officer.

[ Lubricate guides that are located in lines with expansion joints with silicone molybdenum disulfide lubricant.

]3.1.2 Joints

Ream pipe ends before the joint connections are made.

Make up screwed joints with joint compound.

Apply joint compounds to the male thread only. Exercise care 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, and chatter, and for coolant and lubricant effectiveness.

Provide unions or flanges wherever necessary to permit convenient removal of equipment, valves, and piping accessories from the piping system.

Assemble flanged joints with appropriate flanges, gaskets, and bolting. Ensure that the clearance between flange faces is such that the connections can be gasketed and bolted tight without imposing unaccounted strain on the piping system. Ensure that flange faces are parallel and that the bores are concentric. Center the gaskets on the flange faces without projecting into the bore. Lubricate all bolting with oil and graphite before assembly to ensure uniform bolt stressing. Draw up and tighten flange bolts 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, machine down the raised face to a smooth matching surface and use a full face gasket. After the piping system has been tested, retighten all bolting. Use only hex-head nuts and bolts. Use only fresh-stock gasket material, 1.6 millimeter 1/16 inch thick.

Ensure that all field-welded joints conform to AWS WHB-2.9 and ASME B31.1.

3.1.3 Control and Instrument Air Piping

Use hard-core tubing in all exposed areas, and use either hard-drawn or annealed tubing in concealed areas.

Provide wrought-copper solder joint fittings for supply system copper tubing except at connections to apparatus where specified brass mechanical and ips thread adapter fittings may be used. Tool-made bends instead of fittings are acceptable. Neatly nest all multiple tube runs.

Mechanically attach tubing to supporting surfaces. Do not use adhesives to attach tubing to support surfaces.

Provide horizontal supports of rigid copper tubing for less than three tubes using 25 by 10 millimeter 1 by 3/8 inch metal channel. Provide proprietary metal tube race for three or more tubes.

[ Anneal and protect copper tubing runs embedded in concrete by metallic or plastic electric conduit.

][Ensure that the copper tubing runs in soil are jointless and protected by 0.3048 millimeter 12-mil thick bituminous coating or equivalent PVC tape wrapping.

] Make tubing penetrations of concrete surfaces with minimum 25 mm 1 inch ips, Schedule 40 rigid unplasticized PVC pipe sleeves, except that

multitube harnesses 37 mm 1-1/2 inches outside diameter and larger need not have additional protection. Extend sleeves 150 millimeter 6 inches above floors and 25 millimeter 1 inch below grade surface of slabs. Where water- or vapor-barrier sealing is required, apply 13 millimeter 1/2 inch deep elastomer caulk to surfaces cleaned of oil and other deleterious substances.

Sequentially purge tubing with dry, oil-free compressed air to rid the system of impurities generated during joint making and installation and atmospheric moisture before connecting control instruments.

### 3.1.4 Supporting Elements Installation

Provide supporting elements in accordance with the requirements of referenced codes and standards.

Hang piping from building construction. Do not hang piping from roof deck or from other pipe.

Welding and cutting of building structural steel is prohibited.

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

Embed fish plates in the concrete to transmit hanger loads to the reinforcing steel where hanger rods exceed 22 millimeter 7/8 inch in diameter.

For overhead applications, construct masonry anchors selected of ferrous materials only.

Install masonry anchors in accordance with AASHTO M 314 and CID A-A-1922, CID A-A-1923, and CID A-A-1924 in rotary, nonpercussion, electrically drilled holes. Self-drilling anchors (Group III) may be used, provided that masonry drilling is done with electric hammers selected and applied in a manner that precludes concrete spalling or cracking (visible or invisible). Pneumatic tools are not allowed.

Select percussive action, electric hammers, and combination rotary-electric hammers used for the installation of self-drilling anchors in accordance with the following guide:

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

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

Size the inserts and anchors for the total applied stress with a safety factor as required by applicable codes, but in no case less than 4.

Insert anchor devices into concrete sections at least twice the overall length of the device, and locate at least the following distance from any side or end edge or centerline of adjacent anchor service:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Anchor Bolt Size M Designatior | 6 | 8 | 10 | 13 | 16 | 19 | 22 |
| Minimum Edge Space (millimeter | 90 | 85 | 105 | 130 | 150 | 180 | 200 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 |

*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 the given distance, provided that the load on the device is reduced in direct proportion to the reduced distance.

Run all piping parallel with the lines of the building unless otherwise indicated. Space and install the piping and components so that a threaded pipe fitting may be removed between adjacent pipes and so that there is not less than 13 millimeter 1/2 inch of clear space between the finished surface and adjacent piping. Arrange hangers on different adjacent service lines running parallel with each other in line with each other and parallel to the lines of the building.

Place identical service system piping, where practicable, at the same elevation and hung on trapeze hangers adjusted for the proper pitch.

Where piping is grouped in parallel runs, spacing distance of trapeze hangers is 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, use constant-support pipe hangers.

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

Suitably brace the piping against reaction, sway, and vibration. Bracing

consists of hydraulic and spring devices, brackets, anchor chairs, rods, or structural steel, or any suitable combination thereof.

Locate pipe lines, when supported from roof purlins, not greater than one-sixth of the purlin span from the roof truss. Do not exceed 1780 Newton 400 pounds load per hanger when the support is from a single purlin or 3560 Newton 800 pounds when the hanger load is applied to purlins halfway between purlins by means of auxiliary support steel. When a support is not halfway between purlins, ensure that the allowable hanger load is 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, furnish and install reinforcing of the roof purlin(s) or additional support beam(s). When an additional beam is used, the beam bears on the top chord of the roof trusses, and the bearing is over gusset plates of top chord. Stabilize the beam by connecting it to the roof purlin along the bottom flange.

Purlins used to support fire protection sprinkler lines, electrical lighting fixtures, and electrical power ducts or cable trays are considered fully loaded; provide supplemental reinforcing for these purlins or auxiliary support steel.

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

Establish the load rating for all pipe hangers based on weight and forces imposed on all lines. Ensure that the deflection per span does not exceed the slope gradient of pipe.

[ Ensure that the support provisions and support spacing for Type SWP materials is in accordance with the manufacturer's recommendations for the application.

] Ensure that the Schedule 40 and heavier pipe supports are in accordance with the following minimum rod size and maximum allowable hanger spacing; concentrated loads reduce the allowable span proportionately:

| PIPE SIZE MILLIMETER | ROD SIZE MILLIMETER | STEEL PIPE SPAN MILLIMETER |
|---|---|---|
| Up to 25 | 10.0 | 2438 |
| 32 to 40 | 10.0 | 2048 |
| 50 | 10.0 | 3658 |
| 65 to 90 | 13.0 | 3658 |
| 100 to 125 | 16.0 | 4877 |
| 150 | 19.0 | 4877 |
| 200 | 22.0 | 6096 |

| PIPE SIZE (INCHES) | ROD SIZE (INCHES) | STEEL PIPE SPAN (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 |

Support vertical risers independently of connected horizontal piping wherever practicable, and guide for lateral stability. Place clamps under fittings.

[ Support pipe at each floor and at not more than 4500 millimeter 15 foot intervals for pipe 50 mm 2 inches and smaller, and at not more than 6100 millimeter 20 foot intervals for pipe 67 mm 2-1/2 inches and larger.

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

]3.1.5 Sound Stopping

Provide effective sound stopping and adequate operating clearance to prevent structure contact where pipes penetrate walls, floors, or ceilings. Where pipe chases penetrate occupied spaces, provide special acoustic treatment of ceilings. Ensure the finish penetration is compatible with surface being penetrated.

Sound stopping is as specified with paragraph SLEEVES.

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

3.1.6 Sleeves

Install sleeves where piping passes through roofs, through masonry or concrete walls, and through floors.

Lay out sleeve work before placement of slabs or construction of walls and roof, and set all sleeves necessary to complete the work.

Where pipe sleeves are required after slabs and masonry are installed, core-drill holes to accommodate these sleeves. Set the sleeves in place with a two-component epoxy adhesive system approved by the Contracting Officer. Do not allow such sleeves to carry loads unless approved by the Contracting Officer.

Ensure that the sleeves are flush with the ceilings and floor in finished spaces and extend 50 millimeter 2 inches above the floor in unfinished spaces.

Ensure that the sleeves passing through steel decks are continuously welded or brazed to the deck.

Ensure that the sleeves extending through floors, roofs, load bearing walls, and fire barriers are continuous and fabricated from Schedule 40 steel pipe with welded anchor lugs. Form all other sleeves by molded linear polyethylene liners or similar materials that are removable. Provide a sleeve diameter large enough to accommodate pipe and sealing materials with a minimum of 10 millimeter 3/8 inch clearance. Ensure that the sleeve accommodates mechanical and thermal motion of pipe to preclude transmission of vibration to walls and the generation of noise.

Pack solid the space between a pipe and the inside of a pipe sleeve or a construction surface penetration with a mineral fiber conforming to ASTM C592, Form B, Class 8 wherever the piping passes through firewalls, equipment room walls, floors, or ceilings connected to occupied spaces, and at other locations where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces. Fill the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration with an elastomer caulk to a depth of 13 millimeter 1/2 inch. Ensure that the surfaces to be caulked are oil- and grease-free.

### 3.1.7 Escutcheons

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

### 3.1.8 Flashings

Provide the required flashings at mechanical system penetrations of building boundaries.

## 3.2 FIELD QUALITY CONTROL

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

**********

### 3.2.1 Vacuum Systems Testing

**********

**NOTE: If the specified system is identified as critical, configured, or mission-essential, use Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS to establish predictive and acceptance testing criteria, above and beyond that listed below.**

**********

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

Before acceptance of the work, pressure-test and vacuum-test completed systems 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.**

**********

Conduct pneumatic pressure tests using dry, oil-free compressed [air] [carbon dioxide] [nitrogen] for the system under test. Pressure-test in two stages, preliminary and acceptance.

Evacuate all areas not directly involved in pneumatic pressure testing of ferrous piping in excess of 34.5 kilopascal 5 psi.

Pressure testing of any system for any purpose includes preliminary testing by applying internal pressures not in excess of 35 kilopascal 5 psi, swabbing joints under test with standard high-film-strength soap solution conforming to MIL-PRF-25567, and observing for bubbles.

When testing reveals that leakage exceeds specified limits, isolate the leaks, replace the repaired defective materials where necessary, and retest the system until specified requirements are met. Remake leaking gasket joints with new gaskets and new flange bolting, and discard used bolting and gaskets. Remake leaking tubing joints with the new fittings and new tube ends.

Use only standard piping flanges, plugs, caps, and valves for sealing off piping for test purposes.

Remove components that would otherwise be damaged by test pressure from piping systems during testing. Check piping system components such as valves for proper operation under system test pressure.

[ Protect expansion joints against system pressures by suitable movement-limiting devices.

] Add no test media 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

[ Ensure that pressure test gages conform to ASME B40.100 and have a dial diameter of at least 125 millimeter 4-1/2 inches. Maximum permissible scale range for a given pressure test is such that during the test the pointer has a starting position at midpoint of the dial or within the middle third of the scale range. Ensure that a certification of accuracy

and correction table bears a date within 90 calendar days before 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

Test during steady-state ambient temperature conditions.

Test piping systems at 175 kilopascal 25 psi. Maintain test pressure for a period of not less than 2 hours with no pressure drop.

Test control and instrumentation tubing systems at 210 kilopascal 30 psi. Maintain test pressure for not less than 24 hours with no measurable pressure drop.

3.2.4 Acceptance Vacuum Testing

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

**********

Evacuate the piping system to a pressure of 13 millimeter 0.51 inches of mercury, absolute. Operate each system at least three times during leakage tests. Rate of pressure rise cannot exceed 0.8 millimeter 0.032 inches of mercury per hour.

When leakage exceeds the allowable rate, test the suspected area using a helium mass spectrometer in either the detector-probe or tracer-probe configuration.

a. Detector Probe Method: Internally pressurize the test piece with helium gas and use a mass spectrometer (tuned for helium) to probe the exterior surface to spatially isolate the leak. Employ a flexible line to scan a capillary tube over the surface to detect the leak.

b. Tracer Probe Method: Evacuate the test piece and flood the suspected area in helium gas. Simultaneously, use a helium mass spectrometer 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, jacket the suspected area and fill the area between the jacket and the test piece with 90 to 100-percent pure helium gas as the testing is conducted.

-- End of Section --