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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION TABLE OF CONTENTS

DIVISION 22 - PLUMBING

SECTION 22 15 14.00 40

GENERAL SERVICE COMPRESSED-AIR SYSTEMS, LOW PRESSURE

02/11

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 GENERAL REQUIREMENTS
- 1.3 SUBMITTALS
- 1.4 GENERAL REQUIREMENTS
- 1.5 OPERATION AND MAINTENANCE
- 1.6 DRAWINGS
- 1.7 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

PART 2 PRODUCTS

- 2.1 UNDERGROUND PIPING MATERIALS
 - 2.1.1 Piping Types
 - 2.1.2 Fittings
- 2.2 ABOVEGROUND PIPING MATERIALS
 - 2.2.1 Compressed Air Systems 862 Kilopascal 125 Psig and Less
 - 2.2.1.1 Type BCS Black Carbon Steel
 - 2.2.1.2 Type GCS Galvanized Carbon Steel
 - 2.2.2 Control and Instrumentation Tubing, to 207 kilopascal 30 Psig
 - 2.2.2.1 Copper
 - 2.2.2.2 Polyethylene
- 2.3 PIPING SPECIALTIES
 - 2.3.1 Air Pressure Reducing Stations
 - 2.3.2 Air Line Lubricators
 - 2.3.3 Compressed Air Receivers
 - 2.3.4 Grooved Pipe Couplings and Fittings
 - 2.3.5 Pressure Gages
 - 2.3.6 Thermometers
 - 2.3.7 Line Strainers
- 2.4 AIR COMPRESSORS
- 2.5 VALVES
 - 2.5.1 Ball Valves (BAV)
 - 2.5.2 Butterfly Valves (BUV)
 - 2.5.3 Diaphragm Control and Instrument Valves (DCIV)
 - 2.5.4 Gage Cocks (GC)

- 2.5.5 Gate Valves (GAV)
- 2.5.6 Globe and Angle Valves (GLV and ANV)
- 2.5.7 Eccentric Plug Valves (EPV)
- 2.6 MISCELLANEOUS MATERIALS
 - 2.6.1 Bolting
 - 2.6.2 Elastomer Caulk
 - 2.6.3 Escutcheons
 - 2.6.4 Flashing
 - 2.6.5 Flange Gaskets
 - 2.6.6 Pipe Thread Compounds
- 2.7 SUPPORTING ELEMENTS
 - 2.7.1 Building Structure Attachments
 - 2.7.2 Horizontal Pipe Attachments
 - 2.7.3 Vertical Pipe Attachments
 - 2.7.4 Hanger Rods and Fixtures
 - 2.7.5 Supplementary Steel

PART 3 EXECUTION

- 3.1 UNDERGROUND PIPING SYSTEM INSTALLATION
 - 3.1.1 Compressed Air System Installation
 - 3.1.2 Valve Boxes
- 3.2 ABOVE GROUND PIPING SYSTEM INSTALLATION
 - 3.2.1 Piping Systems
 - 3.2.2 Joints
 - 3.2.3 Control and Instrument Air Tubing
 - 3.2.4 General Service Valve Locations
 - 3.2.5 Bypass Throttling Valves
 - 3.2.6 Supporting Elements Installation
 - 3.2.7 Sound Stopping
 - 3.2.8 Sleeves
 - 3.2.9 Escutcheons
 - 3.2.10 Flashings
- 3.3 COMPRESSED AIR SYSTEMS TESTING
 - 3.3.1 Preliminary Stage Tests
 - 3.3.2 Test Gages
 - 3.3.3 Acceptance Pressure Testing
- 3.4 COMPRESSED AIR SYSTEM CLEANING
- 3.5 COMPRESSED AIR SYSTEMS IDENTIFICATION

-- End of Section Table of Contents --

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 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 (2010) Specification for Structural Steel Buildings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4 (2008; Errata 2010) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water

AWWA C504 (2010) 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 (2001) Welding Handbook, Volumes 1 thru 4

ASME INTERNATIONAL (ASME)

ASME A112.18.1/CSA B125.1 (2011) Plumbing Supply Fittings

ASME B16.1 (2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.22 (2001; R 2010) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.3 (2011) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.39 (2009) Standard for Malleable Iron

	Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B18.2.2	(2010) Standard for Square and Hex Nuts
ASME B19.3	(1991; Addenda A 1994; Addenda B 1995) Safety Standard for Compressors for Process Industries
ASME B31.1	(2010) Power Piping
ASME B31.3	(2010) Process Piping
ASME B40.100	(2005; R 2010) Pressure Gauges and Gauge Attachments
ASME BPVC	(2010) Boiler and Pressure Vessels Code
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A126	(2004; R 2009) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A181/A181M	(2006) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A183	(2003; R 2009) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A197/A197M	(2000; R 2011) Standard Specification for Cupola Malleable Iron
ASTM A216/A216M	(2008) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A234/A234M	(2011a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A278/A278M	(2001; R 2011) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A307	(2010) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

ASTM A395/A395M	(1999; R 2009) Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A436	(1984; R 2011) Standard Specification for Austenitic Gray Iron Castings
ASTM A53/A53M	(2010) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2009) Standard Specification for Ductile Iron Castings
ASTM A563M	(2007) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A666	(2010) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B148	(1997; R 2009) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B164	(2003; R 2008) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B280	(2008) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B370	(2011) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B584	(2011) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B61	(2008) Standard Specification for Steam or Valve Bronze Castings
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B749	(2003; R 2009) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C592	(2010) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C920	(2011) Standard Specification for Elastomeric Joint Sealants
ASTM D1693	(2008) Standard Test Method for Environmental Stress-Cracking of Ethylene

Plastics

ASTM D2000	(2012) 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	(2007) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM F104	(2011) Standard Classification System for Nonmetallic Gasket Materials
ASTM F568M	(2007) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

ISA - INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air
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MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2011) Butterfly Valves
MSS SP-69	(2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-72	(2010) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2008) Bronze Gate, Globe, Angle and Check Valves

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide
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U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS FF-S-325	(Basic; Int Amd 3; Notices 3, 4) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
FS L-C-530	(Rev C; Notice 1) Coating, Pipe, Thermoplastic Resin

1.2 GENERAL REQUIREMENTS

NOTE: If Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

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

1.3 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation 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

Submit [Installation Drawings](#) for low-pressure compressed air systems in accordance with paragraphs entitled, "Drawings,"

"Aboveground Piping Materials," and "Underground Piping Materials," of this section.

SD-03 Product Data

Submit [Equipment and Performance Data](#) for piping systems.

Submit manufacturer's catalog data for the following items:

[Underground Piping Materials](#)

[Aboveground Piping Materials](#)

[Piping Specialties](#)

[Supporting Elements](#)

[Air Compressors](#)

[Valves](#)

[Accessories](#)

[Miscellaneous Materials](#)

[Vibration Isolation](#)

SD-05 Design Data

Submit [Design Analysis and Calculations](#) for low-pressure compressed air systems for the following in accordance with paragraph entitled, "General Requirements," of this section.

[Flow Rates](#)

[Air Distribution](#)

[Pressure Requirements](#)

[Insulation Requirements](#)

[Equipment and Performance Data](#) submitted for piping systems shall show conformance with ASME Code.

SD-06 Test Reports

Submit test reports for the following items in accordance with paragraph entitled, "Compressed Air Systems Testing," of this section.

[Hydrostatic Testing](#)

[Compressed Air Systems Testing](#)

[Valve-Operating Tests](#)

[Drainage Tests](#)

[Pneumatic Testing](#)

Each acceptance test shall require the signature of the Contracting Officer and [two] [_____] record copies shall be delivered to the Contracting Officer after acceptance.

SD-07 Certificates

Submit certificates for the following items showing conformance with the referenced standards contained in this section.

Underground Piping Materials

Aboveground Piping Materials

Supporting Elements

Riser Alarm Equipment

Sprinkler Heads

Valves

Miscellaneous Materials

SD-10 Operation and Maintenance Data

Submit [Operation and Maintenance Manuals](#) in accordance with paragraph entitled, "Operation and Maintenance," of this section.

1.4 GENERAL REQUIREMENTS

NOTE: If Section 40 17 30.00 40 WELDING GENERAL PIPING is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

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

[Equipment and performance data](#) submitted for piping systems shall show conformance with ASME Code.

Certificates for [riser alarm equipment](#) and [sprinkler heads](#) shall be submitted meeting referenced standards contained within this section.

[design analysis and calculations](#) for low-pressure compressed air systems shall consist of [flow rates](#), [air distribution](#), [pressure requirements](#) and [insulation requirements](#) meeting requirements for referenced standards contained in this section.

1.5 OPERATION AND MAINTENANCE

Contractor shall 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.

1.6 DRAWINGS

Submit **installation drawings** for low-pressure compressed air systems in accordance with paragraphs entitled, "Aboveground Piping Materials" and "Underground Piping Materials," of this section.

Shop drawings shall be accompanied by curves indicating that an essentially flat reduced pressure curve for the capacity demand of the system will be met by the proposed valves.

Submit complete shop drawing data for pipe attachments for approval.

In lieu of separate hangers, the Contractor may submit for approval a shop drawing of trapeze hangers with a solid or split-ring clamp which he proposes to furnish.

1.7 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 and/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 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 and/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 UNDERGROUND PIPING MATERIALS

2.1.1 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."

Type BCS-PS black carbon steel piping with polyethylene sheath shall conform to [ASTM A53/A53M](#), Type [E] [S], in sizes through [DN250 10 inch](#) iron pipe size (ips). Pipe in size [DN300 12 inches](#) and larger shall have Schedule 40 wall. Pipe wall shall be [10 millimeter 0.375 inch](#) thick.

Thermoplastic sheath shall conform to [FS L-C-530](#). Make sheath joints with thermally fitted shrinking sleeves applied with factory-approved shrinking devices. Make taped fitting protection and repairs in accordance with manufacturer's instructions. Electrical flaw detection testing at the factory shall require 10,000 volts to be impressed across the sheath. Sheath breakdown voltage shall be not less than 13,000 volts.

2.1.2 Fittings

Fittings shall be long radius butt weld carbon steel conforming to [ASTM A234/A234M](#) and [ASME B16.9](#) to match pipe wall thickness. Pipe bending is not p. Aboveground terminal fittings shall be [1034 kilopascal 150-pound](#) working steam pressure (wsp) forged steel weld neck flanges to match wall thickness, conforming to [ASME B16.5](#) and [ASTM A181/A181M](#) Class 60.

2.2 ABOVEGROUND PIPING MATERIALS

2.2.1 Compressed Air Systems [862 Kilopascal 125 Psig](#) and Less

2.2.1.1 Type BCS Black Carbon Steel

Pipe [DN6 through DN40 1/8 through 1-1/2 inches](#) shall be Schedule 40, furnace butt welded, black carbon steel, conforming to [ASTM A53/A53M](#), Type F, Grade B.

Pipe [DN50 through DN250 2 through 10 inches](#) shall be Schedule 40, [seamless] [electric resistance welded], black carbon steel, conforming to [ASTM A53/A53M](#), Grade B, Type [E] [S]. Grade A pipe should be used for permissible field bending.

Pipe [DN300 12 inches](#) and over shall be [10 millimeter 0.375 inch](#) wall, [seamless, black carbon steel, conforming to [ASTM A53/A53M](#), Grade B, Type [E] [S]].

Fittings [DN50 2 inches](#) and under shall be [1034 kilopascal gage 150-pounds per square inch, gage \(psig\)](#) wsp, banded, black malleable iron, screwed, conforming to [ASTM A197/A197M](#) and [ASME B16.3](#).

Unions [50 millimeter 2 inches](#) and under shall be [1724 kilopascal gage 250-psig](#) wsp, female, screwed, black malleable iron, with brass-to-iron seat and ground joint conforming to [ASME B16.39](#), ductile iron conforming to [ASTM A536](#) for grooved pipe couplings.

Couplings [DN50 2 inches](#) and under shall be [standard weight, screwed, black carbon steel] [ductile iron conforming to [ASTM A536](#)].

Fittings [65 millimeter 2-1/2 inches](#) and over shall be [steel, butt welded, to match pipe wall thickness, conforming to [ASTM A234/A234M](#) and [ASME B16.9](#)] [ductile iron conforming to [ASTM A536](#)].

Flanges 65 millimeter 2-1/2 inches and over shall be 1034 kilopascal 150-psig wsp, forged steel, welding neck to match pipe wall thickness, conforming to ASME B16.5.

Grooved pipe couplings and fittings DN65 2-1/2 inches and over shall be malleable iron couplings and fittings conforming to paragraph entitled, "Piping Specialties," of this section.

2.2.1.2 Type GCS Galvanized Carbon Steel

Pipe DN15 through DN250 1/2 through 10 inches shall be 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 DN50 2 inches.

Fittings DN50 2 inches and under shall be 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].

Fittings DN65 2-1/2 inches and over shall be 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].

Unions 50 millimeter 2 inches and under shall be 2068 kilopascal 300-psig wsp, female, screwed, galvanized, malleable iron with brass-to-iron seat and ground joint.

2.2.2 Control and Instrumentation Tubing, to 207 kilopascal 30 Psig

2.2.2.1 Copper

Tubing all sizes with DN8 1/4 inch minimum outside diameter shall be [hard-drawn] [annealed] seamless copper, conforming to ASTM B280.

Fittings shall be solder joint wrought copper conforming to ASME B16.22.

Ball sleeve shall be of the compression type, [rod] [forged brass], conforming to SAE [72] [88], UL approved, with minimum pressure rating 1380 kilopascal at 38 degrees C 200 pounds per square inch (psi) at 100 degrees F.

Solder shall be 95-5 tin-antimony, alloy Sb 5, conforming to AWS WHB-2.9.

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

2.2.2.2 Polyethylene

Tubing shall be black virgin polyethylene, conforming to ASTM D2239, Type I, Grade 2, Class C, conforming to stress-crack tests performed in accordance with ASTM D1693. Multitube harness with polyester film barrier and vinyl jacket shall not be less than [1.57] millimeter [0.062] inch [_____] thick.

Ball sleeve fittings shall be of the compression type, and shall be [brass] [aluminum] [acetal resin].

2.3 PIPING SPECIALTIES

2.3.1 Air Pressure Reducing Stations

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

Construct pressure regulator body of zinc or aluminum die castings, rated for the service. Diaphragm shall be reinforced air-, oil-, and water-resistant elastomer. All components, exposed to fluid stream being controlled, shall be of [nonferrous] [suitable nonmetallic materials]. Valves shall be of a balanced construction relieving type to automatically prevent excess pressure buildup.

Construct filters of [zinc] [aluminum] die castings, rated for the service, and furnished with ips connections. Bowl materials shall be aluminum. Filter shall be serviceable by bowl quick-disconnect devices. Equip bowl with manual drain cock. Separate liquid particles by centrifugal and quiet zone action. Remove solid particles to 15-micrometer size by filter elements of [sintered bronze] [corrosion-resistant steel] mesh.

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

] Pressure relief valves shall be rated for the pressure of the high-pressure side and sized for the full installed capacity of the pressure regulating station at the pressure of the low-pressure side. Set valve at not more than [20] [_____] percent more than the correct low side pressure. Rate and label valve. Seat material shall be suitable for the service.

2.3.2 Air Line Lubricators

Air line lubricators shall be of the pulse-type with pickup tube, polycarbonate resin bowl, large fill opening, metering rod flow adjuster, sight ball, and drain cock.

Lubricators shall be suitable for 1380 kilopascal at 74 degrees C 200 psig at 165 degrees F.

2.3.3 Compressed Air Receivers

Compressed air receivers shall conform to the sizes and capacities specified. Design such vessels for the applicable working pressures and service in accordance with the ASME BPVC SEC VIII D1, and label.

Vessels shall be complete with connections for drain, supports, and other required accessories.

2.3.4 Grooved Pipe Couplings and Fittings

Couplings shall have a housing fabricated in at least [two] [_____] parts of [malleable] [ductile] iron castings. Coupling gasket shall be molded synthetic rubber conforming to requirements of ASTM D2000. Coupling bolts shall be oval-neck track-head type 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, fabricated fittings may be used.

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

2.3.5 Pressure Gages

Pressure gages shall conform to ASME B40.100. Pressure gages shall be Type I, Class 1, (pressure) for pressures indicated. Pressure gage size shall be 90 millimeter 3-1/2 inches nominal diameter. Case shall be corrosion-resistant steel conforming to [the AISI 300 series] [ASTM A666] with an ASM No. 4 standard commercial polish or better. Equip gages with damper screw adjustment in inlet connection.

[Equip gages with an adjustable, red marking indicator.

] 2.3.6 Thermometers

Thermometers shall conform to ASTM E1. Thermometers shall be industrial pattern Type I, Class 3. All thermometers installed [1830] millimeter [6] feet [_____] or higher above the floor shall have an adjustable angle body. Scale shall be not less than [178] millimeter [7] inches [_____] long, and case face shall be [manufacturer's standard polished aluminum] [AISI 300 series polished corrosion-resistant steel]. Thermometer range shall be as required for service, and provided with nonferrous separable wells.

2.3.7 Line Strainers

Strainers shall be [Y-type] [T-type grooved end] with removable basket. Strainers in sizes DN50 2 inch ips and smaller shall have screwed ends and in sizes DN65 2-1/2 inch ips and larger shall have flanged ends. Body working pressure rating shall exceed maximum service pressure of system in which installed by at least 50 percent. Body shall have cast-in arrows to indicate direction of flow. Strainer bodies fitted with screwed screen retainers shall have straight threads and gasketed with nonferrous metal. Strainer bodies fitted with bolted-on screen retainers shall have offset blowdown holes. Fit strainers larger than DN65 2-1/2-inches with manufacturer's standard blowdown valve. Body material shall be [cast bronze conforming to ASTM B62] [cast iron conforming to ASTM A278/A278M Class 30] [ductile iron conforming to ASTM A536]. Where system material is nonferrous, strainer body material shall be nonferrous.

Minimum free-hole area of strainer element shall be equal to not less than [3.4] [_____] times the internal area of connecting piping. Strainer screens for air service shall have mesh cloth not to exceed [0.15] millimeter [0.006] inch [_____] . Strainer screens shall have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material shall be [AISI Type [304] [316] corrosion-resistant steel] [Monel metal].

2.4 AIR COMPRESSORS

Provide an air compressor of the standard piston type complete with air tank, [air dryer,] and other appurtenances. Compressor and installation shall conform to ASME B19.3. Compressor capacity shall be 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. [Air dryers shall be of the [continuous duty silica-gel type with reactivation] [mass refrigerated dryer type] and shall maintain the air in the system with a dew point low enough to prevent condensation minus 11 degrees C at 124 kilopascal 13 degrees F at 18 psi main pressure. Locate air dryer at the outlet of the tank.] Control air delivered to the system shall conform to ISA 7.0.01.

2.5 VALVES

2.5.1 Ball Valves (BAV)

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

Grooved end ball valves may be used provided that the manufacturer certifies valve performance in accordance with MSS SP-72.

Rate valves for service at not less than [1207] [_____] kilopascal at [93] [_____] degrees C [175] [_____] psi at [200] [_____] degrees F.

Valve bodies in sizes DN50 2 inch ips and smaller shall be screwed end connection type constructed of Class A copper alloy.

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

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

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

Design valves for flow from either direction and seal equally tight in either direction.

Valves shall have full pipe size flow areas.

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

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

2.5.2 Butterfly Valves (BUV)

Butterfly valves shall conform to MSS SP-67.

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

Butterfly valves shall be wafer type for mounting between specified flanges and rated for 1034 kilopascal 150-psig shutoff and nonshock working pressure. Body shall be cast ferrous metal 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.

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

Valve boxes shall be of not less than [4.7] millimeter [3/16] inch [_____] thick cast-iron construction with locking cover with an appropriate identification legend. Boxes shall be adjustable extension type with [screw] [slide-type] adjustment. Fit valves DN80 3 inches and under with 108 millimeter 4-1/4 inch diameter shaft and valves DN100 4 inches and fit larger with 133 millimeter 5-1/4 inch shaft. Fit bases to the valve. Box full-extended length shall be greater than required by depth of cover by not less than 100 millimeter 4 inches. Supply one valve operating wrench for each size of valve wrench nut. Provide guide rings where operating rods are longer than 1830 millimeter 6 feet. Coat internal and external surfaces with bituminous sealer conforming to AWWA C104/A21.4.

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

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

Fabricate shafts from [AISI 300 series] [17-4 PH corrosion-resistant steel] [nickel copper alloy conforming to ASTM B164] and may be [one-piece] [stub-shaft] type. Extend stub shafts into the disk hub at least 1-1/2 shaft diameters except for angle disk construction. Design connection between the valve shaft and disk to transmit shaft torque equivalent to not less than [75] [_____] percent of the torsional strength of the minimum required shaft diameter. Minimum nominal shaft diameter for all valves shall be in accordance with the following:

VALVE SIZE (DN) <u>MILLIMETER</u>	SHAFT DIAMETER <u>MILLIMETER</u>	VALVE SIZE <u>MILLIMETER</u>	SHAFT DIAMETER <u>MILLIMETER</u>
65	11	250	28
80	13	300	32
100	15	356	38

VALVE SIZE (DN) <u>MILLIMETER</u>	SHAFT DIAMETER <u>MILLIMETER</u>	VALVE SIZE <u>MILLIMETER</u>	SHAFT DIAMETER <u>MILLIMETER</u>
125	17	406	41
150	19	457	47
200	22	508	54
VALVE SIZE <u>INCHES</u>	SHAFT DIAMETER <u>INCHES</u>	VALVE SIZE <u>INCHES</u>	SHAFT DIAMETER <u>INCHES</u>
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

Seats and seals shall be resilient elastomer type, designed for field removal and replacement. Elastomers shall be [Buna-N] [ethylene propylene terpolymer] [chloroprene] [_____] formulated for continuous immersion service at [107] degrees C [225] degrees F [_____] minimum and shall be applied at least [10] [_____] percent below maximum continuous service temperature. Bonding adhesives shall comply with elastomer temperature requirements and shall have an effective life equal to or greater than the elastomer.

Design seals on DN500 20 inch and smaller valves to use [standard split V packing] [dual O-rings] [quad rings] [the adjustable pulldown type].

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

Seat or disk mating surfaces shall be of corrosion-resistant material. These materials shall be [welded to substrate and ground] [mechanically retained]. Plated or similarly applied surfacing materials shall not be acceptable.

Ensure bearings are permanently lubricated sleeve type of [manufacturer's standard corrosion-resistant steel] [bronze] [nickel-copper alloy] [nylon] [filled tetrafluoroethylene]. Design bearings 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 operating end of the shaft with [dual inboard bearings] [a single inboard and an outboard bearing in or beyond the operator].

Provide padlocking feature to make valve tamperproof.

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

Provide manual nonchain-operated valves through DN200 8 inches with not less than nine-position lever lock handles not exceeding [457] millimeter

[18] inches [_____] in length.

Provide manual valves DN250 10 inches and larger, or smaller if the application torque exceeds a pull of [108] newton-meter [80] pounds [_____] , with gear operators.

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

Gear operators shall be worm-gear type. Totally enclose operator in a cast iron housing suitable for grease or oil lubrication. Gears shall be "hobcut." Cast-iron-housed traveling-nut operators shall conform to AWWA C504. Size operators to provide the required torque, static or dynamic, 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 shall not exceed [85] [_____] percent of rated operator capacity.

2.5.3 Diaphragm Control and Instrument Valves (DCIV)

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

2.5.4 Gage Cocks (GC)

Gage cocks shall be T-head or lever handle ground key type with washer and screw, constructed of polished ASTM B62 bronze, and rated for 862 kilopascal 125 psi saturated steam service. End connections shall suit the service, with or without union and nipple.

2.5.5 Gate Valves (GAV)

Gate valves DN50 2 inches and smaller shall conform to MSS SP-80. Ensure packing is woven non-asbestos material impregnated with not less than [25] [_____] percent, by weight, tetrafluoroethylene resin. Packing shall be woven non-asbestos material impregnated with not less than [25] [_____] percent, by weight, tetrafluoroethylene resin.

Gate valves DN65 2-1/2 inches and larger shall be Type I, Class 1, conforming to MSS SP-70. Valves shall be flanged, with bronze trim and outside screw and yoke (OS&Y) construction. Ensure packing is woven non-asbestos material impregnated with not less than [25] [_____] percent, by weight, tetrafluoroethylene resin.

2.5.6 Globe and Angle Valves (GLV and ANV)

Globe and angle valves DN50 2 inches and smaller shall conform to MSS SP-80. Valves located in tunnels, equipment rooms, or factory-assembled equipment, shall be union-ring bonnet, screwed-end type. Disk shall be free to swivel on the stem in all valve sizes. Composition seating surface disk construction may be substituted for all metal disk construction. Packing shall be a woven material impregnated with not less than 25 percent, by

weight, tetrafluoroethylene resin.

Globe and angle valves DN65 2-1/2 inches and larger shall conform to MSS SP-80. Valve bodies shall be cast iron conforming to ASTM A126, Class A, as specified for Class 1 valves under MSS SP-70. Flange valve ends in conformance with ASME B16.1, and valve construction shall be OS&Y type. Packing shall be a woven material impregnated with not less than 25 percent, by weight, tetrafluoroethylene resin.

2.5.7 Eccentric Plug Valves (EPV)

Eccentric plug valves in sizes DN50 2 inches and smaller shall be [constructed of manufacturer's standard brass] [bronze materials conforming to [ASTM B61] [ASTM B62]] [cast iron conforming to ASTM A126, Class B]. Ensure valves are rated for service at 1207 kilopascal 175 psi maximum nonshock pressure at 93 degrees C 200 degrees F.. Valve body shall have [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.

Construct eccentric plug valves in sizes DN65 2-1/2 inches and larger of [Type 2 nickel alloy iron conforming to ASTM A436] [cast iron conforming to ASTM A126]. Ensure valves are rated for service at 1207 kilopascal 175-psi maximum nonshock pressure at 93 degrees C 200 degrees F.. Valve body shall have [screwed] [grooved] ends. Coat eccentric plug surfaces with a 60 to 70 Shore A durometer hardness elastomer resistant to compressed air. For specified applications, in sizes to DN125 5 inch ips, cross-sectional area of valve bore, when open, shall equal pipe inlet area. Valves used for combination shutoff and balancing service shall be fitted with a memory device. Memory device or mechanism shall permit a valve set at a balance point to be opened or closed, but not beyond the balance point. Fit valves up to DN150 6 inch ips with removable lever operator. Valves DN150 6 inch ips and larger shall be fitted with totally enclosed flood-lubricated worm gear drive such that operating torque does not exceed [67] [_____] newton per meter [50] [_____] foot-pounds.

2.6 MISCELLANEOUS MATERIALS

2.6.1 Bolting

Flange and general-purpose bolting shall be hex-head and shall conform to ASTM F568M, Class 4.8 or above ASTM A307, Grade B. Heavy hex-nuts shall conform to ASTM A563M ASME B18.2.2. Square-head bolts shall not be acceptable.

Grooved couplings shall utilize bolts and nuts of heat treated carbon steel conforming to ASTM A183.

2.6.2 Elastomer Caulk

[Polysulfide] [polyurethane base] elastomer caulking material shall be a two-component type conforming to ASTM C920.

2.6.3 Escutcheons

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

Escutcheons shall be [one-piece] [split-pattern] type. Escutcheons shall maintain a fixed position against a surface by means of internal spring tension devices or setscrews.

2.6.4 Flashing

Sheet lead shall conform to ASTM B749, Grade [B] [C] [D] and weigh not less than [19] [_____] kilogram per square meter [4] [_____] pounds per square foot.

Sheet copper shall conform to ASTM B370 and weigh not less than [16] [_____] ounces per square [4.88] [_____] kilogram per square meterfoot.

2.6.5 Flange Gaskets

Compressed non-asbestos sheet shall conform to ASTM F104, Type 1, and be coated on both sides with [graphite] [_____] .

Grooved flange adapters gasketing shall be a pressure responsive elastomer conforming to ASTM D2000.

2.6.6 Pipe Thread Compounds

Use tetrafluorethylene tape not less than [0.05] [0.08] millimeter [2] [3] mils thick in compressed air systems for pipe sizes to and including DN25 1 inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for other applications upon approval by the Contracting Officer.

2.7 SUPPORTING ELEMENTS

Contractor shall provide all necessary piping system components and miscellaneous required supporting elements. Supporting elements shall be 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.

Supporting elements shall be [FM-approved] [UL-listed] and conform to requirements of ASME B31.3, MSS SP-58, and MSS SP-69, except as otherwise noted. Type devices specified herein are defined in MSS standards unless otherwise noted.

2.7.1 Building Structure Attachments

Concrete and masonry anchor devices shall conform to requirements of FS FF-S-325 Group [I] [II], Type 2, Class 2, Style [1] [2]; Group [III] [VIII] .

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

Masonry anchor devices shall be built-in, unless otherwise approved by the Contracting Officer.

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

Beam clamps shall be 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 single or accumulated load and resultant moment on structural steel.

[Do not use C-clamps.]

[Use clamps to support piping sizes DN40 1-1/2 inches and smaller. C-clamps shall be FM approved and UL listed with hardened cup tip, setscrew, locknut, and retaining strap. Retaining strap section shall be not less than [3 by 25] millimeter [1/8 by 1] inch [_____]. Beam flange thickness to which clamps are attached shall not exceed 15 millimeter 0.60 inch.

Construct concrete inserts in accordance with the requirements of MSS SP-58, for Type 18 and MSS SP-69. When applied to piping in sizes DN50 2 inch ips and larger and where otherwise required by imposed loads, a 305 millimeter length of 13 millimeter 1-foot length of 1/2 inch reinforcing rod shall be inserted and wired through wing slots. Approved proprietary-type continuous inserts may be similarly used upon approval by the Contracting Officer.]

2.7.2 Horizontal Pipe Attachments

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

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

Piping in sizes larger than DN200 8 inch ips shall be supported with Type [41] [49] pipe rolls.

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

2.7.3 Vertical Pipe Attachments

Vertical pipe attachments shall be Type 8.

2.7.4 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.

2.7.5 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, such supplementary steel shall be designed and fabricated in accordance with AISC 360.

PART 3 EXECUTION

3.1 UNDERGROUND PIPING SYSTEM INSTALLATION

3.1.1 Compressed Air System Installation

Perform installation of compressed air systems in accordance with the manufacturer's instructions. Installation shall be in the presence of the Contracting Officer who shall be notified by the Contractor [48] [_____] hours in advance of the work.

Excavations shall be in accordance with Section 31 00 00 EARTHWORK.

Piping shall be laid beginning at the low point of a system, and when in final position, shall be true to the grades and alignment with unbroken continuity of invert.

[Do not permit blocking and wedging.

] Pipes passing through walls below grade and ground floor slab shall pass through pipe sleeves.

In fill areas, pipe passing under or through building grade beams shall have a minimum of [100] millimeter [4] inches [_____] clearance in all directions.

Where pipe penetrates earth or concrete grade, not less than [300] millimeter [12] inches [_____] of polyethylene-coated Type BCS-PS pipe shall be exposed to view.

Install Type BCS-PS materials in accordance with the applicable requirements for underground piping and aboveground piping. Pipe shall be palletized in padded pallets at the factory and shall be handled from pallet to final position with padded gear. Protect surfaces from the sun with black polyethylene sheeting. Prior to being lowered into a trench, check sheathing for continuity with 10,000 volts applied by a continuity detector. In the trench, after joints and fittings are made, check previously untested surfaced for continuity. Where discontinuities in thermoplastic are found, not less than [0.30] millimeter [12] inches [_____] of material upstream and downstream of fault shall be discarded.

[After valves, valve operators, and valve boxes have been inspected and not less than [48] [_____] hours prior to being lowered into a trench, coat external surfaces with a compatible bituminous coating for protection against brackish ground water. Application shall be single coat in accordance with the manufacturer's instructions, and shall result in a dry-film thickness of not less than [0.30] millimeter [12] mils [_____].

]3.1.2 Valve Boxes

Valves and valve boxes shall be set plumb. Center valve boxes on the valves.

[Provide concrete slabs 100 millimeter 4 inches thick to protect valve boxes.

]3.2 ABOVE GROUND PIPING SYSTEM INSTALLATION

3.2.1 Piping Systems

Fabricate and install piping systems in accordance with ASME B31.3, MSS SP-69, ASME BPVC, and applicable AWS requirements.

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

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

Pipe, tubing, fittings, valves, equipment, and accessories shall be clean and free of all foreign material before being installed in their respective systems. Clean pipe by a method approved by the Contracting Officer. Purge lines with dry, oil-free compressed air after erection, but purging shall not be relied upon for removing all foreign matter. Purge lines at a velocity equal to 1-1/2 times maximum normal flow velocity. During the progress of construction, protect open ends of pipe, fittings, and valves at all times to prevent the admission of foreign matter. Except when connections are actually underway, install plugs or caps on all pipe and component openings. Plugs or caps shall be 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. No mitered joints or unapproved pipe bends shall be permitted.

Pipe bends in seamless pipe may be made with hydraulic benders in the field for pipe sizes to DN100 4 inch ips, upon approval of the Contracting Officer. Radius of pipe bends shall be not less than [five] [_____] nominal pipe diameters.

Tee connections shall be made with screwed tee fittings or grooved tee fittings, or, where pipe is being welded, branch connections shall be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitations. Branch outlet fittings shall be 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.

Horizontal piping shall have 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. Pipe drains shall consist of DN15 1/2 inch globe valves with renewable disks and 20 millimeter 3/4 inch hose adapter.

Perform installation of piping in a manner that will prevent stresses and strains from being imposed on connected equipment.

Make expansion bends in steel pipe from pipe sections and long-radius welding elbows in sizes DN25 1 inch and larger. Expansion U-bends shall be cold sprung and welded into the line. Anchor line before removing the spreader from the expansion U-bend.

3.2.2 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 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. Clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system. Flange faces shall be parallel and the bores 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 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, the raised face shall be machined to a smooth matching surface, and a full facegasket shall be used. After the piping system has been tested and is in service at its maximum temperature, bolting shall be retightened. Only use hex-head nuts and bolts. Gasket material shall be fresh stock, 1.6 millimeter 1/16 inch thick.

Field welded joints shall conform to the requirements of the AWS-03 and ASME B31.3.

Copper tubing for solder joints shall be cut square, and burrs shall be removed with approved cutting and reaming tools. Clean inside surfaces of fittings and outside surfaces of tubes in joint area before assembly of joint. Apply joint flux, solder, and heat source in accordance with the manufacturer's instructions to provide proper capillary action to fill the socket space and to achieve 100 percent of shear-line strength capability. Valves in copper piping shall 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.

Tubing for mechanical joints shall be cut square, and burrs shall be removed. Exercise care to avoid work-hardened copper surfaces and cut off or anneal tube ends. Heating temperature and air-cooling shall be in accordance with the manufacturer's instructions.

3.2.3 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 anneal copper in concealed locations.

Fittings for supply system copper tubing shall be wrought copper solder joint-type, except at connection to apparatus where specified brass mechanical and ips thread adapter fittings shall be 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:

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.

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

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

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

Routing has prior approval of the Contracting Officer.

Plastic tubing installed inside or behind control panels shall be [color coded] [number coded]. Neatly tie and support tubing. Flexible connections bridging the cabinet and its door shall be neatly fastened along the hinge side and protected against abrasion.

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

] Mechanically attach tubing to supporting surfaces. Supports using adhesives shall not be acceptable.

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

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

-] [Use 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.
-] Copper-tubing runs imbedded in concrete shall be annealed and protected by [metallic] [plastic] electric conduit.

Copper-tubing runs in soil shall be jointless and protected from brackish ground water and leaching concrete alkali by 0.30 millimeter 12-mil thick [bituminous coating] [equivalent polyvinylchloride (PVC) tape wrapping].

Make tubing penetrations of concrete surfaces through minimum DN25 1 inch ips, Schedule 40, rigid unplasticized PVC pipe sleeves, except that multitube harness 40 millimeter 1-1/2-inches outside diameter and larger need not have additional protection. Sleeve shall extend [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 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 system of impurities [generated during joint-making and installation] and atmospheric moisture before connection to control instruments.

3.2.4 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 DN65 2-1/2 inches and larger. Tap and fit shutoff valve body with a DN15 1/2 inch plugged globe valve.

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

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

3.2.5 Bypass Throttling Valves

Valves shall be globe type with [metallic] [composition disc].

3.2.6 Supporting Elements Installation

Provide support elements in accordance with the requirements of ASME B31.1, MSS SP-58, MSS SP-69. Hang piping from building construction. No piping shall be hung from roof deck or from other pipe.

Attachment to building construction concrete shall be by approved cast-in

concrete inserts wherever possible. Attachment to building construction solid masonry shall be by built-in anchors. Where attachment by either of above methods is not possible, specified masonry anchor devices may be used upon receipt of 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.

Construct masonry anchors selected for overhead applications of ferrous materials only.

Install masonry anchors conforming to FS FF-S-325 [Group I] [Group II, Type 2, Class 2, Style [1] [2]]; [Group VIII] in rotary, nonpercussion, electric drilled holes. Group III self-drilling anchors may be used provided masonry drilling is done with electric hammers selected and applied in a manner that will preclude concrete spalling or cracking both visible or invisible. Pneumatic tool use is not allowed.

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

For nominal anchor device sizes M6 through M14 1/4- through 1/2 inch, the tool shall be hammer type only or combination rotary-hammer type and shall be rated at load to draw not more than 5.0 amperes when operating on 120-volt, 60-hertz power.

For nominal anchor device sizes M16 5/8 inch and larger, the hammer type only tool shall be rated at load to draw not more than 8.0 amperes when operating on 120-volt, 60-hertz power. Combination rotary hammer tools on the same power supply shall have a full-load current rating not to exceed 10 amperes.

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 not less than twice the overall length of the device and locate them not less than the following applicable distance from any side or end edge or centerline of adjacent anchor service:

<u>Anchor Bolt Length (Millimeter)</u>	<u>Minimum Edge Space (Millimeter)</u>
6	90
8	95
10	100
14	125
16	150
20	175
22	200
<u>Anchor Bolt Length (Inches)</u>	<u>Minimum Edge Space (Inches)</u>
1/4	3-1/2
5/16	3-3/4
3/8	4
1/2	5

<u>Anchor Bolt Length (Inches)</u>	<u>Minimum Edge Space (Inches)</u>
5/8	6
3/4	7
7/8	8

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

Piping shall run 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 will be not less than [13] millimeter [1/2] inch [_____] of clear space between the finished surface and other work and between the finished surface and parallel adjacent piping. Hangers on different adjacent service lines running parallel with each other shall be arranged to be in line with each other and parallel to the lines of the building.

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

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

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

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.

Anchors incorporated in piping systems for the purpose of maintaining permanent pipe positions shall be welded to the piping and attached to the building structure in a manner approved by the Contracting Officer.

Suitably brace piping against sway and vibration. Bracing shall consist of brackets, anchor chairs, rods, and structural steel for vibration isolation.

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

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

Purlins used for supporting fire protection sprinkler lines, electrical lighting fixtures, or electrical power duct or cable tray shall be considered fully loaded, and supplemental reinforcing for these purlins or

auxiliary support steel shall be furnished and installed by the Contractor.

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.

Load rating for all pipe hanger supports shall be based on weight and forces imposed on all lines. Deflection per span shall not exceed slope gradient of pipe. Schedule 40 and heavier pipe supports shall be in accordance with the following minimum rod size. Maximum allowable hanger spacing and concentrated loads will reduce allowable span proportionately:

<u>PIPE SIZE (DN)</u> <u>MILLIMETER</u>	<u>ROD SIZE</u> <u>MILLIMETER</u>	<u>STEEL PIPE</u> <u>MILLIMETER</u>
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
<u>PIPE SIZE</u> <u>INCHES</u>	<u>ROD SIZE</u> <u>INCHES</u>	<u>STEEL PIPE</u> <u>FEET</u>
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 intervals specified and guide 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 DN50 2 inches and smaller and at not more than 6100 millimeter 20-foot intervals for pipe DN65 2-1/2 inches and larger.

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

3.2.7 Sound Stopping

Provide effective sound stopping and adequate operating clearance to prevent structure contact where piping penetrates walls, floors, or ceilings, into occupied spaces adjacent to equipment rooms, where similar penetrations occur between occupied spaces, and where penetrations occur from pipe chases into occupied spaces. Occupied spaces includes space above ceilings where no special acoustic treatment of ceiling is provided. Penetrations shall be finished to be compatible with surface being penetrated.

Sound stopping provisions shall be essentially the materials and procedures specified under "Sleeves" in this section.

- [Sound stopping and vapor barrier sealing of pipe shafts and large floor and wall openings shall be accomplished by packing to high density with properly supported mineral fiber 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 not less than [150] millimeter [6] inches [____]. Finish foam with a rasp. Vapor barrier shall be not less than [3] millimeter [1/8] inch [____] thickness of vinyl coating applied to visible and accessible surfaces. Where high temperatures and fire-stopping are a consideration, only mineral fiber shall be used and openings shall, in addition, be covered with [1.6] millimeter [16]-gauge [____] sheet metal.
-] All mineral materials shall conform to requirements specified under "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.

3.2.8 Sleeves

Sleeves are required where piping passes through roofs, through masonry or concrete walls, or through floor.

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

Where pipe sleeves are required after slabs and masonry are installed, holes to accommodate these sleeves shall be made with core drills. Set 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.

Sleeves shall be flush with all ceilings.

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

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

Sleeves extending through floors, roofs, and load bearing walls, and sleeves through fire barriers shall be continuous and fabricated 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. Diameter of sleeves shall be large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and provide a minimum [10] millimeter [3/8] inch [_____] clearance. Sleeve size shall accommodate mechanical and thermal motion of pipe to preclude transmission of vibration to walls and generation of noise.

Space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration shall be packed solid with a mineral fiber conforming to ASTM C592, Form B, Class 8. Wherever 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, similar packing shall be provided. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration shall be filled with an elastomer caulk to a depth of [13] millimeter [1/2] inch [_____]. Surfaces to be calked shall be oil- and grease-free.

Exterior wall sleeves shall be [calked watertight with lead and oakum] [made watertight with mechanically expandable chloroprene inserts with mastic sealed metal components].

Sleeve height above roof surface shall be [300] millimeter [12] inches [_____].

3.2.9 Escutcheons

Provide escutcheons at 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. Provide plates at the underside only of such ceilings, where suspended ceilings are installed. Plates shall be large enough to fit around the insulation, for insulated pipes. Escutcheons shall be chrome-plated in occupied spaces and shall be of sufficient size to conceal openings in building construction. Firmly attach escutcheons with setscrews.

3.2.10 Flashings

Provide required flashings at mechanical systems penetrations of building boundaries.

3.3 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.

- [Testing shall be done 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 his own purposes, but preliminary testing and the acceptance test shall be conducted as specified.

] 3.3.1 Preliminary Stage Tests

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

- [Tests shall be pneumatic and shall use dry, oil-free compressed air. Use carbon dioxide or nitrogen in metallic systems.
-] [Testing of any system for any purpose shall include preliminary testing by swabbing joints under test with standard high-strength film soap solution and observing for bubbles at internal pressures not in excess of 35 kilopascal 5 psi.
-] 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. Published safe test pressure rating of any plug used shall be not less than 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 piping systems to be tested.

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

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

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

Duration of a test will be 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.

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

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

- [Tests shall be hydrostatic. Only use potable water for testing. Government will supply testing water at a location determined by the Contracting Officer. Contractor shall be responsible for approved disposal of contaminated water. Temperature of water used for testing shall not be 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 any 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.
-] [Irrespective of the amount of measured leakage, immediately repair visible leaks or defects in the pipeline.

] 3.3.2 Test Gages

Contractor's test gages shall conform to ASME B40.100 and have a dial size of 200 millimeter 8 inches or larger. Maximum permissible scale range for a given test shall be such that the pointer during a test shall have a starting position at midpoint of the dial or within the middle third of the scale range. Certification of accuracy and correction table shall bear a date within [90] [_____] calendar days prior to test use, test gage number, and the project number, unless otherwise approved by the Contracting Officer.

3.3.3 Acceptance Pressure Testing

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

Test ferrous piping systems at [1-1/2] [_____] times maximum operating pressure. Maintain test pressure for a period of not less than [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 test pressure for a period of not less than [24] [_____] hours with essentially no pressure drop during that time.

3.4 COMPRESSED AIR SYSTEM 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. Degreased waste material including the degreaser itself shall be disposed

of 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.

3.5 COMPRESSED AIR SYSTEMS IDENTIFICATION

Identification plates shall be protected and kept 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. Also label each riser.

In long straight runs, locate labels at distances visible to each other, but in no case shall the distance between labels exceed [22860] millimeter [75] feet [_____]. Labels shall be legible from the primary service and operating area.

-- End of Section --