UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 22 - PLUMBING

SECTION 22 15 14.00 40

GENERAL SERVICE COMPRESSED-AIR SYSTEMS, LOW PRESSURE

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USACE / NAVFAC / AFCEC / NASA **UFGS-22 15 14.00 40 (November 2017)**

Preparing Activity: NASA **Superseding UFGS-22 15 14.00 40 (November 2014)**

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References are in agreement with UMRL dated January 2021
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SECTION 22 15 14.00 40

GENERAL SERVICE COMPRESSED-AIR SYSTEMS, LOW PRESSURE
11/17

****
NOTE: This guide specification covers the requirements for aboveground and underground piping systems and certain components with pressure ratings of 862 kilopascal 125 pounds per square inch, gage and less, using existing air supply.

Show on the drawing, size, rating, or other details of piping requirements for specific project application not covered in the specifications.

Use symbols or legends on the drawing indicated herein, adding proper suffix where provided. For example," 100 millimeter 4 inch Type BCS-PS."

Indicate on drawing underground piping requiring supports from slabs.

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 40 17 30.00 40 WELDING GENERAL PIPING is not included in the project specification, insert the applicable requirements from that

document and delete the following paragraph.
****

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

****
NOTE: If Section 23 30 00 HVAC AIR DISTRIBUTION is not included in the project specification, insert the applicable requirements from that document and delete the following paragraph.
****

Section 23 30 00 HVAC AIR DISTRIBUTION 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 INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.18.1/CSA B125.1	(2018) Plumbing Supply Fittings
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings

	NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.22	(2018) Standard for 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 B18.2.2	(2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.1	(2020) Power Piping
ASME B31.3	(2016) Process Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC	(2010) Boiler and Pressure Vessels Code
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
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
AWS-03	(2011) Welding Handbook, Volumes 1 thru 4

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
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	(2016) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A278/A278M	(2001; R 2020) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A395/A395M	(1999; R 2018) Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A436	(1984; R 2020) Standard Specification for Austenitic Gray Iron Castings
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A666	(2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B61	(2015) Standard Specification for Steam or Valve Bronze Castings
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	(2012; R 2019) Standard Specification for Copper Sheet and Strip for Building Construction

ASTM B584	(2014) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B733	(2015) Standard Specification for Autocatalytic (Electroless) Nickel-Phosphorus Coatings on Metal
ASTM B749	(2020) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C592	(2016) 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 D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM D2239	(2012) Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials
ASTM F568M	(2007) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

CAGI B19.1	(2010) Safety Standard for Compressor Systems

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2017; Errata 1 2017) Butterfly Valves
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and

	Threaded Ends
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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

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

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1922	(Rev A; Notice 3) Shield, Expansion (Caulking Anchors, Single Lead)
CID A-A-1923	(Rev A; Notice 3) 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

Installation Drawings; G[, [____]]

SD-03 Product Data

Equipment and Performance Data; G[, [____]]

Underground Piping Materials; G[, [____]]

Aboveground Piping Materials; G[, [____]]

Piping Specialties; G[, [____]]

Supporting Elements; G[, [____]]

Air Compressors; G[, [____]]

Valves; G[, [____]]

Accessories; G[, [____]]

Miscellaneous Materials; G[, [____]]

SD-05 Design Data

Design Analysis and Calculations; G[, [____]]

SD-06 Test Reports

Piping System Test Report

SD-07 Certificates

Underground Piping Materials

Aboveground Piping Materials

Supporting Elements

Valves

Miscellaneous Materials

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

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 noncritical, nonconfigured, and not mission-essential, use sound engineering discretion to assess the value of adding these test and acceptance requirements. See Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS for 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 the RCBEA GUIDE to ensure that building equipment and systems 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 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 installation drawings for low-pressure compressed air systems in accordance with the paragraphs titled ABOVEGROUND PIPING MATERIALS and UNDERGROUND PIPING MATERIALS.

Accompany drawings with curves indicating that an essentially flat reduced-pressure curve for the capacity demand of the system is met by the proposed valves.

In lieu of separate hangers, a shop drawing of trapeze hangers with solid or split-ring clamps may be submitted for approval.

2.1.1 Design Requirements

Provide equipment and performance data submitted for piping systems showing conformance with ASME Code.

Provide design analysis and calculations for low-pressure compressed air systems that have flow rates, air distribution, pressure, and insulation that meet the requirements of the standards cited in this section.

2.2 EQUIPMENT

2.2.1 Piping Specialties

2.2.1.1 Air-Pressure-Reducing Stations

Install a pressure-reducing station complete with a relieving pressure-reducing valve, valve bypass, particle filter, pressure indicator upstream of station, pressure indicator downstream of station, and regulated air-pressure relief valve.

Construct the pressure regulator body of zinc or aluminum die castings that are rated for the service. Use a diaphragm material that is a reinforced air-, oil-, and water-resistant elastomer. Ensure that all components exposed to the fluid stream being controlled are made of [nonferrous] [suitable nonmetallic] materials. Ensure that valves are a balanced construction-relieving type that will automatically prevent excess pressure buildup.

Construct filters of [zinc] [aluminum] die castings, rated for the service, and furnished with iron pipe size (ips) connections. Ensure that bowl materials are aluminum and that the filter is serviceable by bowl quick-disconnect devices. Equip the bowl with a manual drain cock. Separate liquid particles by centrifugal and quiet zone action. Remove solid particles up to 15 micrometers by filter elements of [sintered bronze] [corrosion-resistant steel] mesh.

[Combination manual drain filter-regulator units conforming to the above requirements are acceptable in lieu of separate units.

] Provide pressure-relief valves rated for the pressure experienced on the high-pressure side and sized for the full installed capacity of the pressure regulating station at the pressure experienced on the low-pressure side. Set the valve so that the pressure does not exceed the correct low-side pressure by greater than [20] [_____] percent. Rate and label the valve. Ensure that the seat material is suitable for the service.

2.2.1.2 Air Line Lubricators

Install air line lubricators that feed the lubricant in pulses and that have a pickup tube, polycarbonate resin bowl, large fill opening, metering rod flow adjuster, sight ball, and drain cock.

Use lubricators suitable for 1380 kilopascal at 74 degrees C 200 psig at 165 degrees F.

2.2.1.3 Compressed-Air Receivers

Ensure that the compressed air receivers conform to the sizes and capacities specified. Design such vessels for working pressures and service in accordance with the ASME BPVC SEC VIII D1, and label the receivers with this information.

Provide complete vessels, with connections for drain, supports, and other required accessories.

2.2.1.4 Grooved Pipe Couplings and Fittings

Fabricate the housing for couplings in at least [two] [_____] parts of [malleable] [ductile] iron castings. Provide molded synthetic rubber coupling gaskets conforming to ASTM D2000. Provide oval-neck track-head coupling bolts with hexagonal heavy nuts, conforming to ASTM A183.

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

Fabricate fittings from[Schedule 40][10 millimeter 0.375-inch wall] in accordance with ASTM A53/A53M, Grade B, seamless steel pipe. Ensure that the wall thickness of the long-radius seamless welding fittings match the wall thickness of the pipe, and conform to ASTM A234/A234M and ASME B16.9.

2.2.1.5 Pressure Gages

Ensure that the pressure gages conform to ASME B40.100 and are Type I, Class 1, (pressure) for the pressures indicated. Provide a pressure gage size that is 90 millimeter 3 1/2 inches. Ensure the cases are constructed of corrosion-resistant steel conforming to [the AISI 300 series] [ASTM A666] with an ASM No. 4 standard commercial polish or better. Equip the gages with a damper screw adjustment in the inlet connection.

[Equip the gages with an adjustable, red marking indicator.

]2.2.1.6 Thermometers

Provide the thermometers that conform to ASTM E1 and that are 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 the scale is at least [178] millimeter [7]-inches [_____] long. Ensure the case face is constructed of [the manufacturer's standard polished aluminum] [AISI 300 series polished corrosion-resistant steel]. Ensure that the thermometer range meets the service requirements. Provide a thermometer with nonferrous separable wells.

2.2.1.7 Line Strainers

Provide [Y-type] [T-type grooved end] strainers with a removable basket. Ensure that strainers of 50 mm 2 inch ips or smaller have screwed ends and that strainers of 65 mm 2 1/2 inch ips or larger have flanged ends. Ensure that the body working pressure rating exceeds the maximum service pressure of the system by at least 50 percent. Ensure that the body has cast-in arrows to indicate the direction of flow. Ensure that the strainer bodies fitted with screwed screen retainers have straight threads and are gasketed with nonferrous metal. Ensure that the strainer bodies fitted with bolted-on screen retainers have offset blowdown holes. Fit strainers larger than 65 mm 2 1/2 inches with the manufacturer's standard blowdown valve. Provide [cast bronze conforming to ASTM B62] [cast iron conforming to ASTM A278/A278M Class 30] [ductile iron conforming to ASTM A536] body material. Where the system material is nonferrous, provide a nonferrous strainer body material.

Ensure the minimum free-hole area of the strainer element is equal to at least [3.4] [_____] times the internal area of connecting piping. Ensure that the strainer screens for air service have a mesh cloth smaller than [0.15] millimeter [0.006] inch [_____] and that the screens have finished

ends fitted to machined screen chamber surfaces to preclude bypass flow. Ensure that the strainer element material is [AISI Type [304] [316] corrosion-resistant steel] [Monel metal].

2.2.2 Air Compressors

Provide a standard piston air compressor complete with air tank, [air dryer,][air cooler,] and other appurtenances. Ensure that the compressor and installation conforms to CAGI B19.1. Ensure that the compressor capacity is as required for service and provide continuous control air when operating on a 1/3-on 2/3-off cycle. Provide an oil-level sight indicator on the compressor and a coalescing oil filter on the compressor discharge line. [Provide [continuous-duty silica-gel air dryers with reactivation] [mass-refrigerated air dryer] that maintain the air in the system with a dew point low enough to prevent condensation at minus 11 degrees C at 124 kilopascal 13 degrees F at 18 psi main pressure. Locate the air dryer at the outlet of the tank.] Ensure that the control air delivered to the system conforms to ISA 7.0.01.

2.2.3 Valves

2.2.3.1 Ball Valves (BAV)

Ensure that ball valves conform to MSS SP-72 and are Style [1] [3].

Ensure that grooved end ball valves are used only if the manufacturer certifies valve performance in accordance with MSS SP-72.

Provide valves rated for service at [1207] [_____] or more kilopascal at [93] [_____] degrees C [175] [_____] or more psi at [200] [_____] degrees F.

For valve bodies of 50 mm 2 inch ips or smaller, use screwed end connections constructed of Class A copper alloy.

For valve bodies in sizes 65 mm 2 1/2 inch ips or larger, use flanged-end connections constructed of Class [D] [E] [F] material.

Provide balls and stems for valves 50 mm or smaller 2 inch or smaller ips are [the manufacturer's standard Class A copper alloy with 900 Brinell hard chrome plating finish] [Class C corrosion-resistant steel alloy with hard chrome plate]. Ensure that electroless nickel plating conforms to ASTM B733.

Provide balls and stems for valves 65 mm or larger 2-1/2 inch or larger ips are the manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome plate. For valves 150 mm or larger 6 inch or larger ips, ensure that balls are Class D with 900 Brinell hard chrome plate. Ensure electroless nickel plating conforms to ASTM B733.

Design valves that allow flow from either direction and that will seal equally tight in either direction.

Ensure that valves have flow areas that are the same size as the pipe flow area.

Do not provide valves with ball seals kept in place by spring washers. Ensure that all valves have adjustable packing glands. Use tetrafluoroethylene seats and seals.

Ensure that valve body construction is such that torque from a pipe with a valve in installed condition does not tend to disassemble the valve by stripping setscrews or by loosening body end inserts or coupling nuts. Ensure that torque from a pipe is resisted by a one-piece body between end connections or by bolts in shear where the body has a mating flange or surface-bolted construction.

2.2.3.2 Butterfly Valves (BUV)

Ensure that butterfly valves conform to MSS SP-67.

Use grooved end butterfly valves in services to 110 degrees C 230 degrees F provided the manufacturer certifies valve performance in accordance with MSS SP-67.

For mounting between specified flanges, use wafer type butterfly valves that are rated for 1034 kilopascal 150 psig shutoff and nonshock working pressure. Select a cast ferrous metal body conforming to ASTM A126, Class B, and to ASME B16.1 for body wall thickness.

Provide valves installed in insulated piping systems with extended bonnets, placing the operator beyond the specified insulation.

Ensure that butterfly valves used in buried piping systems conform to requirements of AWWA C504, Class 150B, with integrally cast flanges and a manual worm gear operator. [Design and construct valves for buried or 60 kilopascal 20-foot head submerged service in brackish water.]Ensure that flanged ends conform to the requirements of ASME B16.1. Ensure that valve operation requires at least [20] [_____] turns for full closure of the valve with an input effort of [68] [_____] newton per meter [50] [_____] foot-pounds of torque. Coat the external surfaces with a bituminous sealer conforming to AWWA C104/A21.4.

Ensure that the valve boxes are at least [4.7] millimeter [3/16] inch [_____] thick-cast-iron construction with locking cover with an identification legend. Install adjustable extension boxes with a [screw] [slide] adjustment. Fit valves 80 mm 3 inches and under with 108 millimeter a 4 1/4 inch diameter shaft and valves 100 mm 4 inches or larger, fitted with1 33 millimeter a 5 1/4 inch shaft. Fit the bases to the valve. Ensure that the fullyextended length of the box exceeds the depth of cover by at least 4 inches. Supply one valve operating wrench for each size valve nut. Provide guide rings where operating rods are longer than 1830 millimeter 6 feet. Coat internal and external surfaces with a bituminous sealer in accordance with AWWA C104/A21.4.

Ensure that the disk is free of external ribs and streamlined. Fabricate the disk from cast [ferrous] [nonferrous] alloys conforming to [ASTM A126 for Class B, cast iron] [ASTM A436 for Type [1] [2] copper-free austenitic cast iron] [ASTM A216/A216M for Grade WCB cast steel] [ASTM A395/A395M and ASTM A536 for ductile iron] [ASTM B62] [ASTM B584] [ASTM B148].

Do not use taper pins to secure the valve disk to the shaft.

Fabricate shafts from [AISI 300 series] [17-4 PH corrosion-resistant steel] [nickel copper alloy conforming to ASTM B164]. Shafts may be [one-piece] [stub-shaft]. Extend stub shafts into the disk hub to at least 1-1/2 times the shaft diameter except where angle disk construction is used. Design the connection between the valve shaft and disk so that it transmits shaft torque equivalent to at least [75] [_____] percent of

the torsion strength of the minimum required shaft diameter. Ensure that the minimum nominal shaft diameter for all valves is in accordance with the following:

VALVE SIZE MILLIMETER	SHAFT DIAMETER MILLIMETER	VALVE SIZE MILLIMETER	SHAFT DIAMETER MILLIMETER
65	11	250	28
80	13	300	32
100	15	356	38
125	17	406	41
150	19	457	47
200	22	508	54

VALVE SIZE INCHES	SHAFT DIAMETER INCHES	VALVE SIZE INCHES	SHAFT DIAMETER INCHES
2 1/2	7/16	10	1 1/8
3	1/2	12	1 1/4
4	5/8	14	1 1/2
5	11/16	16	1 5/8
6	3/4	18	1 7/8
8	7/8	20	2 1/8

Use resilient elastomer seats and seals designed for field removal and replacement. Provide [Buna-N] [ethylene propylene terpolymer] [chloroprene] [_____] elastomers formulated for continuous immersion service at [107] degrees C [225] degrees F [_____] minimum. Apply at least [10] [_____] percent below the maximum continuous service temperature. Apply bonding adhesives that comply with elastomer temperature requirements and that have an effective life equal to or greater than that of the elastomer.

Design seals to be used on 500 mm 20 inch and smaller valves with [standard split V packing] [dual O-rings] [quad rings] [an adjustable pulldown].

If seats are installed in the valve body or on the disk, do not use circular cross-section O-ring construction.

Ensure that seat or disk mating surfaces are corrosion-resistant material, and are [welded to substrate and ground] [mechanically retained]. Do not use plated or similarly applied surfacing materials.

Ensure that bearings are the permanently lubricated sleeve type of [manufacturer's standard corrosion-resistant steel][bronze][nickel-copper alloy][nylon][filled tetrafluoroethylene]. Ensure that the bearings are

designed for [a pressure not exceeding the published design load for the bearing material] [one-fifth of the compressive strength of the bearing or shaft material]. Provide the operating end of the shaft with [dual inboard bearings] [a single inboard and an outboard bearing in or beyond the operator].

Provide a padlocking feature to make the valve tamperproof.

For balancing service, ensure that valve operators are capable of infinite position locking.

Provide manual nonchain-operated valves up to 200 mm 8 inches with lever lock handles that have at least nine positions and that do not exceed [457] millimeter [18] inches [_____] in length.

Provide manual valves with gear operators when the valves are 250 mm 10 inches or larger, or smaller if the application torque exceeds a pull of [108] newton-meter [80] pounds [_____].

Where valves are indicated to be chain-operated, equip all sizes with gear operators, and ensure that the chain lengths are suitable for proper stowage and operation.

Use worm-gear operators. Totally enclose the operator in a cast-iron housing suitable for grease or oil lubrication. Ensure that the gears are "hobcut." Ensure that cast-iron-housed traveling-nut operators conform to AWWA C504. Size the operators to provide the required static or dynamic torque, with a maximum manual pull of [108] newton-meter [80] pounds [_____] on the handwheel or chain wheel.

Provide modulating or remotely actuated two-position service valves with pneumatic operators, pilot positioners, valve position indicators, and boosters and relays.

Maximum load on a pneumatic operator cannot exceed [85] [_____] percent of rated operator capacity.

2.2.3.3 Diaphragm Control and Instrument Valves (DCIV)

Ensure that 8 mm and 10 mm 1/4 and 3/8 inch diaphragm valves have a forged brass body with a reinforced tetrafluoroethylene diaphragm, AISI 300 series corrosion-resistant steel spring.

2.2.3.4 Gage Cocks (GC)

Provide T-head or lever handle ground key gage cocks, with washer and screw, constructed of polished ASTM B62 bronze, and rated for 862 kilopascal125 psi saturated steam service. Ensure that end connections suit the service, with or without a union and nipple.

2.2.3.5 Gate Valves (GAV)

Ensure that gate valves 50 mm 2 inches or smaller conform to MSS SP-80. Ensure that the packing is woven nonasbestos material that is at least [25][_____] percent, by weight, impregnated with tetrafluoroethylene resin.

Provide gate valves 65 mm 2 1/2 inches or larger that are Type I, Class 1, conforming to MSS SP-70. Install flanged valves, with bronze trim and outside screw and yoke (OS&Y) construction. Ensure that the packing is

woven nonasbestos material that is at least [25][_____] percent, by weight, impregnated with tetrafluoroethylene resin.

2.2.3.6 Globe and Angle Valves (GLV and ANV)

Ensure that globe and angle valves 50 mm 2 inches and smaller conform to MSS SP-80. For tunnels, equipment rooms, or factory-assembled equipment, provide union-ring bonnet, screwed-end valves. Ensure that the disk is free to swivel on the stem in all valve sizes. A composition seating surface disk construction may be substituted for all metal disk construction.

Ensure that the globe and angle valves 65 mm 2 1/2 inches and larger conform to MSS SP-80. Provide valve bodies of cast iron conforming to ASTM A126, Class A, as specified for Class 1 valves under MSS SP-70. Provide flange valve ends that conform with ASME B16.1, and ensure that outside stem and yoke (OS&Y) valves are used.

For packing, use a woven material that is at least 25 percent, by weight, impregnated with tetrafluoroethylene resin.

2.2.3.7 Eccentric Plug Valves (EPV)

Provide eccentric plug valves in sizes 50 mm 2 inches and smaller constructed of [manufacturer's standard brass] [bronze materials conforming to [ASTM B61] [ASTM B62]] [cast iron conforming to ASTM A126, Class B]. Ensure that the valves are rated for service at 1207 kilopascal 175 psi maximum nonshock pressure at 93 degrees C 200 degrees F. Use a valve body with [screwed] [grooved] ends. Coat eccentric plug surfaces in contact with flow with a 60 to 70 Shore A durometer hardness elastomer resistant to compressed air.

Ensure that material for eccentric plug valves in sizes 65 mm 2 1/2 inches or larger consists of [Type 2 nickel alloy iron conforming to ASTM A436] [cast iron conforming to ASTM A126]. Ensure that the valves are rated for service at 1207 kilopascal 175 psi maximum nonshock pressure at 93 degrees C200 degrees F. Use valve bodies with [screwed] [grooved] ends. Coat eccentric plug surfaces with a 60 to 70 Shore A durometer hardness elastomer that is resistant to compressed air. For specified applications, in sizes to 125 mm 5 inch ips, the cross-sectional area of the valve bore, when open, equals the pipe inlet area. Ensure that the valves used for combination shutoff and balancing service are fitted with a memory device. Provide a memory device or mechanism that permits a valve set at a balance point to be opened or closed, but not beyond the balance point. Fit valves up to 150 mm 6 inch ips with a removable lever operator. Fit valves 150 mm of 6 inch ips or larger, with a totally enclosed flood-lubricated worm gear drive such that the operating torque does not exceed [67] [_____] newton per meter [50] [_____] foot-pounds.

2.3 MATERIALS

2.3.1 Underground Piping Materials

2.3.1.1 Piping Types

****

NOTE: Type BCS-PS materials are suitable for leak tight compressed air 862 kilopascal 125 pounds per square inch gage and less, all butt weld (no flange,

no thread) construction.

Anode and rectifier cathodic protection should be used to protect against rapid point metal loss due to failure to detect a fault or "holiday."

****

Ensure that BCS-PS black carbon steel piping with a polyethylene sheath conforms to ASTM A53/A53M, Type [E] [S], in sizes through 250 mm 10 inch ips. For pipe in sizes 12 inches and larger, select Schedule 40 or be 10 millimeter 0.375 inch thick.

Make sheath joints with a thermally fitted shrinking sleeves applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with manufacturer's instructions. Ensure that the electrical flaw detection testing at the factory requires 10,000 volts to be impressed across the sheath. Sheath breakdown voltage is at least 13,000 volts.

2.3.1.2 Fittings

Provide long-radius butt-weld carbon steel fittings conforming to ASTM A234/A234M and ASME B16.9 to match pipe wall thickness. Do not use pipe bending. Ensure that aboveground terminal fittings are 1034 kilopascal 150-pound working steam pressure (wsp) forged-steel weld-neck flanges to match the wall thickness, conforming to ASME B16.5 and ASTM A181/A181M Class 60.

2.3.2 Aboveground Piping Materials

2.3.2.1 Compressed Air Systems 862 Kilopascal 125 Psig And Less

a. Type BCS Black Carbon Steel

For pipe 6 mm through 40 mm 1/8 through 1 1/2 inches provide Schedule 40, furnace butt welded, black carbon steel, conforming to ASTM A53/A53M, Type F, Grade A.

For pipe 50 mm through 250 mm 2 through 10 inches, provide Schedule 40, [seamless] [electric resistance welded], black carbon steel, conforming to ASTM A53/A53M, Grade B, Type [E] [S]. Use Grade A pipe for permissible field bending.

For pipe 300 mm 12 inches and over use a 10 millimeter a 0.375 inch wall, [provide seamless, black carbon steel, conforming to ASTM A53/A53M, Grade B, Type [E] [S]].

For fittings 50 mm 2 inches and under, provide 150 (psig) wsp, banded, black malleable iron, screwed, conforming to ASTM A197/A197M and ASME B16.3.

For unions 50 millimeter 2 inches and under, provide 1724 kilopascal gage 250 psig wsp, female, screwed, black malleable iron, with brass-to-iron seat and a ground joint conforming to ASME B16.39. Use ductile iron conforming to ASTM A536 for grooved pipe couplings.

For couplings 50 mm 2 inches and under, provide [standard weight, screwed, black carbon steel] [ductile iron conforming to ASTM A536].

For fittings 65 millimeter 2 1/2 inches and over, provide [steel, butt

welded, to match pipe wall thickness, conforming to ASTM A234/A234M and ASME B16.9] [ductile iron conforming to ASTM A536].

For flanges 65 millimeter 2 1/2 inches and over, provide 150-psig wsp, forged steel, welding neck to match pipe wall thickness, conforming to ASME B16.5.

For grooved pipe couplings and fittings 65 mm 2 1/2 inches and over, use malleable iron couplings and fittings conforming to the paragraph PIPING SPECIALTIES.

b. Type GCS Galvanized Carbon Steel

For pipe 15 mm through 250 mm 1/2 through 10 inches, provide Schedule 40, [seamless] [electric resistance welded], galvanized steel, conforming to ASTM A53/A53M, Grade B, Type [E] [S]. Type F is acceptable for sizes less than 50 mm 2 inches.

For fittings 50 mm 2 inches and under, provide 1034 kilopascal 150-psig wsp, [banded, galvanized, malleable iron, screwed, conforming to ASTM A197/A197M, ASME B16.3] [ductile iron conforming to ASTM A53/A53M and ASTM A536].

For fittings 65 mm 2 1/2 inches and over, provide 862 kilopascal 125 psig wsp, cast-iron flanges and [flanged fittings, conforming to ASTM A126, Class A, and ASME B16.1] [ductile iron conforming to ASTM A53/A53M and ASTM A536].

For unions 50 millimeter 2 inches and under, provide 2068 kilopascal 300 psig wsp, female, screwed, galvanized, malleable iron with a brass-to-iron seat and a ground joint.

2.3.2.2 Control and Instrumentation Tubing, to 207 Kilopascal 30 psig

a. Copper

For tubing with a 8 mm 1/4 inch minimum outside diameter use [hard-drawn] [annealed] seamless copper, in accordance with ASTM B280.

Provide solder joint wrought copper fittings conforming to ASME B16.22.

Use a compression ball sleeve, [rod] [forged brass], conforming to SAE [72] [88], UL-approved, with a minimum pressure rating of 1380 kilopascal at 38 degrees C 200 psi at 100 degrees F.

Use solder that is 95-5 tin-antimony, alloy Sb 5, conforming to AWS WHB-2.9.

Copper tubing systems may be installed using bolted mechanical pipe couplings with a central cavity design pressure responsive gasket. Groove copper pipe and fittings in accordance with the coupling manufacturer's recommendations.

b. Polyethylene

Use tubing constructed of black virgin polyethylene, conforming to ASTM D2239, Type I, Grade 2, Class C, and conforming to stress-crack tests performed in accordance with ASTM D1693. Ensure that multitube harnesses with polyester film barrier and vinyl jacket are at least [1.57] millimeter [0.062] inch [_____] thick.

Use compression ball sleeve fittings that are manufactured from [brass] [aluminum] [acetal resin].

2.4 ACCESSORIES

2.4.1 Miscellaneous Materials

2.4.1.1 Bolting

For flange and general-purpose bolting, use hex-head bolts and conform to ASTM F568M, Class 4.8 or above ASTM A307, Grade B. Ensure that the heavy hex-nuts conform to ASTM A563M ASME B18.2.2. Square-head bolts are not acceptable.

For grooved couplings, use heat-treated carbon steel bolts and nuts conforming to ASTM A183.

2.4.1.2 Elastomer Caulk

Provide a two-component [polysulfide] [polyurethane-base] elastomer caulking material conforming to ASTM C920.

2.4.1.3 Escutcheons

Provide escutcheons manufactured from nonferrous metals and [chrome plated] [hot-dipped galvanized] except when AISI 300 series corrosion-resistant steel is provided. Select the metals and finish in accordance with ASME A112.18.1/CSA B125.1.

Provide [one-piece] [split-pattern] escutcheons. Ensure that escutcheons maintain a fixed position against a surface by means of internal spring tension devices or setscrews.

2.4.1.4 Flashing

Ensure that the sheet lead conforms to ASTM B749, Grade [B] [C] [D] and weighs at least [19] [_____] kilogram per square meter [4] [_____] pounds per square foot.

Ensure that the sheet copper conforms to ASTM B370 and weighs at least [4.88] [_____] kilogram per square meter [16] [_____] ounces per square foot.

2.4.1.5 Flange Gaskets

Ensure that the compressed non-asbestos sheet conforms to ASTM F104, Type 1, and is coated on both sides with [graphite] [_____].

Ensure that the gasketing for grooved flange adapters is a pressure-responsive elastomer conforming to ASTM D2000.

2.4.1.6 Pipe Thread Compounds

Use tetrafluoroethylene tape at least [0.05] [0.08] millimeter [2] [3] mils thick for pipe sizes to and including 25 mm 1 inch ips.

Tetrafluoroethylene dispersions and other suitable compounds may be used for other applications upon approval by the Contracting Officer.

2.4.2 Supporting Elements

Provide all necessary piping system components and miscellaneous required supporting elements. Ensure that supporting elements are suitable for stresses imposed by system pressures and temperatures, and natural and other external forces.

****
NOTE: Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations.
****

Ensure that the supporting elements are [FM-approved] [UL-listed] and conform to requirements of ASME B31.3, and MSS SP-58, except as otherwise noted. Type devices specified herein are defined in MSS standards unless otherwise noted.

2.4.2.1 Building Structure Attachments

Use concrete and masonry anchor devices that conform to requirements of CID A-A-1922, CID A-A-1923, CID A-A-1924, CID A-A-55614.

Install cast-in floor-mounted equipment anchor devices that provide adjustable positions.

Use built-in masonry anchor devices, unless otherwise approved by the Contracting Officer.

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

Ensure that beam clamps are center-loading Type [21] [28] [29] [30], UL-listed, cataloged, and load-rated, and commercially manufactured.

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

[Do not use C-clamps.]

[Use clamps to support piping that is 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. Use a retaining strap section of at least [3 by 25] millimeter [1/8 by 1] inch [_____]. Ensure that the thickness of beam flanges to which clamps are attached does not exceed 15 millimeter 0.60 inch.

][Construct concrete inserts in accordance with the requirements of MSS SP-58 for Type 18 hangars. When applied to piping of 50 mm 2 inch ips or larger and where otherwise required by imposed loads, insert a 305 millimeter length of 13 millimeter 1-foot length of 1/2-inch reinforcing rod that is wired through wing slots. Proprietary designs for continuous inserts may be used upon approval by the Contracting Officer.

]2.4.2.2 Horizontal Pipe Attachments

Use Type 6 solid malleable-iron pipe rings to support piping in sizes to and including 50 mm 2 inch ips. Split-band rings may be used for piping up to 25 mm 1 inch ips.

Use Types [1] [3] [4] attachments to support piping in sizes through 200 mm 8 inch ips.

Use Type [41] [49] pipe rolls to support piping in sizes larger than 200 mm 8 inch ips.

Use trapeze hangers fabricated from approved structural steel shapes, and use U-bolts in congested areas and where multiple pipe runs occur. Structural steel shapes [conform to supplementary steel requirements] [are a commercially available, proprietary-design, rolled steel].

2.4.2.3 Vertical Pipe Attachments

Use Type 8 vertical pipe attachments.

2.4.2.4 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 support system to accommodate pipe accessibility and adjustment for load and pitch.

2.4.2.5 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, design and fabricate such supplementary steel in accordance with AISC 360.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Underground Piping System

3.1.1.1 Compressed Air System Installation

Install compressed air systems in accordance with the manufacturer's instructions. Conduct installation in the presence of the Contracting Officer. Notify the Contracting Officer [48] [_____] hours in advance of the work.

Conduct excavations in accordance with Section 31 00 00 EARTHWORK.

Lay piping at the beginning at the low point of a system, and when the piping is in the final position, ensure that the piping is true to the grades and aligns with unbroken continuity of invert.

[Blocking and wedging is not permitted.

] Ensure that pipes that pass through the walls are below grade and that ground floor slabs pass through pipe sleeves.

In fill areas, ensure that pipe passing under or through building grade beams have at least [100] millimeter [4] inches [_____] clearance in all directions.

Where pipe penetrates earth or concrete grade, ensure that at least [300] millimeter [12] inches [_____] of polyethylene-coated Type BCS-PS pipe is exposed to view.

Install Type BCS-PS materials in accordance with the applicable requirements for underground piping and aboveground piping. Palletize the pipe in padded pallets at the factory and use padded gear to handle the pipefrom pallet to final position. Protect surfaces from the sun by using black polyethylene sheeting. Before lowering pipe into a trench, check the sheathing for continuity with 10,000 volts applied by a continuity detector. In the trench, after joints and fittings are made, check previously untested surfaces for continuity. Where discontinuities in thermoplastic are found, discard at least [0.30] millimeter [12] inches [_____] of material upstream and downstream of fault.

[After valves, valve operators, and valve boxes have been inspected and at least [48] [_____] hours before lowering these items into a trench, coat external surfaces with a compatible bituminous coating for protection against brackish ground water. Apply a single coat in accordance with the manufacturer's instructions, produces a dry-film thickness of at least [0.30] millimeter [12] mils [_____].

]3.1.1.2 Valve Boxes

Set valves and valve boxes plumb. Center valve boxes on the valves.

[Install a 100 millimeter 4 inch thick concrete slab to protect valve boxes.

]3.1.2 Aboveground Piping System

3.1.2.1 Piping Systems

Fabricate and install piping systems in accordance with ASME B31.3, MSS SP-58, ASME BPVC, and applicable AWS requirements.

Fabricate pipe to measurements established on the job and carefully work the pipe into place without springing or forcing the pipe.

****

NOTE: When the instructions in the following paragraph do not provide the cleanliness level by project conditions and if pickling of pipe and temporary line strainers are required, rewrite the following paragraph. Do not oil the pipe bore. Use a phosphoric acid rust-preventing treatment.

****

Ensure that pipe, tubing, fittings, valves, equipment, and accessories are clean and free of all foreign material before installation. Clean pipe by a method approved by the Contracting Officer. Purge lines with dry, oil-free compressed air after erection, but do not rely on purging for

removing all foreign matter. Purge lines at a velocity equal to 1 1/2 times the maximum normal flow velocity. During construction, protect the open ends of pipe, fittings, and valves at all times to prevent foreign matter from entering the pipe. Except when connections are actually underway, install plugs or caps on all pipe and component openings. Use plugs or caps that are commercially manufactured products.

Install piping 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.

Use standard long sweep pipe fittings for changes in direction. Do not use mitered joints or unapproved pipe bends.

Pipe bends in seamless pipe may be made with hydraulic benders in the field for pipe sizes to 100 mm 4 inch ips, upon approval from the Contracting Officer. Ensure that the radius of pipe bends is at least [five] [_____] times the nominal pipe diameters.

Make tee connections with screwed tee fittings or grooved tee fittings. Where pipe is being welded, make branch connections with either welding tees or forged branch outlet fittings, either of which is acceptable without size limitations. Provide branch outlet fittings that are forged, flared for improved flow where attached to the run, reinforced against external strains, and designed to withstand full burst-pressure strength requirements. Provide tool space between parallel piping runs whenever threaded unions or couplings are installed.

Install horizontal piping with a grade of [25.0 millimeter per 30480 millimeter] [1 inch per 100 feet] [_____].

Use eccentric reducers where required to permit proper drainage of pipe lines. Do not permit bushings for this purpose. Provide drain valves in piping systems at low points. Use pipe drains that consist of 15 mm 1/2 inch globe valves with renewable disks and a 20 millimeter 3/4 inch hose adapter.

Install piping in a manner that does not stress or strain connected equipment.

Make expansion bends in steel pipe from pipe sections and long-radius welding elbows that are 25 mm 1 inch or larger. Ensure that expansion U-bends are cold-sprung and welded into the line. Anchor the line before removing the spreader from the expansion U-bend.

3.1.2.2 Joints

Ream pipe ends before joint connections are made.

Make up screwed joints with joint compound.

Apply joint compounds to the male thread only, and exercise care to prevent the compound from reaching the interior of the pipe.

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

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

Ensure that field-welded joints conform to the requirements of AWS-03 and ASME B31.3.

Use square-cut copper tubing for solder joints and use cutting and reaming tools to remove burrs. Clean the inside surfaces of fittings and the outside surfaces of tubes in the joint area before assembly of the joint. Apply the joint flux, solder, and heat source in accordance with the manufacturer's instructions, using capillary action to fill the socket space and achieve 100 percent of the shear-line strength capability. Ensure that the valves in copper piping have screwed ends with end adapters to suit mechanical connections, unless solder joining is specified for a given application. Remake copper joints that fail pressure tests with new materials, including pipe or tubing fittings and filler metal.

Use square-cut, tubing for mechanical joints and remove burrs. Exercise care to avoid work-hardened copper surfaces and cut off or anneal tube ends. Meet heating temperature and air-cooling requirements in accordance with the manufacturer's instructions.

3.1.2.3 Control and Instrument Air Tubing

Conceal tubing, except in mechanical rooms or areas where other piping is exposed.

Use hard-drawn copper tubing in exposed areas. Do not use annealed copper in concealed locations.

For supply system copper tubing, use wrought copper solder joint-type fittings, except at the connection to the apparatus where brass mechanical and ips thread adapter fittings are used. Tool-made bends in lieu of fittings are acceptable. Neatly nest multiple tube runs.

[Use fittings for plastic tubing in accordance with the manufacturer's instructions.

][Plastic tubing, sheathed or unsheathed, may be used in lieu of copper tubing, provided:

a. Plastic tubing is not exposed to ultraviolet light and continuous ambient temperatures in excess of 49 degrees C 120 degrees F at any point along run.

b. Plastic tubing is free from danger of mechanical damage and readily accessible for replacement with a minimum of tools and without the need to remove plaster, furring, equipment, and similar permanent construction.

c. Plastic tubing is not embedded in concrete or concealed within the walls of a structure or in hot pipe and duct chases.

d. Plastic tubing is enclosed within control panel cabinets or concealed behind control panels.

e. Routing has prior approval of the Contracting Officer.

Install [color] [number] code tubing installed inside or behind control panels. Neatly tie and support tubing. Neatly fasten connections bridging the cabinet and its door along the hinge side and protect the connections against abrasion.

When the tubing run is less than 300 millimeter 12 inches, plastic tubing may be used. Otherwise, use hard-drawn copper tubing for the terminal single line.

] Mechanically attach tubing to supporting surfaces. Do not use adhesive to attach supports.

For copper tubing horizontal supports with less than 3 tubes use a rigid 25 mm by 10 mm 1-inch by 3/8-inch metal channel, use a proprietary metal tube race for 3 or more tubes.

[Run exposed plastic tubing in mechanical rooms or spaces where copper tubing is exposed within adequately supported [metal raceway] [metallic or plastic electric conduit] [pipe].

][Use a multiple-tube plastic harness or sheathing in place of single plastic tubes where a number of plastic tubes run to the same points.

][Multiple-tube plastic harness or sheathing may be imbedded in concrete or run in soil below concrete provided it is jointless, contains 30 percent spares, and prior approval of the Contracting Officer has been obtained.

] For runs imbedded in concrete, use annealed copper tubing protected with [metallic] [plastic] electric conduit.

Ensure that copper-tubing runs in soil are jointless. Protect the copper tubing from brackish ground water and leaching concrete alkali with 0.30 millimeter 12-mil thick [bituminous coating] [equivalent polyvinylchloride (PVC) tape wrapping].

Make tubing penetrations of concrete surfaces through minimum 25 mm 1 inch ips, Schedule 40, rigid unplasticized PVC pipe sleeves, except that multitube harness 40 millimeter 1 1/2 inches outside diameter or larger need not have additional protection. Extend sleeve [150] millimeter [6] inches [_____] above floors and [25] millimeter [1] inch [_____] below the grade surfaces of slabs. Where water or vapor-barrier sealing is required, apply a 15 millimeter 1/2 inch deep elastomer caulk to surfaces that are free from oil and other deleterious substances.

Systematically purge tubing with [dry, oil-free compressed air] [nitrogen] to rid the system of impurities [generated during joint-making and

installation] and atmospheric moisture before connection to control instruments.

3.1.2.4 General Service Valve Locations

Provide valves to permit isolation of branch piping and each equipment item from the balance of the system, to allow safe and convenient access without moving equipment, and to require a minimum of piping and equipment disassembly.

Provide valves in piping mains and branches at equipment and equipment items.

Provide riser and downcomer drains above piping shutoff valves in piping 65 mm 2 1/2 inches or larger. Tap and fit shutoff valve body with a 15 mm 1/2 inch plugged globe valve.

Provide three-valve bypass around each pressure-regulating valve.

Provide access panels for valves unavoidably located in furred or other normally inaccessible places.

3.1.2.5 Bypass Throttling Valves

Install globe valves with a [metallic] [composition] disc.

3.1.2.6 Supporting Elements Installation

Provide supporting elements in accordance with the requirements of ASME B31.1, and MSS SP-58. Hang piping from building construction. Do not hang piping from the roof deck or from other pipe.

Whenever possible, use approved cast-in concrete inserts to attach to structures made of concrete. Use built-in anchors to attach to structures made of solid masonry. Where attachment by either of the above methods is not possible, specified masonry anchor devices may be used with written approval 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 diameter.

Use masonry anchors only for overhead application of ferrous material.

Install masonry anchors conforming to CID A-A-1922, CID A-A-1923, CID A-A-1924, CID A-A-55614 in rotary, nonpercussion, electric-drilled holes. Group III self-drilling anchors may be used provided masonry drilling is done with electric hammers that do not cause concrete spalling or cracking, whether the defects are visible or invisible. Do not use pneumatic tools

Use percussive-action electric hammers, and combination rotary-electric hammers to install self-drilling anchors selected in accordance with the following guide:

a. For anchor devices of M6 through M14 1/4 through 1/2 inch, use a hammer only or a combination rotary tool-hammer rated at load to draw not more than 5.0 amperes when operating on 120-volt, 60-hertz power.

b. For anchor devices of M16 5/8 inch or larger, use a hammer 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 used on the same power supply have a full-load current rating that does not exceed 10 amperes.

Size inserts and anchors for the total stress to be applied 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. Locate the devices so that they are at least the following distances from any side or end edge or the centerline between adjacent anchor:

Anchor Bolt Length (Millimeter)	Minimum Edge Space (Millimeter)
6	90
8	95
10	100
14	125
16	150
20	175
22	200

Anchor Bolt Length (Inches)	Minimum Edge Space (Inches)
1/4	3 1/2
5/16	3 3/4
3/8	4
1/2	5
5/8	6
3/4	7
7/8	8

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

Run piping parallel with the lines of the building. Space and install piping and components so that a threaded pipe fitting may be removed between adjacent pipes and so that there is at least [13] millimeter [1/2] inch [_____] of clear space between the finished surface and other work and between the finished surface and parallel adjacent piping. Arrange

hangers on adjacent service lines so that the hangers run parallel with each other and parallel to the lines of the building.

Place identical service systems piping, where practical, at the same elevation and hang the piping on trapeze hangers adjusted for the proper pitch.

Where piping is grouped in parallel runs, space trapeze hangers at the closest interval required for any size pipe supported.

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

Provide approved pipe alignment guides, attached in an approved manner to the building structure, to control pipe movement in true alignment in the piping adjacent to and on each side of all pipe expansion loops.

Use a welding method approved by the Contracting Officer to incorporate anchors into piping systems for the purpose of permanently attaching the pipe to the building structure.

Brace piping in a way that prevents sway and vibration. Use bracing that consists of brackets, anchor chairs, rods, and structural steel for vibration isolation.

[Locate pipe lines supported from roof purlins not farther than [one-sixth] [_____] of the purlin span from the roof truss. The load per hanger cannot exceed [1780] newton [400] pounds [_____] when support is from a single purlin, and cannot exceed [3560] newton [800] pounds [_____] when the hanger load is applied to the purlins halfway between the purlins by means of auxiliary support steel installed by the Contractor.] When support is not provided halfway between purlins,ensure that the allowable hanger load is the product of [400] [_____] times the inverse ratio of the longest distance in the purlin-to-purlin spacing.

When the hanger load exceeds the above limits, furnish and install reinforcing for the roof purlins or additional support beams. When an additional beam is used, ensure that the beam bears on the top chord of the roof trusses, and that the bearing is over the gusset plates of the top chord. Stabilize the beam by a connection to the roof purlin along the bottom flange.

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

Ensure that the load rating for all pipe hanger supports is based on weight and forces imposed on all lines. Ensure that deflection per span does not exceed the slope gradient of pipe. Ensure that Schedule 40 and heavier pipe supports are in accordance with the following minimum rod sizes. Maximum allowable hanger spacing and concentrated loads reduces the allowable span proportionately:

PIPE SIZE MILLIMETER	ROD SIZE MILLIMETER	STEEL PIPE MILLIMETER
Up to 25	10	2438
32 to 40	10	3048
50	10	3660
65 to 90	15	3660
100 to 125	16	4880
150	20	4880
200 to 300	22	6100

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 to 12	7/8	20

Where possible, support vertical risers at the base at the intervals specified and guide the risers for lateral stability. Place clamps under fittings wherever possible. Support carbon steel pipe at each floor at not more than 4570 millimeter 15 foot intervals for pipe 50 mm 2 inches and smaller and at not more than 6100 millimeter 20 foot intervals for pipe 65 mm 2 1/2 inches and larger.

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

3.1.2.7 Sound Stopping

Provide effective sound stopping and provide an operating clearance that is sufficient to prevent the piping from making contact with the structure where the piping penetrates walls, floors, or ceilings in occupied spaces adjacent to equipment rooms, where similar penetrations occur between occupied spaces, and where penetrations occur from pipe chases that penetrate occupied spaces. Occupied spaces includes the space above ceilings where no special acoustic treatment of the ceiling is provided. Create finished penetrations compatible with the surface being penetrated.

Ensure that sound stopping materials and procedures are the same as those specified under the paragraph SLEEVES.

[Ensure that sound stopping and vapor barrier sealing of pipe shafts and large floor and wall openings are accomplished by packing properly supported mineral fiber to high density, or, where ambient or surface temperatures do not exceed 49 degrees C 120 degrees F, by foaming in place with self-extinguishing, 0.9 kilogram 2-pound density polyurethane foam to a depth of at least [150] millimeter [6] inches [_____]. Finish foam with a rasp. Ensure the vapor barrier consists of at least a [3] millimeter [1/8] inch [_____] thickness of vinyl coating applied to visible and accessible surfaces. Where high temperatures and fire-stopping are a consideration, use only mineral fiber. In addition, cover openings with [1.6] millimeter [16]-gage [_____] sheet metal.

] Ensure that all mineral materials conform to the requirements specified under the paragraph SLEEVES in this section.

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

3.1.2.8 Sleeves

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

Lay out and set sleeve work before placement of slabs or construction of walls and roof. Furnish the sleeves needed to complete the work.

Where pipe sleeves are required after slabs and masonry are installed, create holes to accommodate these sleeves with core drills. Set the sleeves in place with a two-component epoxy adhesive system approved by the Contracting Officer. Carry no load by such sleeves unless approved by the Contracting Officer.

Ensure that the sleeves are flush with all ceilings.

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

Ensure that sleeves passing though steel decks are continuously [welded] [brazed].

Fabricate sleeves that continuously extend through floors, roofs, and load-bearing walls, and sleeves that run through fire barriers, from Schedule 40 steel pipe with welded anchor lugs. Other sleeves may be formed by molded linear polyethylene liners or similar materials that are removable. Ensure that the sleeve diameter is large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and provide at least [10] millimeter [3/8] inch [_____] clearance. Select a sleeve size that will accommodate mechanical and thermal motion of pipe in order not to transmit vibration to walls and generate noise.

Solidly pack the space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration with a mineral fiber conforming to ASTM C592, Form B, Class 8. Provide similar packing whenever the piping passes through firewalls, equipment room walls, floors and ceilings connected to occupied spaces, and other locations where

sleeves or construction surface penetrations occur between occupied spaces. 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 caulked surfaces are oil- and grease-free.

[Caulk watertight with lead and oakum] [Make watertight with mechanically expandable chloroprene inserts with mastic sealed metal components] exterior wall sleeves.

Ensure that the sleeve extends [304.8] millimeter [12] inches [_____] above the surface of the roof.

3.1.2.9 Escutcheons

Provide escutcheons where piping penetrates finished areas. Where finished areas are separated by partitions through which piping passes, provide escutcheons on both sides of the partition. In areas where suspended ceilings are installed, provide plates only on the underside of such ceilings. In areas where insulated pipes are used, install plates large enough to fit around the insulation. In occupied spaces, use chrome-plated escutcheons that are large enough to conceal openings in building construction. Firmly attach escutcheons with setscrews.

3.1.2.10 Flashings

Provide flashings at locations where mechanical systems penetrate the building boundaries.

3.1.3 Compressed-Air Systems Identification

Protect and keep identification plates clean. Replace damaged and illegible identification plates at no additional expense.

Label and arrow piping at each point of entry and exit of piping passing through walls; at each change in direction, such as at elbows and tees; and in congested or hidden areas, at each point required to clarify service or indicate a hazard. Label each riser.

In long, straight runs, locate labels at distances that allow a label to be seen from the location of another label, but in no case allow the distance between labels to exceed [22860] millimeter [75] feet [_____]. Ensure that labels are legible from the primary service and operating area.

3.2 FIELD QUALITY CONTROL

3.2.1 Compressed-Air 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.

Prior to acceptance of the work, pressure-test completed systems in the presence of the Contracting Officer.

[Conduct testing in two stages: preliminary stage and acceptance stage, including gage tests.

][Perform no testing until personnel not directly involved in the test have been evacuated from the area.

][Contractor may conduct tests for their own purposes in addition to the preliminary test and the acceptance test specified below.

]3.2.1.1 Preliminary Stage Tests

****
NOTE: Select the following paragraph only when pneumatic testing is specified.
****

[Conduct pneumatic tests with dry, oil-free compressed air. Use carbon dioxide or nitrogen in metallic systems.

][Ensure that each system test includes a preliminary test in which the joints under test are swabbed with a standard high-strength film soap solution, so that bubbles, if any exist, can be observed at internal pressures of 35 kilopascal 5 psi or less.

] When testing reveals that leakage exceeds specified limits, isolate and repair the leaks, replace defective materials where necessary, and retest the system until specified limits are met. Remake leaking gaskets with new gaskets and new flange bolting, and discard used bolting and gaskets.

Other than standard piping flanges, plugs, caps and valves, only use commercially manufactured expandable elastomer plugs for sealing off piping for test purposes. Ensure that the published safe test pressure rating of any plug used is at least three times the actual test pressure being applied. During pneumatic testing or hydrostatic testing, evacuate personnel from areas where plugs are used.

Remove components that could be damaged by test pressure from the piping systems to be tested.

Perform valve-operating tests and drainage tests according to cited standards.

Check piping system components, such as valves, for proper operation under the system test pressure.

Do not add test media to a system during a test for a period specified or determined by the Contracting Officer.

Duration of a test is determined by the Contracting Officer and will be for a minimum of [15] [_____] minutes with a maximum of [24] [_____] hours. Test may be terminated by direction of the Contracting Officer at any point after it has been determined that the leakage rate is within limits.

****
NOTE: Select the following paragraph only when hydrostatic testing is specified.
****

[Only use potable water for hydrostatic testing. Government will supply testing water at a location determined by the Contracting Officer. Contractor is responsible for approved disposal of contaminated water. Ensure that the temperature of water used for testing is not low enough to cause condensation of atmospheric moisture on system surfaces. Provide supplementary heat when necessary.

][To preclude injury and damage, take necessary precautions by venting the expansive force of compressed air trapped during high-pressure hydrostatic testing. When purging or vent valves are not provided, the Contracting Officer may require the removal of system component such as plugs or caps to verify that the water has reached all parts of the system.

][Upon completion of testing, drain and purge the system with dry air. Verify system dryness by hygrometer comparison with purging air.

][Immediately repair visible leaks or defects in the pipeline.

]3.2.1.2 Test Gages

Ensure that test gages conform to ASME B40.100 and have a dial size of 200 millimeter 8-inches or larger. The maximum permissible scale range for a given test is such that the pointer during a test has a starting position at midpoint of the dial or within the middle third of the scale range. Ensure that the certification of accuracy and correction table bears a date no more than [90] [_____] calendar days before the gage is used in a test, and that it indicated the test gage number and the project number, unless otherwise approved by the Contracting Officer.

3.2.1.3 Acceptance Pressure Testing

Ensure that the testing takes place during steady-state ambient temperature conditions.

Test ferrous piping systems at [1-1/2] [_____] times the maximum operating pressure. Maintain test pressure for at least [2] [_____] hours with an allowable pressure drop of [14] kilopascal [2] psi [_____] during that time unless otherwise approved by the Contracting Officer.

Test control and instrumentation tubing systems at [205] kilopascal [30] psi [_____]. Maintain the test pressure for at least [24] [_____] hours with essentially no pressure drop during that time.

Each acceptance test requires the signature of the Contracting Officer. Deliver [two] [_____] record copies to the Contracting Officer after acceptance.

3.2.1.4 Piping System Test Report

Prepare and maintain test records of all piping systems tests. Ensure the records show the responsibilities of Governmental and Contractor test personnel, dates, test gage identification numbers, ambient temperatures, pressure ranges, rates of pressure drop, and leakage rates. Submit

reports to the Contracting Officer.

3.3 ADJUSTING AND CLEANING

Remove rust and dirt from the bore and exterior surface of all piping and equipment. Clean pipeline strainers, temporary and permanent, during purging operations, after startup, and immediately prior to final acceptance by the Government.

Flush and clean new steel piping with a suitable degreasing agent, [____], until visible grease, dirt, and other contaminants have been removed. Dispose of degreased waste material including the degreaser itself in accordance with written instructions received from the Environmental Authority having jurisdiction through the Contracting Officer and in accordance with all local, State, and Federal Regulations.

3.4 CLOSEOUT ACTIVITIES

Submit [6] [_____] copies of the operation and maintenance manuals [30] [_____] calendar days prior to testing the low-pressure compressed air system. Update and resubmit data for final approval no later than [30] [_____] calendar days prior to contract completion.

-- End of Section --