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NASA-15211 (May 2005)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Superseding NASA-15211 (March 2005)

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DIVISION 15 - MECHANICAL

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LOW-PRESSURE COMPRESSED AIR SYSTEMS

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SECTION 15211

LOW-PRESSURE COMPRESSED AIR SYSTEMS
05/05

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

This section covers aboveground and underground piping systems and certain components with pressure ratings of 125 pounds per square inch, gage 862 kilopascal and less, using existing air supply.

Drawings shall show size, rating, or other details of piping requirements for specific project application not covered in the specifications.

Drawings must use symbols or legends indicated herein adding proper suffix where provided. For example, "4-(inch) 100 millimeter Type BCS-PS."

Drawings must indicate underground piping requiring supports from slabs.

****

PART 1 GENERAL

1.1 REFERENCES

****

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

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

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 350	(1999) Load and Resistance Factor Design (LFRD) Specification for Structural Steel Buildings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A112.18.1M	(1996) Plumbing Fixture Fittings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2003) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C504	(2000) Standard for Rubber-Seated Butterfly Valves

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.8	(1991; 8th Ed) Welding Handbook; Volume Two - Welding Processes
AWS-03	(2001) Welding Handbook, Volumes 1 thru 5

ASME INTERNATIONAL (ASME)

ASME B16.1	(1998) Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.22	(2002) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.3	(1998) Malleable Iron Threaded Fittings Classes 150 and 300
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B16.5	(2003) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24
ASME B16.9	(2001) Factory-Made Wrought Steel Buttwelding Fittings
ASME B18.2.2	(1987; R 1999) Square and Hex Nuts
ASME B19.3	(1991) Safety Standard for Compressors for Process Industries
ASME B31.1	(2001) Power Piping
ASME B31.3	(2002) Process Piping
ASME B40.100	(1998) Pressure Gauges and Gauge Attachments
ASME BPVC	(2001) Boiler and Pressure Vessel Code
ASME BPVC SEC VIII D1	(2001) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASTM INTERNATIONAL (ASTM)

ASTM A 126/A 126M	(1995) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A 181/A 181M	(2001) Standard Specification for Forgings, Carbon Steel, for General-Purpose Piping
ASTM A 183	(2003) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A 197/A 197M	(2000) Standard Specification for Cupola Malleable Iron
ASTM A 216/A 216M	(1993; R 2003) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A 234/A 234M	(2003) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperatures
ASTM A 278	(1993) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 Degrees F
ASTM A 278M	(2001) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 345 Degrees C (Metric)
ASTM A 307	(2004) Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 395	(1988) Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A 395M	(1999e1) Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures (Metric)
ASTM A 436	(1984; R 2001) Standard Specification for Austenitic Gray Iron Castings
ASTM A 53/A 53M	(2002) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 536	(1994) Standard Specification for Ductile Iron Castings
ASTM A 563M	(2003) Standard Specification for Carbon and Alloy Steel Nuts (Metric)

ASTM A 666	(2003) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B 148	(1997; R 2003) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B 164	(2003) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B 280	(2003) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B 370	(2003) Standard Specifications for Copper Sheet and Strip for Building Construction
ASTM B 584	(2000) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B 61	(2002) Standard Specification for Steam or Valve Bronze Castings
ASTM B 62	(2002) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 749	(2003) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C 592	(2000) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C 920	(2002) Standard Specification for Elastomeric Joint Sealants
ASTM D 1693	(2001) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D 2000	(2003a) Standard Classification System for Rubber Products in Automotive Applications
ASTM D 2239	(2003) Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR), Based on Controlled Inside Diameter
ASTM E 1	(2003a) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM F 104	(2003) Standard Classification System for Nonmetallic Gasket Materials
ASTM F 568M	(2004) Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

ISA - THE INSTRUMENTATION, SYSTEMS AND AUTOMATION SOCIETY (ISA)

ISA S7.0.01	(1996) Quality Standard for Instrument Air

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

MSS SP-58	(2002) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-67	(2002) Butterfly Valves
MSS SP-69	(2002) Pipe Hangers and Supports - Selection and Application
MSS SP-70	(1998) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-72	(1999) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2003) Bronze Gate, Globe, Angle and Check Valves

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

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

1.2 GENERAL REQUIREMENTS

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NOTE: If Section 15003, "General Mechanical Provisions," is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.
****

Section 15003, "General Mechanical Provisions," applies to work specified in this section.

1.3 SUBMITTALS

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

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

SD-02 Shop Drawings

Installation Drawings shall be submitted 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

Equipment and Performance Data submitted for piping systems.

Manufacturer's catalog data shall be submitted 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

Design Analysis and Calculations for low-pressure compressed air systems shall be submitted 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

Test reports shall be submitted 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

Certificates shall be submitted 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

Operation and Maintenance Manuals shall be submitted in accordance with paragraph entitled, "Operation and Maintenance," of this section.

1.4 GENERAL REQUIREMENTS

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NOTE: If Section 15055, "Welding Mechanical," is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.
****

Section 15055, "Welding Mechanical," 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. Data shall be updated and resubmitted for final approval no later than [30] [_____] calendar days prior to contract completion.

1.6 DRAWINGS

Installation drawings shall be submitted 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.

Complete shop drawing data for pipe attachments shall be submitted 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.

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 125 pounds per square inch gage 862 kilopascal 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 A 53/A 53M, Type [E] [S], in sizes through 10 inch DN250 iron pipe size (ips). Pipe in size 12 inches DN300 and larger shall have Schedule 40 wall. Pipe wall shall be 0.375 inch 10 millimeter thick.

Thermoplastic sheath shall conform to FS L-C-530. Sheath joints shall be made with thermally fitted shrinking sleeves applied with factory-approved shrinking devices. Taped fitting protection and repairs shall be made 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 A 234/A 234M and ASME B16.9 to match pipe wall thickness. Bending of pipe shall not be permitted. Aboveground terminal fittings shall be 150-pound 1034 kilopascal working steam pressure (wsp) forged steel weld neck flanges to match wall thickness, conforming to ASME B16.5 and ASTM A 181/A 181M Class 60.

2.2 ABOVEGROUND PIPING MATERIALS

2.2.1 Compressed Air Systems 125 Psig 862 Kilopascal and Less

2.2.1.1 Type BCS Black Carbon Steel

Pipe 1/8 through 1-1/2 inches DN6 through DN40 shall be Schedule 40, furnace butt welded, black carbon steel, conforming to ASTM A 53/A 53M, Type F, Grade B.

Pipe 2 through 10 inches DN50 through DN250 shall be Schedule 40, [seamless] [electric resistance welded], black carbon steel, conforming to ASTM A 53/A 53M, Grade B, Type [E] [S]. Grade A pipe should be used for

permissible field bending.

Pipe 12 inches DN300 and over shall be 0.375 inch 10 millimeter wall, [seamless, black carbon steel, conforming to ASTM A 53/A 53M, Grade B, Type [E] [S]].

Fittings 2 inches DN50 and under shall be 150-pounds per square inch, gage (psig) 1034 kilopascal gage wsp, banded, black malleable iron, screwed, conforming to ASTM A 197/A 197M and ASME B16.3.

Unions 2 inches 50 millimeter and under shall be 250-psig 1724 kilopascal gage wsp, female, screwed, black malleable iron, with brass-to-iron seat and ground joint conforming to ASME B16.39, ductile iron conforming to ASTM A 536 for grooved pipe couplings.

Couplings 2 inches DN50 and under shall be [standard weight, screwed, black carbon steel] [ductile iron conforming to ASTM A 536].

Fittings 2-1/2 inches 65 millimeter and over shall be [steel, butt welded, to match pipe wall thickness, conforming to ASTM A 234/A 234M and ASME B16.9] [ductile iron conforming to ASTM A 536].

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

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

2.2.1.2 Type GCS Galvanized Carbon Steel

Pipe 1/2 through 10 inches DN15 through DN250 shall be Schedule 40, [seamless] [electric resistance welded], galvanized steel, conforming to ASTM A 53/A 53M, Grade B, Type [E] [S]. Type F is acceptable for sizes less than 2 inches DN50.

Fittings 2 inches DN50 and under shall be 150-psig 1034 kilopascal wsp, [banded, galvanized, malleable iron, screwed, conforming to ASTM A 197/A 197M, ASME B16.3] [ductile iron conforming to ASTM A 53/A 53M and ASTM A 536].

Fittings 2-1/2 inches DN65 and over shall be 125-psig 862 kilopascal wsp, cast-iron flanges and [flanged fittings, conforming to ASTM A 126/A 126M, Class A, and ASME B16.1] [ductile iron conforming to ASTM A 53/A 53M and ASTM A 536].

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

2.2.2 Control and Instrumentation Tubing, to 30 Psig 207 kilopascal

2.2.2.1 Copper

Tubing all sizes with 1/4 inch DN8 minimum outside diameter shall be [hard-drawn] [annealed] seamless copper, conforming to ASTM B 280.

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 200 pounds per square inch (psi) at 100 degrees F 1380 kilopascal at 38 degrees C.

Solder shall be 95-5 tin-antimony, alloy Sb 5, conforming to AWS WHB-2.8.

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

2.2.2.2 Polyethylene

Tubing shall be black virgin polyethylene, conforming to ASTM D 2239, Type I, Grade 2, Class C, conforming to stress-crack tests performed in accordance with ASTM D 1693. Multitube harness with polyester film barrier and vinyl jacket shall not be less than [0.062] inch [1.57] millimeter [_____] 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

Pressure reducing station shall be installed 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.

Pressure regulator body shall be constructed 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.

Filters shall be constructed 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. Bowl shall be equipped with manual drain cock. Liquid particles shall be separated by centrifugal and quiet zone action. Solid particles to 15-micrometer size shall be removed 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. Valve shall be set at not more than [20] [_____] percent more than the correct low side pressure. Valve shall be rated and labeled. 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 200 psig at 165 degrees F 1380 kilopascal at 74 degrees C.

2.3.3 Compressed Air Receivers

Compressed air receivers shall conform to the sizes and capacities specified. Such vessels shall be designed for the applicable working pressures and service in accordance with the ASME BPVC SEC VIII D1, and shall be labeled.

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 D 2000. Coupling bolts shall be oval-neck track-head type with hexagonal heavy nuts, conforming to ASTM A 183.

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

Fittings shall be fabricated from [Schedule 40] [0.375 inch10 millimeter wall], in accordance with ASTM A 53/A 53M, Grade B, seamless steel pipe. Long radius seamless welding fittings with wall thickness to match pipe, conforming to ASTM A 234/A 234M 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 3-1/2 inches 90 millimeter nominal diameter. Case shall be corrosion-resistant steel conforming to [the AISI 300 series] [ASTM A 666] with an ASM No. 4 standard commercial polish or better. Gages shall be equipped with damper screw adjustment in inlet connection.

[Gages shall be equipped with an adjustable, red marking indicator.]

2.3.6 Thermometers

Thermometers shall conform to ASTM E 1. Thermometers shall be industrial pattern Type I, Class 3. All thermometers installed [6] feet [1830] millimeter [_____] or higher above the floor shall have an adjustable angle body. Scale shall be not less than [7] inches [178] millimeter [_____] 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 shall be 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 2 inch ips DN50 and smaller shall have screwed ends and in sizes 2-1/2 inch ips DN65 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 shall be gasketed with nonferrous metal. Strainer bodies fitted with bolted-on screen retainers shall have offset blowdown holes. Strainers larger than 2-1/2-inches DN65 shall be fitted with manufacturer's standard blowdown valve. Body material shall be [cast bronze conforming to ASTM B 62] [cast iron conforming to ASTM A 278 ASTM A 278M Class 30] [ductile iron conforming to ASTM A 536]. 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 [0.006] inch [0.15] millimeter [_____]. 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

An air compressor of the standard piston type shall be provided 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 13 degrees F at 18 psi minus 11 degrees C at 124 kilopascal main pressure. Air dryer shall be located at the outlet of the tank.] Control air delivered to the system shall conform to ISA S7.0.01.

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.

Valves shall be rated for service at not less than [175] [_____] psi at [200] [_____] degrees F [1207] [_____] kilopascal at [93] [_____] degrees C.

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

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

Balls and stems of valves 2 inch ips DN50 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 2-1/2 inch ips DN65 and larger shall be manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome plate. In valves 6 inch ips DN150 and larger, balls shall be Class D with 900 Brinell hard chrome plate. Electroless nickel plating is acceptable.

Valves shall be designed for flow from either direction and shall 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 230 degrees F 110 degrees C provided the manufacturer certifies valve performance in accordance with MSS SP-67.

Butterfly valves shall be wafer type for mounting between specified flanges and shall be rated for 150-psig 1034 kilopascal shutoff and nonshock working pressure. Body shall be cast ferrous metal conforming to ASTM A 126/A 126M, Class B, and to ASME B16.1 for body wall thickness.

Valves installed in insulated piping systems shall be provided 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. Valves shall be designed and constructed for buried or 20-foot 60 kilopascal 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 [50] [_____] foot-pounds [68] [_____] newton per meter of torque. External surfaces shall be coated with bituminous sealer conforming to AWWA C104/A21.4.

Valve boxes shall be of not less than [3/16] inch [4.7] millimeter [_____] thick cast-iron construction with locking cover with an appropriate identification legend. Boxes shall be adjustable extension type with [screw] [slide-type] adjustment. Valves 3 inches DN80 and under shall be fitted with 4-1/4 inch 108 millimeter diameter shaft and valves 4 inches DN100 and larger shall be fitted with 5-1/4 inch 133 millimeter shaft. Bases shall be fitted to the valve. Box full-extended length shall be greater than required by depth of cover by not less than 4 inches. 100

millimeter. One valve operating wrench shall be supplied for each size of valve wrench nut. Guide rings shall be provided where operating rods are longer than 6 feet 1830 millimeter. Internal and external surfaces shall be coated with bituminous sealer conforming to AWWA C104/A21.4.

Disk shall be free of external ribs and shall be streamlined. Disk shall be fabricated from cast [ferrous] [nonferrous] alloys conforming to [ASTM A 126/A 126M for Class B, cast iron] [ASTM A 436 for Type [1] [2] copper free austenitic cast iron] [ASTM A 216/A 216M for Grade WCB cast steel] [ASTM A 395 ASTM A 395M and ASTM A 536 for ductile iron] [ASTM B 62] [ASTM B 584] [ASTM B 148].

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

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

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

VALVE SIZE (DN) 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

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 [225] degrees F [107] degrees C [_____] 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.

Seals on 20 inch DN500 and smaller valves shall be designed 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.

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

Padlocking feature shall be provided to make valve tamperproof.

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

Manual nonchain-operated valves through 8 inches DN200 shall be provided with not less than nine-position lever lock handles not exceeding [18] inches [457] millimeter [_____] in length.

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

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

Gear operators shall be worm-gear type. Operator shall be totally enclosed 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. Operators shall be sized to provide the required torque, static or dynamic, with a maximum manual pull of [80] pounds [108] newton-meter [_____] on the handwheel or chain wheel.

Modulating or remotely actuated two-position service valves shall be provided 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 1/4- and 3/8 inch DN8 and DN10 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 B 62 bronze, and rated for 125 psi 862 kilopascal saturated steam service. End connections shall suit the service, with or without union and nipple.

2.5.5 Gate Valves (GAV)

Gate valves 2 inches DN50 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. Packing shall be woven non-asbestos material impregnated with not less than [25] [_____] percent, by weight, tetrafluoroethylene resin.

Gate valves 2-1/2 inches DN65 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. Packing shall be 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 2 inches DN50 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 2-1/2 inches DN65 and larger shall conform to MSS SP-80. Valve bodies shall be cast iron conforming to ASTM A 126/A 126M, Class A, as specified for Class 1 valves under MSS SP-70. Valve ends shall be flanged 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 2 inches DN50 and smaller shall be [constructed of manufacturer's standard brass] [bronze materials conforming to [ASTM B 61] [ASTM B 62]] [cast iron conforming to ASTM A 126/A 126M, Class B]. Valves shall be rated for service at 175-psi 1207 kilopascal maximum nonshock pressure at 200 degrees F 93 degrees C. Valve body shall have [screwed] [grooved] ends. Eccentric plug surfaces in contact with flow shall be coated with a 60 to 70 Shore A durometer hardness elastomer resistant to compressed air.

Eccentric plug valves in sizes 2-1/2 inches DN65 and larger shall be constructed of [Type 2 nickel alloy iron conforming to ASTM A 436] [cast iron conforming to ASTM A 126/A 126M]. Valves shall be rated for service at 175-psi 1207 kilopascal maximum nonshock pressure at 200 degrees F 93 degrees C. Valve body shall have [screwed] [grooved] ends. Eccentric plug surfaces shall be coated with a 60 to 70 Shore A durometer hardness elastomer resistant to compressed air. For specified applications, in sizes to 5 inch ips DN125, 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. Valves up to 6 inch ips DN150 shall be fitted with removable lever operator. Valves 6 inch ips DN150 and larger shall be fitted with totally enclosed flood-lubricated worm gear drive such that operating torque does not exceed [50] [_____] foot-pounds [67] [_____] newton per meter.

2.6 MISCELLANEOUS MATERIALS

2.6.1 Bolting

Flange and general-purpose bolting shall be hex-head and shall conform to ASTM A 307, Grade B ASTM F 568M, Class 4.8 or above. Heavy hex-nuts shall conform to ASME B18.2.2 ASTM A 563M. Square-head bolts shall not be acceptable.

Grooved couplings shall utilize bolts and nuts of heat treated carbon steel conforming to ASTM A 183.

2.6.2 Elastomer Calk

[Polysulfide] [polyurethane base] elastomer calking material shall be a two-component type conforming to ASTM C 920.

2.6.3 Escutcheons

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

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 B 749, Grade [B] [C] [D] and shall weigh not less than [4] [_____] pounds per square foot [19] [_____] kilogram per square meter.

Sheet copper shall conform to ASTM B 370 and shall weigh not less than [16] [_____] ounces per square foot [4.88] [_____] kilogram per square meter.

2.6.5 Flange Gaskets

Compressed non-asbestos sheet shall conform to ASTM F 104, Type 1, and be coated on both sides with [graphite] [_____].

Grooved flange adapters gasketing shall be a pressure responsive elastomer conforming to ASTM D 2000.

2.6.6 Pipe Thread Compounds

Tetrafluoroethylene tape not less than [2] [3] mils [0.05] [0.08] millimeter thick shall be used in compressed air systems for pipe sizes to and including 1 inch ips DN25. 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 15072, "Vibration Isolation for Air Conditioning Equipment," for vibration isolation considerations.
****

Supporting elements shall be [FM-approved] [UL-listed] and shall 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.

Power-actuated anchoring devices shall not be used 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.
****

[C-clamps shall not be used.]

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

Concrete inserts shall be constructed in accordance with the requirements of MSS SP-58, for Type 18 and MSS SP-69. When applied to piping in sizes 2 inch ips DN50 and larger and where otherwise required by imposed loads, a 1-foot length of 1/2 inch 305 millimeter length of 13 millimeter 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 2 inch ips DN50 shall be supported by Type 6 solid malleable-iron pipe rings except that split-band-type rings may be used in sizes up to 1 inch ips DN25.

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

Piping in sizes larger than 8 inch ips DN200 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

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

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

2.7.5 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 350.

PART 3 EXECUTION

3.1 UNDERGROUND PIPING SYSTEM INSTALLATION

3.1.1 Compressed Air System Installation

Installation of compressed air systems shall be performed 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 02312, "Excavating, Backfilling, and Compacting for Utilities."

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.

[Blocking and wedging shall not be permitted.]

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 [4] inches [100] millimeter [_____] clearance in all directions.

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

Type BCS-PS materials shall be installed 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. Surfaces shall be protected from the sun with black polyethylene sheeting. Prior to being lowered into a trench, sheathing shall be checked for continuity with 10,000 volts applied by a continuity detector. In the trench, after joints and fittings are made, previously untested surfaces shall be checked for continuity. Where discontinuities in thermoplastic are found, not less than [12] inches [0.30] millimeter [_____] 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, external surfaces shall be coated 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 [12] mils [0.30] millimeter [_____].]

3.1.2   Valve Boxes

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

[Concrete slabs 4 inches 100 millimeter thick shall be provided to protect valve boxes.]

3.2   ABOVE GROUND PIPING SYSTEM INSTALLATION

3.2.1   Piping Systems

Piping systems shall be fabricated and installed in accordance with ASME B31.3, MSS SP-69, ASME BPVC, and applicable AWS requirements.

Pipe shall be fabricated to measurements established on the job and shall be carefully worked 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. Pipe shall be cleaned by a method approved by the Contracting Officer. Lines shall be purged with dry, oil-free compressed air after erection, but purging shall not be relied upon for removing all foreign matter. Lines shall be purged at a velocity equal to 1-1/2 times maximum normal flow velocity. During the progress of construction, open ends of pipe, fittings, and valves shall be protected at all times to prevent the admission of foreign matter. Except when connections are actually underway, plugs or caps shall be installed on all pipe and component openings. Plugs or caps shall be commercially manufactured products.

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

Standard long sweep pipe fittings shall be used 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 4 inch ips DN100, 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. Tool space shall be provided between parallel piping runs whenever threaded unions or couplings are installed.

Horizontal piping shall have a grade of [1 inch per 100 feet] [25.0 millimeter per 30480 millimeter] [_____].

Eccentric reducers shall be used where required to permit proper drainage of pipe lines. Bushings shall not be permitted for this purpose. Drain valves shall be provided in piping systems at low points. Pipe drains shall consist of 1/2 inch DN15 globe valves with renewable disks and 3/4 inch 20 millimeter hose adapter.

Installation of piping shall be performed in a manner that will prevent stresses and strains from being imposed on connected equipment.

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

3.2.2 Joints

Pipe ends shall be reamed before joint connections are made.

Screwed joints shall be made up with joint compound.

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

Screwed unions, welded unions, or bolted flanges shall be provided wherever required to permit convenient removal of equipment, valves, and piping Accessories from the piping system.

Flanged joints shall be assembled with appropriate flanges, gaskets, and bolting. Clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system. Flange faces shall be parallel and the bores concentric. Gaskets shall be centered on the flange faces without projecting into the bore. Bolting shall be lubricated with oil and graphite before assembly to ensure uniform bolt stressing. Flange bolts shall be drawn up and tightened in staggered sequence 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 hex-head nuts and bolts shall be used. Gasket material shall be fresh stock, 1/16 inch 1.6 millimeter 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. Inside surfaces of fittings and outside surfaces of tubes in joint area shall be cleaned before assembly of joint. Joint flux, solder, and heat source shall be applied 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. Copper joints that fail pressure tests shall be remade with new materials, including pipe or tubing fittings and filler metal.

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

3.2.3 Control and Instrument Air Tubing

Tubing shall be concealed, except in mechanical rooms or areas where other piping is exposed.

Hard-drawn copper tubing shall be used in exposed areas. Annealed copper shall not be used 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. Multiple tube runs shall be neatly nested.

[Fittings for plastic tubing shall be used 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 120 degrees F 49 degrees C 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]. Tubing shall be neatly tied and supported. 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 12 inches 300 millimeter, plastic tubing may be used. Otherwise, terminal single line shall be hard-drawn copper tubing.]

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

Copper tubing horizontal supports for less than 3 tubes shall be rigid 1-by 3/8 inch 25 by 10 millimeter 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].]

[Multiple-tube plastic harness or sheathing shall be used 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 shall be protected by [metallic] [plastic] electric conduit.

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

Tubing penetrations of concrete surfaces shall be made through minimum 1 inch ips DN25, Schedule 40, rigid unplasticized PVC pipe sleeves, except that multitube harness 1-1/2-inches 40 millimeter outside diameter and

larger need not have additional protection. Sleeve shall extend [6] inches [150] millimeter [_____] above floors and [1] inch [25] millimeter [_____] below grade surface of slabs. Where water- or vapor-barrier sealing is required, 1/2 inch 15 millimeter deep elastomer calk shall be provided to surfaces that are free from oil and other deleterious substances.

Tubing shall be systematically purged 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

Valves shall be provided 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.

Valves shall be provided in piping mains and branches at equipment and equipment items.

Riser and downcomer drains shall be provided above piping shutoff valves in piping 2-1/2 inches DN65 and larger. Shutoff valve body shall be tapped and fitted with a 1/2 inch DN15 plugged globe valve.

Three-valve bypass shall be provided around each pressure-regulating valve.

Valves unavoidably located in furred or other normally inaccessible places shall be provided with access panels.

3.2.5 Bypass Throttling Valves

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

3.2.6 Supporting Elements Installation

Supporting elements shall be provided in accordance with the requirements of ASME B31.1, MSS SP-58, MSS SP-69. Piping shall be hung 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.

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

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

Masonry anchors conforming to FS FF-S-325 [Group I] [Group II, Type 2, Class 2, Style [1] [2]]; [Group VIII] shall be installed 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 tools shall not be allowed.

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

For nominal anchor device sizes 1/4- through 1/2 inch M6 through M14, 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 5/8 inch M16 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.

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

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

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

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

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. Piping and components shall be spaced and installed so that a threaded pipe fitting may be removed between adjacent pipes and so that there will be not less

than [1/2] inch [13] millimeter [_____] of clear space between the finished surface and 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.

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

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

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

Approved pipe alignment guides, attached in an approved manner to the building structure, shall be provided 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.

Piping shall be suitably braced against sway and vibration. Bracing shall consist of brackets, anchor chairs, rods, and structural steel for Vibration Isolation.

[Pipe lines supported from roof purlins shall be located not greater than [one-sixth] [_____] of the purlin span from the roof truss. Load per hanger shall not exceed [400] pounds [1780] newton [_____] when support is from a single purlin, [800] pounds [3560] newton [_____] 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, the reinforcing of the roof purlin(s) or additional support beam(s) shall be furnished and installed. When an additional beam is used, the beam shall bear on the top chord of the roof trusses, and bearing shall be over gusset plates of top chord. Beam shall be stabilized by connection to roof purlin along bottom flange.

Purlins used 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.

Hangers and supports for piping shall be installed at intervals specified herein at locations not more than [3] feet [900] millimeter [_____] 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:

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

PIPE SIZE (DN) 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

Where possible, vertical risers shall be supported at the base at intervals specified and shall be guided for lateral stability. Clamps shall be placed under fittings wherever possible. Carbon steel pipe shall be supported at each floor at not more than 15-foot 4570 millimeter intervals for pipe 2 inches DN50 and smaller and at not more than 20-foot 6100 millimeter intervals for pipe 2-1/2 inches DN65 and larger.

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

3.2.7 Sound Stopping

Effective sound stopping and adequate operating clearance shall be provided 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 120 degrees F 49 degrees C, by foaming in place with self-extinguishing, 2-pound 0.9 kilogram density polyurethane foam to a depth not less than [6] inches [150] millimeter [_____]. Foam shall be finished with a rasp. Vapor barrier shall be not less than [1/8] inch [3] millimeter [_____] 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 [16]-gage [1.6] millimeter [_____] 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.

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

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

Sleeves shall be flush with all ceilings.

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

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

Sleeves extending through floors, roofs, and load bearing walls, and sleeves through fire barriers shall be continuous and shall be 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 shall provide a minimum [3/8] inch [10] millimeter [_____] 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 C 592, 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 calk to a depth of [1/2] inch [13] millimeter [_____]. 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 [12] inches [300] millimeter [_____].

3.2.9 Escutcheons

Escutcheons shall be provided at penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, escutcheons shall be provided on both sides of the partition. Plates shall be provided 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. Escutcheons shall be firmly attached with setscrews.

3.2.10 Flashings

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

3.3 COMPRESSED AIR SYSTEMS TESTING

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

[Testing shall be done in two stages: preliminary stage and acceptance stage, including gage tests.]

[No testing shall be performed 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. Carbon dioxide or nitrogen shall be used 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 5 psi 35

kilopascal.]

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

Other than standard piping flanges, plugs, caps and valves, only commercially manufactured expandable elastomer plugs shall be used 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, personnel shall be evacuated from areas where plugs are used.

Components that could be damaged by test pressure shall be removed from piping systems to be tested.

Valve-Operating Tests and Drainage Tests shall be performed according to referenced standards.

Piping system components, such as valves, shall be checked 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.

Test records of all piping systems tests shall be prepared and maintained. 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 potable water shall be used 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. Supplementary heat shall be provided, when necessary.]

[To preclude injury and damage, necessary precautions shall be taken 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, the system shall be drained and purged with dry air. System dryness shall be verified by hygrometer comparison with purging air.]

[Irrespective of the amount of measured leakage, visible leaks or defects in the pipeline shall be immediately repaired.]

3.3.2 Test Gages

Contractor's test gages shall conform to ASME B40.100 and shall have a dial size of 8 inches 200 millimeter 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.

Ferrous piping systems shall be tested at [1-1/2] [_____] times maximum operating pressure. Test pressure shall be maintained for a period of not less than [2] [_____] hours with an allowable pressure drop of [2] psi [14] kilopascal [_____] during that time unless otherwise approved by the Contracting Officer.

Control and instrumentation tubing systems shall be tested at [30] psi [205] kilopascal [_____]. Test pressure shall be maintained for a period of not less than [24] [_____] hours with essentially no pressure drop during that time.

3.4 COMPRESSED AIR SYSTEM CLEANING

Rust and dirt shall be removed from the bore and exterior surface of all piping and equipment. Pipeline strainers, temporary and permanent, shall be cleaned during purging operations, after startup, and immediately prior to final acceptance by the Government.

New steel piping shall be flushed and cleaned 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. Damaged and illegible identification plates shall be replaced at no additional expense.

Piping shall be labeled and arrowed 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. Each riser shall also be labeled.

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

-- End of Section --