Preparing Activity: NAVFAC Replacing without change
UFGS-15212N (August 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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HIGH AND MEDIUM PRESSURE COMPRESSED AIR PIPING
04/06

NOTE: This guide specification covers the requirements for non-breathing air compressed air systems inside of buildings with pressures up to 34,470 kPa (gage) 5000 psig.

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

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

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

NOTE: Project requirements may require supplemental information added to the paragraphs contained herein.

PART 1 GENERAL

1.1 REFERENCES

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

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

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

****

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

ANSI/AHRI 520	(2004) Performance Rating of Positive Displacement Condensing Units

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B16.20	(2017) Metallic Gaskets for Pipe Flanges
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2022) Power Piping
ASME B36.10M	(2022) Welded and Seamless Wrought Steel Pipe
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments
ASME B46.1	(2020) Surface Texture, Surface Roughness, Waviness and Lay
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for

Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A182/A182M	(2023) Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2023) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2023) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A269/A269M	(2022) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A312/A312M	(2022a) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A351/A351M	(2018) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A380/A380M	(2017) Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A403/A403M	(2022b) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM B127	(2019) Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip
ASTM B164	(2003; R 2014) Standard Specification for

	Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B165	(2019) Standard Specification for Nickel-Copper Alloy (UNS N04400)* Seamless Pipe and Tube
ASTM B564	(2022) Standard Specification for Nickel Alloy Forgings
ASTM E11	(2022) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
ASTM E381	(2022) Standard Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators

NATIONAL FLUID POWER ASSOCIATION (NFLPA)

ANSI/NFLPA T3.12.3	(1992; Rev 2) Pneumatic Fluid Power - Pressure Regulator - Industrial Type

PIPE FABRICATION INSTITUTE (PFI)

PFI ES 22	(2016) Recommended Practice for Color Coding of Piping Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 10/NACE No. 2	(2015) Near-White Blast Cleaning

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS7276	(2020; Rev J) Rings, Sealing Fluorocarbon (FKM) Rubber High-Temperature Fluid Resistant Low Compression Set 70 to 80
SAE AS4841	(2021; Rev D) Fittings, 37 Degree Flared, Fluid Connection
SAE AS4842	(2016; Rev A) Fittings and Bosses, Pipe Threaded, Fluid Connection
SAE AS4842/1	(2016; Rev A) Fittings, 37 Degree Flared to Pipe Threaded, Fluid Connection
SAE AS4843	(2016; Rev A) Fittings, Beaded, Fluid Connection
SAE AS4843/1	(2016; Rev A) Fittings, Beaded to 37 Degree Flared, Fluid Connection
SAE AS4843/2	(2016; Rev A) Fittings, Beaded to Pipe Threaded, Fluid Connection
SAE AS4875	(2016; Rev A) Fittings, Straight Threaded Boss, Fluid Connection
SAE AS4875/1	(2021; Rev B) Fittings, Straight Thread Boss or Flanged to 37 Degree Flared, Fluid Connection
SAE AS4875/2	(2016; Rev A) Fittings, Flanged to Beaded, Fluid Connection
SAE J514	(2012) Hydraulic Tube Fittings

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-C-15726	(1988; Rev F; Am 1 1991; Notice 1 2020) Copper-Nickel Alloy, Sheet, Plate, Strip, Bar, Rod, and Wire
MIL-T-16420	(1978; Rev K; Am 1 1988) Tube, Copper-Nickel Alloy, Seamless and Welded (Copper Alloy Numbers 715 and 706)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1689	(Rev B) Tape, Pressure-Sensitive Adhesive, (Plastic Film)
CID A-A-58092	(Basic; Notice 1; Notice 2) Tape, Antiseize, Polytetrafluoroethylene

CID A-A-60001	(Rev A) Traps, Steam
FS QQ-B-654	(Rev A; Notice 1; Notice 2) Brazing Alloys, Silver
FS WW-S-2739	(Basic; Notice 1; Notice 2) Strainers, Sediment: Pipeline, Water, Air, Gas, Oil, or Steam

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.219	Mechanical Power Transmission Apparatus

U.S. NAVAL SEA SYSTEMS COMMAND (NAVSEA)

QPL-24109	(2014) Valve, Globe, Angle, Quick Change Cartridge Trim, High Pressure (H.P.) Hydraulic and Pneumatic (Sizes 1/8 - 1-1/4 Inches)

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

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

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

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

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

SD-02 Shop Drawings

High Pressure Compressed Air System

SD-03 Product Data

Air Compressor

Air Dryer

Instrumentation and Controls

Air Receivers [and] [Separators]

Desiccant Air Dryers

Piping and Tubing

Fittings

Valves

Adapters

Pressure gages

Snubbers

Timed Solenoid Drain

Traps

Filters

Strainers

Unions

O-ring Gaskets

Flexible connections

Hangers and Supports

Valve box

Identification Labels For Piping

For receivers[and separators] include Manufacturer's Data Report Form U-1 or U-1A.

SD-06 Test Reports

Non-Destructive Examination (NDE) Report For Welding of Piping

Leak Tightness Test

SD-07 Certificates

Employer's Record Documents

Welding Procedures and Qualifications

SD-08 Manufacturer's Instructions

Air receivers [and] [Separators]

Include recommended certification test procedure and procedure for cleaning, external painting, and delivery preparation.

SD-10 Operation and Maintenance Data

Air Compressor, Data Package 4

Air Dryer, Data Package 4

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions for Air Compressor

Posted Operating Instructions for Air Dryer

Posted Operating Instructions for Compressed Air Systems

1.4 QUALITY ASSURANCE

****

NOTE: The SMACNA Seismic Restraint Manual referenced in the paragraph below shall be applied to locations subject to significant risk of seismic induced loads. The degree to which this manual is to be used for contract drawings and specifications shall be determined by the designer of record in coordination with the NAVFAC Engineering Field Division's Mechanical Design Branch.

****

Provide all work specified in this section, including design, materials, fabrication, assembly, erection, installation, and examination, inspection and testing of compressed air systems in conformance with ASME B31.1, ASME BPVC SEC VIII D1 [and ASME BPVC SEC IX] [ASME BPVC SEC IX and SMACNA 1981], as modified and supplemented by this specification section and accompanying drawings. In ASME B31.1, ASME BPVC SEC VIII D1 and

ASME BPVC SEC IX, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should" wherever it appears; reference to the "authority having jurisdiction" and "owner" shall be interpreted to mean the Contracting Officer.

1.4.1 Equipment Data

Submit the following data for equipment listed for "Operation and Maintenance Instructions, Parts and Testing."

a. Name and address of authorized branch or service department.

b. Characteristic curves.

c. Following applicable data completely filled in:

Manufacturer and model number [_____]

Operating speed [_____]

Capacity [_____] (CMS) (CFM)

Type of bearings in unit [_____]

Type of lubrication [_____]

Type and adjustment of drive [_____]

Capacity of tank [_____]

Electric motor: Manufacturer, frame and type [_____]

Motor speed [_____] rad/sec RPM

Current characteristics and kW HP of motor [_____]

[_____] Thermal cut-out switch: Manufacturer, type and model [_____]

Starter: Manufacturer: Type and model [_____]

1.4.2 High Pressure Compressed Air System

Show location, length, and type of welds or brazes, and indicate welding and brazing procedures to be used, preheat, postweld heat treatment, and nondestructive welding and brazing testing required.

1.4.3 Laboratory Test Reports and Material Control

Laboratory Test Reports and Material Control for high Pressure Compressed Air Systems:

1.4.3.1 Laboratory Test Reports

Furnish the following laboratory test reports for pipe, tube, fittings, valves, and other pressure containing components (except pressure gages) for each heat and lot of material.

a. Full chemical analyses.

b. Physical properties.

c. Etch test per ASTM E381 as modified for the alloy to verify pipe and tube are seamless and free of defects.

1.4.3.2 Material Control

Where more than one type of corrosion resistant alloy (stainless steel and copper-nickel or nickel-copper for example) is to be installed at project site, the Contractor shall implement and maintain a material control system with markings and/or tags to identify positively each piece as to the type of metal.

1.4.4 Welding Requirements

****

NOTE: The drawings should be checked to ensure that any supplementary information required by the welding and Non-Destructive Examination (NDE) paragraphs has been shown and that there is not conflict between the project drawings and the specifications.

****

****

NOTE: Drawings must indicate, or test of the project specifications must specify, the tensile strength, elongation, shear strength, size, length, type, and location of the welds, as necessary.

****

Provide all welding work specified in this section for compressed air piping systems and in conformance with ASME B31.1, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, brazing procedures, welders, brazers, welding operators, brazing operators, inspection personnel, nondestructive examination personnel, maintenance of welding records, and examination methods for welds.

1.4.4.1 Butt Welded Joints

Butt welded joints shall be full penetration joints. Butt welded joints in systems with working pressures over 2068 kPa (gage) 300 psig shall be full penetration welds with consumable inserts or backing rings.

1.4.5 Employer's Record Documents

Submit to the ROICC for his review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with ASME B31.1.

a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.

b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.

c. List of qualified weld inspection personnel that are proposed to be

used to provide the work specified in this specification section.

1.4.6 Welding Procedures and Qualifications

Determine performance qualification in accordance with ASME B31.1 and as specified.

1.4.6.1 Specifications and Test Results

Submit copies of the welding procedure specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.

1.4.6.2 Certification

Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

1.4.6.3 Renewal of Qualification

Requalification of a brazer or brazing operator shall be required under any of the following conditions:

a. When a brazer or brazing operator has not used the specific brazing process for a period of 6 months.

b. There is specific reason to question his ability to make brazes that will meet the requirements of the specifications.

1.4.7 Experience for Installation and Testing

Experience for Installation and Testing Of [Medium] [and] [High] Pressure Air System: Install and test [medium] [and] [high] pressure air piping and equipment in accordance with ASME B31.1 and only with competent personnel specially trained and experienced in installation and testing of [medium] [and] [high] pressure air systems. The supervisors and personnel performing installation and testing shall have had previous experience in the satisfactory installation and testing of at least two [medium] [and] [high] pressure air systems. Submit data substantiating this experience to the Contracting Officer for approval prior to performing any work. Supervisors and personnel with experience not acceptable to the Contracting Officer will be prohibited from working on these systems. Experience data shall include the following.

a. Name of employee

b. Employer

c. List educational background and specialized training on installation and testing [medium] [and] [high] pressure systems, including safety precautions.

d. List at least two installations of each type of system worked on and installed and tested satisfactorily.

(1) Type of system and operating or design pressure; for medium pressure 869 to 2751 kPa (gage) 126 to 399 psig; for high pressure 2758 kPa (gage) 400 psig and higher.

(2) Company or owner.

(3) Location.

(4) Name, address, and phone number of a person who can be contacted for verification at the installation.

e. If registered engineer, give the state in which registration is held, and branch of engineering. An engineer is required to supervise safety during testing of medium and high pressure air systems.

1.4.8 Qualification of Pressure Vessel (Receiver) Inspectors

State Certification of Competency and active commission from the National Board of Boiler and Pressure Vessel Inspectors (NBBI), Columbus, Ohio.

1.4.9 Training

Where special cleaning, flushing, material control, testing, and other special requirements are used on a contract, such as required for high pressure compressed air systems, conduct formal training programs for employees on the special requirements. Maintain records on such training which shall be available for inspection by the Contracting Officer. Certify that employees have satisfactorily completed the required training prior to performing work on the contract.

1.5 SAFETY PRECAUTIONS

1.5.1 Temperature Restriction

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NOTE: The designer shall assure that the piping design temperature is not exceeded, especially for high pressure systems. Provide aftercoolers and high temperature shutdown devices as required for safe operation of the systems.

****

Compressors or other equipment shall not discharge compressed air to the piping systems above [38] [_____] degrees C [100] [_____] degrees F unless approved by the Contracting Officer. Aftercoolers or other devices shall be provided to comply with the temperature restriction.

1.5.2 Rotating Equipment

Fully guard couplings, motor shafts, gears and other exposed rotating or rapidly moving parts in accordance with OSHA 29 CFR 1910.219. Provide rigid and suitably secured guard parts readily removable without disassembling guarded unit.

1.5.3 Welding and Brazing

Safety in welding, cutting, and brazing of pipe shall conform to AWS Z49.1.

PART 2 PRODUCTS

2.1 HIGH PRESSURE AIR COMPRESSOR

****
NOTE: Prepare section for cooling water and include in project specification. See Section 23 64 26 for piping and equipment which may be useful.
****

****
NOTE: Select aftercooler for 38 degrees C 100 degrees F discharge or design special piping for higher temperature discharge. Paragraphs entitled "High Pressure Air Piping for 34,470 kPa (gage) at 38 degrees C 5000 psig at 100 degrees F System," and "High Pressure Air Piping for 20,682 kPa (gage) at 38 degrees C 3000 psig at 100 degrees F System" are rated for 38 degrees C 100 degrees F.
****

2758 to 34,470 kPa (gage) 400 to 5000 psig system, multi-cylinder, multi-stage, [air] [water] cooled, reciprocating, [belt][direct]-driven, base-mounted type, rated for continuous duty at [20,682] [_____] kPa (gage) [3,000] [_____] psig and capacity indicated. Mount compressor, motor, controls, and instruments on a welded steel base plate. [Provide means to adjust V-belt tension.] Provide splash lubricated compressor not to exceed 105 rad/sec 1000 rpm, or pressure lubricated compressor not to exceed 188 rad/sec 1800 rpm. Provide three phase squirrel cage induction motor not exceeding 188 rad/sec 1800 rpm, with voltage characteristics as indicated, and open drip-proof enclosure. Crankshaft and connecting rods shall be steel. Frame (crankcase), cylinders, and cylinder heads shall be close grain cast iron. Fully enclose frame. Provide automatic unloaders to permit the compressor to start unloaded. Provide [air] [water] cooled coolers after every stage of compression to cool discharge air to within [4] [-7] [_____] degrees C [40] [20] [_____] degrees F of ambient air temperature. Provide automatic condensate drains to drain condensate during operation and when the compressor stops. Conform to NEMA MG 1for motor and NEMA ICS 2 and NEMA ICS 6 for controls.

2.1.1 Controls

****
NOTE: Select the first paragraph for only start-stop control or the second paragraph and subparagraphs for dual control.
****

[Start-stop control compressors by means of pressure switches[and arrange for a lead compressor and a lag compressor]. [Lead]Compressor shall start when the pressure falls to [17,235] [_____] kPa (gage) [2,500] [_____] psig and stop when the pressure reaches [20,682] [_____] kPa (gage) [3,000] [_____] psig.[Lag compressor shall start when the pressure falls to [13,788] [_____] kPa (gage) [2,000] [_____] psig and stop when the pressure reaches [20,682] [_____] kPa (gage) [3,000] [_____] psig.]

When both compressors stop at cutout pressure, the lead and lag positions of compressors shall be interchanged automatically by means of an electric alternator.

][Regulate compressor by dual control. Dual system shall consist of a combination of constant speed control and an automatic start-and-stop control by automatic or manual selector switch.
]

****
NOTE: Include "Start-and-Stop Control" and "Constant Speed Control" below only for "Dual Control" option.
****

2.1.1.1 Start-and-Stop Control

When set for start-and-stop control, motor shall stop automatically when discharge pressure reaches maximum pressure setting and start automatically when discharge pressure falls to minimum setting. Cylinders shall unload during periods of motor shutdown.

2.1.1.2 Constant Speed Control

Compressor shall operate continuously at constant speed. Provide means to automatically load and unload compressor at preset minimum and maximum pressure settings, respectively. Provide means for automatic release of pressure within cylinders when the unit is operating without load. Also provide means for manual or automatic unloading of cylinders during starting of unit. Equip compressor with a timed control to stop compressor after a 10-minute unloaded period if air is not used.

2.1.2 Safety Controls

Provide safety controls to shutdown [each] compressor on high discharge air temperature or low oil pressure for pressure lubricated compressor and low oil level for splash lubricated compressor. Set high temperature shutdown at [54] [_____] degrees C [130] [_____] degrees F. Indicate each shutdown condition by a light on the compressor control panel.

2.1.3 Accessories

Provide pressure gages and relief valves on intercoolers and on the aftercoolers. Provide [totally enclosed belt guards,] discharge check valves, and pressure switches.

2.1.4 Noise

84 dBA maximum sound level one meter from compressor unit.

2.2 HIGH PRESSURE COMPRESSED AIR DRYER

Include component equipment, inter-connecting piping, wiring and controls, mounted in a cabinet and requiring only the connection to utilities. Degrease dryer cabinet, prime coat, and finish coat with baked enamel. Contractor shall furnish integral components whether specifically required by this specification or not. Air shall leave the dryer at a temperature of [_____] degrees C F and a dew point of [_____] degrees C F, based on an inlet temperature of [38] [_____] degrees C [100] [_____] degrees F. Pressure drop shall not exceed [21] [_____] kPa [3] [_____] psi. Provide

complete internal tubing, wiring, and piping, such that only connections to air inlet and outlet, to refrigerant compressor contactor, and to condensate drain are necessary.

2.2.1 Construction

Heat sink type dryer consisting of a mechanical refrigeration system equipped with an automatic temperature shutdown switch to prevent freezing, a large aluminum granule heat sink to allow a minus 16 degrees C 4 degrees F automatic temperature control, regenerative air to air exchanger, and main compressed air cooling exchanger. Refrigeration system shall cool thermal mass heat sink which shall, in turn, lower compressed air temperature to dry air. A direct air to refrigerant gas heat exchanger is not acceptable. Dryer shall have no internal traps or filters and shall have large internal air passages to minimize pressure drop.

2.2.2 Air Circuit

Include the following:

a. Regenerative heat exchanger: ASTM A269/A269M, Type 304L seamless stainless steel tube construction, inlet compressed air to outlet compressed air heat exchanger designed to reduce cooling load at design conditions minus 7 degrees C 20 degrees F by inlet air precooling.

b. Main heat exchanger: ASTM A269/A269M, Type 304L seamless stainless steel tube construction, single-pass, designed for minimum air pressure drop with air in the tubes surrounded by aluminum granules.

c. Separator: Fabricated of ASTM A269/A269M, Type 304L seamless stainless steel in accordance with ASME B31.1. Code stamp is not required. Provide moisture separator, low velocity type, incorporating change of air flow direction to prevent moisture carryover.

d. Dryer operating pressure: [20,682] [34,470] [_____] kPa (gage) [3,000] [5,000], [_____] psig working pressure.

e. Drain line: Provide drain line to exterior of dryer with [condensate trap] [or] [automatic drain valve].

f. Exterior piping connections: Provide with square ends.

2.2.3 Refrigeration System

Include the following:

a. Compressor: ANSI/AHRI 520. Hermetic reciprocating compressor equipped with automatic start-stop control, inherent motor protection, crankcase oil strainer, and suction screen. Refrigerant shall be R-22.

b. Dryer controls: Capable of automatic 0 to 100 percent capacity control with an automatic control expansion valve with sensing bulb to control capacity, with automatic shutdown switch sensor located at point of lowest temperature to prevent freezing.

c. Air cooled condenser.

2.2.4 Instrumentation and Controls

Provide control panel in dryer cabinet containing:

a. Indicators:

(1) Inlet air pressure gage

(2) Discharge air pressure gage

(3) Inlet air temperature gage

(4) Main exchanger temperature gage

(5) Refrigeration compressor suction pressure gage

(6) Refrigeration compressor discharge pressure gage

(7) Power interruption light

(8) High temperature light

(9) Power on light

b. Electrical relays: Locate in an enclosed portion of panel, accessible for easy servicing.

c. Controls and interlocks:

(1) Condenser fan

(2) Compressor across the line contactor

(3) Thermostatic control switch

2.3 HIGH PRESSURE AIR RECEIVERS [AND] [SEPARATORS]

****
NOTE: Do not permit field welding on high pressure air receivers unless controls over welding processes and nondestructive testing required by the military specification can be implemented in the field.
****

ASME BPVC SEC VIII D1, constructed and stamped, seamless, forged, [20,682] [34,470] kPa (gage) [3,000] [5,000] psig design working pressure, minimum safety factor of 4, corrosion allowance of [1.60] [_____] mm [1/16] [_____] inch, straight thread, 0-ring sealed, forged steel inlet, outlet, and drain plugs, straight or angle connection as indicated or required. [Capacity] [Capacities] as indicated. After heat treatment, examine exterior of vessel by liquid penetrant or magnetic particle test; no defects are permitted. Furnish certified (non-destructive examination) NDE report for high pressure air receiver. After hydrostatic testing at the factory, clean the flask to oil-free condition. Abrasive blast interior and exterior to near white condition in accordance with SSPC SP 10/NACE No. 2. Vacuum clean surfaces to remove dust and debris. Check surfaces with black light to ensure there is no oil. Apply 2 or 3 coats of epoxy coating 0.20 mm 8 mils minimum dry film thickness, with

white finish coat for the interior and gray finish coat for the exterior. Provide certification of factory tests. Securely support receiver and equip with pressure gage, drain valve, and ASME BPVC SEC VIII D1 and ASME BPVC SEC IX code stamped pressure relief valve set as indicated and piped to discharge in a safe manner. Piping shall conform to [20,682] [34,470] kPa (gage) [3,000] [5,000] psig standards. Provide each receiver with internal or external blowdown and drain line with manual valve in accessible location, or with extension stem, discharging through a visible open sight drain. Do not manifold cylinder drain piping together. Attachment welds to receiver [and separator] shall not be permitted. Register vessel with NBBI and mark registration number on vessel.

2.4 MEDIUM PRESSURE AIR COMPRESSOR

****

NOTE: Prepare section for cooling water and include in project specification. See Section 23 64 26 for piping and equipment which may be useful.

****

869 to 2751 kPa (gage)126 to 399 psig system. [Multi-stage][Two-stage][Single-stage], [air] [water] cooled reciprocating, [belt] [direct] driven type, suitable for supplying compressed air at pressures indicated. Provide compressor with ball or roller type bearing, pressure lubricated, thermal overload protection as required by NEMA, pressure switch, inlet filter-mufflers, vibration isolators, intercoolers, aftercooler, and flexible connectors. Provide safety control for shutdown and alarm on high discharge air temperature or low oil pressure. Capacity and operating pressure as indicated on drawings. Mount compressor and motor on a base plate[and set on the receiver. Design receiver for additional load of compressor and motor].

2.4.1 Receiver

Build receiver (tank) of welded steel, in accordance with ASME BPVC SEC VIII D1, Unfired Pressure Vessels, for [2751] [_____] kPa (gage) [399] [_____] psig working pressure at [232] [_____] degrees C [450] [_____] degrees F, complete with pressure gage, ASME BPVC SEC VIII D1 and ASME BPVC SEC IX code stamped safety valve, check valve, shut-off valve on tank outlet, and automatic tank drain on tank. Provide tank with steel supports and bolt to a concrete foundation. Capacity as indicated.

2.4.2 Motor and Starter

Provide motor and starter 40 degrees C 72 degrees F ambient temperature rise, continuous duty, drip-proof type motor, ball bearings, for operation with current of voltage, phase, and cycle indicated on the electrical drawings. Motor of such capacity that brake horsepower required by driven equipment at normal rated capacity will not exceed nameplate rating of motor. Provide each motor with automatic, fully enclosed, magnetic starter. Conform to NEMA MG 1 for motor and NEMA ICS 2and NEMA ICS 6 for starter and controls.

2.4.3 Controls

****

NOTE: Select the first paragraph for only start-stop control or the second paragraph and subparagraphs for dual control.

****

[Provide start-and-stop control. Motor shall stop automatically when discharge pressure reaches maximum pressure setting and start automatically when discharge pressure falls to minimum setting. Cylinders shall unload automatically during periods of motor shutdown.

][Regulate compressor by dual control. Dual system shall consist of a combination of constant speed control and an automatic start-and-stop control by automatic or manual selector switch.
]

****

NOTE: Include "Start-and-Stop Control" and "Constant Speed Control" below only for the "Dual Control" option.

****

2.4.3.1 Start-and-Stop Control

When set for start-and-stop control, motor shall stop automatically when discharge pressure reaches maximum pressure setting and start automatically when discharge pressure falls to minimum setting. Cylinders shall unload during periods of motor shutdown.

2.4.3.2 Constant Speed Control

Compressor shall operate continuously at constant speed. Provide means to automatically load and unload compressor at preset minimum and maximum pressure settings, respectively. Provide means for automatic release of pressure within cylinders when the unit is operating without load. Also provide means for manual or automatic unloading of cylinders during starting of unit.[Equip compressor with a timed control to stop compressor after a 10-minute unloaded period if air is not used.]

2.4.4 Intercoolers and Aftercoolers

Provide intercoolers between all intermediate stages of multi-stage compressors and provide aftercoolers with compressors. Intercoolers for air-cooled compressors shall be the tube-and-fin type. Intercoolers for water-cooled compressors shall be the shell-and-tube type, except that tube-and-fin type may be used when the intercooler is supported by the compressor frame or attached to the compressor. Air or water cooled intercoolers may be the integral cast type when compressor is 19 kW 25 hp or less. Aftercoolers shall be of the water-cooled shell-and-tube type or air-cooled tube-and-fin type. Water-cooled aftercoolers and intercoolers shall be of sufficient capacity to cool the compressed air to within minus 9 degrees C and minus 7 degrees C 15 degrees F and 20 degrees F, respectively, of the temperature of the water entering the coolers. Air-cooled intercoolers and aftercoolers shall have sufficient capacity to cool the compressed air to within minus 7 degrees C 20 degrees F of the ambient temperature under the atmospheric conditions indicated. Provide water-cooled intercoolers and aftercoolers with sight-flow indicator to visually observe the flow of water to the cooler. The pressure drop of compressed air through the cooler shall not exceed 7 kPa one psi. Provide intercoolers and aftercoolers with a moisture separator and drain trap to remove the condensed moisture and oil from the air leaving the cooler.

2.4.4.1 Shell-and-Tube

Floating-head type consisting of a removable and cleanable nest of corrosion-resistant tubes within a steel shell. Air may pass either through the tubes or the shell.

2.4.4.2 Tube-and-Fin

Copper, aluminum, copper-aluminum, or copper-alloy construction. Fins shall be securely bonded to the tubing. Provide tube-and-fin coolers with a fan for circulation of the cooling air. The fan shall be adequately guarded for safety and be driven either from the compressor crankshaft or by an independent electric motor.

2.4.5 Noise

84 dBA maximum sound level one meter from compressor unit.

2.5 MEDIUM PRESSURE Air receivers [and] [separators]

ASME BPVC SEC VIII D1, labeled and rated for [1896] [_____] kPa (gage) [275] [_____] psig, equipped with required valves and trimmings, including gage and automatic drain valve and ASME BPVC SEC VIII D1 and ASME BPVC SEC IX pressure safety relief valve. Pressure as indicated. [Sandblast exterior and interior to SSPC SP 10/NACE No. 2, near-white. Lining shall be a factory applied 0.20 mm 8 mil minimum epoxy coating.] Exterior finish shall be [standard factory finish] [two coats of rust inhibitor primer and one coat epoxy enamel].

2.6 MEDIUM PRESSURE COMPRESSED AIR DRYERS

****
NOTE: Make changes for medium pressure systems and insert the desired operating pressure. Normally used for under 944 scms 2000 scfm capacity systems. CAUTION: ASSURE CORRECT SYSTEM PRESSURE IS SPECIFIED.
****

Provide medium pressure compressed air dryers of the mechanical refrigeration type, equipped with an automatic temperature shutdown switch to prevent freezing, a regenerative air to air exchanger (in capacity sizes above 5 to 28 scms 10 or 60 scfm as standard with the manufacturer), and a main compressed air cooling exchanger. Refrigeration system shall cool compressed air to dry the air. Dryer shall have no internal traps or filters and shall have pressure drop not greater than [21 kPa] [_____ kPa] [3 psi] [_____ psi] [indicated]. Air shall leave the dryer at a temperature of [_____] degrees C F and dew point of [_____] degrees C F, based on an inlet temperature of [38] [_____] degrees C [100] [_____] degrees F. Provide internal tubing, wiring, and piping complete, such that only connections to air inlet and outlet, to refrigerant compressor contactor, and to condensate drain are necessary.

2.6.1 Air Circuit

a. Regenerative heat exchanger: Inlet compressed air to outlet compressed air heat exchanger (in capacity sizes above 5 to 28 scms 10 or 60 scfm as standard with the manufacturer) designed to reduce cooling load at design conditions minus 7 degrees C 20 degrees F by

inlet air precooling.

b. Main heat exchanger: Single-pass, with air in the tubes, heat sink, direct expansion, or flooded cooler type.

c. Separator: Fabricated in accordance with ASME B31.1; code stamp not required; moisture separator low velocity type incorporating change of air flow direction to prevent moisture carryover.

d. Dryer operating pressure: [1896] [_____] kPa (gage) [275] [_____] psig working pressure.

e. Drain line: Provide with exterior mounted condensate trap to facilitate servicing.

2.6.2 Refrigeration System

a. Refrigeration compressor: ANSI/AHRI 520. Hermetic, semi-hermetic, or open reciprocating type equipped with automatic start-stop or unloading capacity control; standard components include inherent motor protection, crankcase oil strainer, and suction screen. Refrigerant shall be R-22.

b. Dryer controls: Capable of automatic 0 to 100 percent capacity control. Refrigeration controls shall maintain pressure dew point within the specified range without freezing of condensate. Controls shall include such devices as capillary tube, expansion valve, suction pressure regulator, thermostat, or other approved devices as standard with the manufacturer. Dryer shall have automatic shutdown switch sensor located at point of lowest temperature to prevent freezing.

c. Refrigerant dryer and suction line strainer.

d. Air-cooled condenser, with condenser fan and motor.

2.6.3 Instrumentation and Control

Include control panel in dryer cabinet containing:

a. Indicators for the following services: Inlet air pressure gage, discharge air pressure gage, inlet air temperature gage, main exchanger temperature gage, refrigeration compressor suction pressure gage, refrigeration compressor discharge pressure gage, green "Power On" light, power interruption light, and high temperature light.

b. Electrical relays: Locate in an enclosed portion of the panel, accessible for ease of servicing.

c. Controls and interlocks: To maintain required compressed air dew point and to cycle air-cooled condenser with refrigeration compressor [while maintaining head pressure control with low ambient temperature].

2.7 MEDIUM PRESSURE COMPRESSED AIR DRYER (CHILLED WATER TYPE)

****

NOTE: Edit for medium pressure systems and insert the operating pressure. Chilled water air dryers are usually provided for 944 scms 2000 scfm and larger capacities. CAUTION: Specify correct system

pressure. If specification is edited to use a dryer with direct heat exchange between air and refrigerant, assure that air is not used for breathing since refrigerant leakage into the compressed air may be hazardous to personnel; warning signs may be required.
****

Provide medium pressure compressed air dryer of the mechanical refrigerator type, with closed chilled water system, regenerative air to air exchanger, and main compressed air to water heat exchanger. Refrigeration system shall produce chilled water which, in turn, circulates through air-water exchanger to dry the air. Provide internal tubing, wiring and piping complete, such that only connections to air inlet and outlet, to pump contactor, to refrigerant compressor contactor, to condensate drain, and to air cooled condenser need be provided. Dryer shall be suitable for a compressed air operating pressure of [1896] [_____] kPa (gage) [275] [_____] psig, with air leaving temperature of [_____] degrees C F and dew point of [_____] degrees C F at rated pressure.

2.7.1 Air Circuit

a. Regenerative heat exchanger: Air to air exchanger, with inlet air passing through tubes and outlet air in shell, designed to reduce cooling load at design conditions by precooling inlet air minus 7 degrees C 20 degrees F.

b. Main heat exchanger: Shell and tube construction, single-pass, with air in tubes and water in shell, designed for minimum air pressure drop, flanged connections, tubes rolled into tube sheets, and ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped.

c. Separator: Fabricated of carbon steel to ASME BPVC SEC VIII D1and ASME BPVC SEC IX Code and stamped.

d. Drain: With condensate trap.

2.7.2 Chilled Water Circuit

a. Circulating pump: Single stage, mechanical seals, electric motor driven with line shut-off valves.

b. Liquid cooler: Direct expansion, refrigerant in tubes, water in shell, designed for 2068 kPa (gage) 300 psig working pressure, removable tube bundle, ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped and insulated with foam type insulation.

c. Expansion tank: With sight glass, vent, and fill cock.

d. Flow switch: To shut down refrigeration compressor on loss of chilled water flow.

2.7.3 Refrigeration System

a. Refrigeration compressor: ANSI/AHRI 520. Hermetic or semihermetic reciprocating type, with 183 rad/sec 1750 rpm motor, integral capacity control, oil pressure pump, oil scavenger pump, full-flow oil filter, oil sight glass, inherent motor protection, crankcase heater, suction and discharge service valve, crankcase oil strainer, Monel suction

screen, and hot gas bypass capacity control below last step of unloading. Refrigerant shall be R-22.

b. Accessories: Include a discharge line muffler, sight glass, refrigerant dryer, solenoid valve, thermostatic expansion valve, and suction line strainer.

c. Air-cooled condenser: As indicated. Complete air-cooled condenser factory-fabricated and assembled unit consisting of coils, fans, and electric-motor drive. Base capacity at design conditions on minus 7 degrees C 20 degrees F temperature differential between entering air and condensing refrigerant. Saturated refrigerant condensing temperature not over 40 degrees C 105 degrees F. Base entering dry bulb outside air temperature on [32] [_____] degrees C [90] [_____] degrees F. Do not take subcooling into account in determining compressor and condenser capacities. Air-cooled condenser may be used for refrigerant storage in lieu of a separate receiver, provided that condenser storage capacity is 20 percent in excess of fully charged system. [Provide head pressure control during low ambient temperature.]

2.7.4 Instrumentation and Control

Provide a control panel on the dryer containing:

a. Pressure gages (114 mm 4 1/2 inches diameter) for the following services:

(1) Inlet air

(2) Condenser water inlet

(3) Refrigeration compressor suction

(4) Refrigeration compressor oil pressure

(5) Outlet air

(6) Condenser water outlet

(7) Refrigeration compressor discharge

b. Electrical relays: Locate in an enclosed portion of the panel, accessible from front of panel.

c. Start-stop buttons and green running indicating light.

d. Controls and interlocks.

(1) 115-volt control transformer

(2) Circulating pump across the line contactor

(3) Compressor across the line contactor

(4) Condenser water pressure safety switch

(5) Freeze protection safety switch

(6) Pump-out relay with normally open and normally closed contacts

(7) Oil safety switch

(8) Four stage thermostatic control

(9) Refrigerant dual pressure switch

2.7.5 Temperature Indicators

a. Air inlet

b. Air outlet

c. Chilled water in

d. Chilled water out

e. Dew point

2.8 DESICCANT AIR DRYERS

Chamber of welded steel, [_____] kPa (gage) psig working pressure, ASME labeled conforming to ASME BPVC SEC VIII D1, with flanged or threaded fittings, and [manual] [automatic] drain valve. Manufacturer's recommended desiccant in tablet form which will not nest or cake. Contractor shall provide a supply of desiccant for initial operations in unbroken shipping containers equal to not less than four charges of desiccant for the dryer.

2.9 HIGH PRESSURE (HP) AIR PIPING AND ACCESSORIES

****

NOTE: The high pressure air system materials listed are tentative suggestions. The designer shall calculate required minimum wall thicknesses for pipe and tube in accordance with ASME B31.1 and verify adequacy of the materials listed. Select material for corrosion resistance required in the service environment. Allowance for corrosion or fabrication, factor "A" in ASME B31.1, paragraph 104.1, shall be selected by the designer. If carbon steel is selected as the piping material, special attention should be given to the corrosion allowance for the higher pressures such as 20,682 kPa (gage) 3000 psig and 34,470 kPa (gage) 5000 psig systems since commercial sizes per ASME B36.10M would not permit selection of large corrosion allowance factors.

****

2.9.1 HP Air Piping and Tubing

HP air piping and tubing for 34,470 kPa (gage) at 38 degrees C 5000 psig at 100 degrees F system shall conform to the following:

a. Stainless steel pipe: ASTM A312/A312M, seamless stainless steel, annealed Type [304L] [316L], Schedule 160 up to 25 mm one inch IPS, double extra strong (XXS) for 32 to 65 mm 1 1/4 to 2 1/2 inches IPS

[,larger sizes shall be special as indicated]. Wall thickness "schedule" and "weight" designations shall conform to ASME B36.10M. Fittings for pipe 40 mm 1 1/2 inches IPS and smaller: ASTM A403/A403M, ASME B16.11, forged stainless steel, Type [304L] [316L], socket welding, Class 6000 for 6 to 25 mm 1/4 to one inch IPS, Class 9000 for 32 and 40 mm 1 1/4 and 1 1/2 inches IPS. Fittings for pipe 50 to 65 mm 2 to 2 1/2 inches IPS: ASTM A403/A403M, ASME B16.9, butt welding, seamless wrought stainless steel Type [304L] [316L], double extra strong (XXS).

b. Nickel-copper pipe: ASTM B165, seamless, annealed, Schedule 160 up to 25 mm one inch IPS, double extra strong (XXS) for 32 to 80 mm 1 1/4 to 3 inches IPS, [,larger sizes shall be special as indicated.] Wall thickness "schedule" and "weight" designations shall conform to ASME B36.10M. Fittings 40 mm 1 1/2 inches IPS and smaller: ASME B16.11, forged nickel-copper ASTM B564, socket welding, Class 6000 for 6 to 25 mm 1/4 to one inch IPS, Class 9000 for 32 and 40 mm 1 1/4 and 1 1/2 inches IPS. Fittings for pipe 50 mm 2 inches IPS and larger: ASME B16.9, butt welding, seamless wrought 70-30 nickel-copper, double extra strong (XXS), 50 to 80 mm 2 to 3 inches IPS.

****

NOTE: Use only one type of fitting for the entire project.

****

c. Stainless steel tubing: ASTM A269/A269M, stainless steel, Type [304] [304L] [316], seamless, annealed, with wall thicknesses as specified below. Fittings for tubing: stainless steel, Type [304] [304L] [316], conforming to [SAE AS4841,] [SAE AS4842,][SAE AS4842/1,][SAE AS4843,][SAE AS4843/1,][SAE AS4843/2,][SAE AS4875][SAE AS4875/1,][SAE AS4875/2,][SAE J514,] flared type, suitable for 34,470 kPa 5000 psi service. Fittings shall have a minimum burst strength of 138 MPa (gage) 20,000 psig; furnish laboratory burst test reports. Do not use flareless fittings or bite type fittings. Do not weld tubing.

MINIMUM WALL THICKNESS FOR STAINLESS STEEL TUBING	
Size (mm O.D.)	Thickness (mm)
10	1.47
15	2.11
16	2.41
20	3.05

MINIMUM WALL THICKNESS FOR STAINLESS STEEL TUBING	
Size (Inches O.D.)	Thickness (Inches)
3/8	.058

MINIMUM WALL THICKNESS FOR STAINLESS STEEL TUBING	
Size (Inches O.D.)	Thickness (Inches)
1/2	.083
5/8	.095
3/4	.120

d. Copper-nickel tube: MIL-T-16420, Composition 70-30, temper-annealed, Type I - seamless Class 6000 (41,364 kPa (gage) 6000 psig working pressure), Grade 2 (material with heat identification), IPS outside diameter sizes. Fittings 40 mm 1 1/2 inches IPS and smaller: ASME B16.11, MIL-C-15726, forged copper-nickel, socket welding, except that body wall thickness shall not be less than the minimum wall thickness for the size listed in MIL-T-16420 for Class 6000, and the average socket wall thickness shall be 1.25 times, and the minimum socket wall 1.09 times the minimum wall thickness for that size listed in MIL-T-16420 for Class 6000. Fittings 50 to 80 mm 2 to 3 inches IPS: ASME B16.9, butt welding, seamless wrought 70-30 copper-nickel, with minimum wall thickness as listed for that size in MIL-T-16420 for Class 6000.

2.9.2 High Pressure Air Piping

High pressure air piping for 20,682 kPa (gage) at 38 degrees C 3000 psig at 100 degrees F system shall conform to the following:

a. Stainless steel pipe: ASTM A312/A312M, seamless stainless steel, annealed Type [304L] [316L], Schedule 80 up to 25 mm one inch IPS, Schedule 160 32 to 150 mm 1 1/4 to 6 inches IPS. Wall thickness "schedule" and "weight" designations shall conform to ASME B36.10M. Fittings for pipe 40 mm 1 1/2 inches IPS and smaller: ASTM A403/A403M, ASME B16.11, forged stainless steel, Type [304L], [316L], socket welding, Class 3000 for 6 to 25 mm 1/4 to one inchIPS, Class 6000 for 32 and 40 mm 1 1/4 and 1 1/2 inchesIPS. Fittings for pipe 50 to 150 mm 2 inches to 6 inchesIPS: ASTM A403/A403M, ASME B16.9, butt welding, seamless wrought stainless steel Type [304L] [316L], Schedule 160.

****

NOTE: Use only one type of fitting for the entire project.

****

b. Stainless steel tubing: ASTM A269/A269M, stainless steel, Type [304] [304L] [316], seamless, annealed, with minimum wall thicknesses as specified below. Fittings for tubing: stainless steel, Type [304] [304L] [316], conforming to [SAE AS4841,] [SAE AS4842,][SAE AS4842/1,][SAE AS4843,][SAE AS4843/1,][SAE AS4843/2,][SAE AS4875,][SAE AS4875/1,][SAE AS4875/2,] [SAE J514,] flared type, suitable for 20,682 kPa 3000 psi service. Fittings shall have a minimum burst strength of 139 MPa 20,000 psig; furnish laboratory burst test reports. Do not use flareless fittings or bite type fittings. Do not weld tubing. Brazed 20,682 kPa 3000 psi tubing fittings may be used where flared fitting connections are not required for equipment. Use FS QQ-B-654, Grade V, brazing alloy where tubing or fitting or both tubing and fitting are stainless steel.

MINIMUM WALL THICKNESS FOR STAINLESS STEEL TUBING	
Size (mm O.D.)	Thickness (mm)
10	1.47
15	2.11
16	2.41
20	3.05

MINIMUM WALL THICKNESS FOR STAINLESS STEEL TUBING	
Size (Inches O.D.)	Thickness (Inches)
3/8	.058
1/2	.083
5/8	.095
3/4	.120

c. Copper-nickel tube: MIL-T-16420, Composition 70-30, temper-annealed, Type I - seamless, Class 3300 (22,750 kPa (gage) 3300 psig working pressure), Grade 2 (material with heat identification). Fittings, Brazing: bronze or copper-nickel, silver brazed ends, rated for not less than 20,682 kPa 3000 psi working pressure. Limit brazed joints to required connections to existing piping. Use welded joints for new and existing piping to the maximum extent practical. Fittings, welding, 40 mm 1 1/2 inches IPS and smaller: ASME B16.11, MIL-C-15726, forged copper-nickel, socket welding, except that body wall thickness shall not be less than the minimum wall thickness for the size listed in MIL-T-16420 for Class 3300, and the average socket wall thickness shall be 1.25 times, and the minimum socket wall 1.09 times the minimum wall thickness for that size listed in MIL-T-16420 for Class 3300; however, for 6 mm 1/4 inch IPS, ASME B16.11, Class 3000 dimensions may be used when approved by the Contracting Officer. Fittings, welding, 50 to 80 mm 2 to 3 inches IPS: ASME B16.9, butt welding, seamless wrought 70-30 copper-nickel, with minimum wall thickness as listed for that size in MIL-T-16420 for Class 3300.

2.9.3 Globe and Angle Valves

QPL-24109, bronze body.

2.9.4 Needle Valves

QPL-24109, bronze body, except provide needle valve cartridges in lieu of shutoff valve cartridges.

2.9.5 Safety Valves

ASME BPVC SEC VIII D1 and ASME BPVC SEC IX Code stamped safety valve, [Type [304L] [316L] stainless steel,] [70-30 copper-nickel,] [70-30 nickel-copper,] [bronze,] [carbon steel,] with 0-ring seal union thread

piece ends as provided for QPL-24109 valves; factory set and sealed.

2.9.6 Pressure Reducing Valves

ANSI/NFLPA T3.12.3, nominal pressure rating of [2758] [10,341] [20,680] [41,364] kPa (gage) [400] [1500] [3000] [6000] psig, body of [stainless steel,] [bronze,] [aluminum bronze,] [naval brass,] outlet pressure and capacity as indicated, shock and vibration test not required, allowance lists not required.

2.9.7 Adapters

Provide suitable tailpiece adapters for installation of valves conforming to QPL-24109 and for other components with similar union end connections. Tailpieces shall match pipe material: [Type 304L or 316L stainless steel,] [70-30 nickel-copper,] [70-30 copper-nickel,] socket welding type for 40 mm 1 1/2 inches IPS and smaller. Tailpieces for tubing: [brazed O.D. type suitable for 20,682 kPa 3000 psi]. Provide thread piece adapters for O-ring union installation of components made of material different from pipe or where welded joint installation is not suitable.

2.9.8 Pressure Gages (High Pressure)

Pressure gages for high pressure systems shall conform to ASME B40.100, for air, with a scale approximately twice the system working pressure, nonshatterable safety glass, and pressure blowout back to prevent glass from flying out in case of an explosion. Gages: [90] [114] mm [3 1/2] [4 1/2] inches in diameter with a steel case and tubing and an accuracy of one percent full scale in middle half section of scale and 1 1/2 percent of full scale value in first and last 1/4 sections of scale. Do not fasten bourdon tube pressure-sensitive elements with low-melting-point solder. Print on gage faces in red letters "USE NO OIL." Provide pressure snubbers or equalizer in pressure gage installations on inflow side of a gage valve. Mount gage branches vertically on top of an air line to avoid branch flow of condensate and dirt. Connect a gage to an air line or component through an equalizer, gage valve (slow-opening needle type), and branch with provision for bleed-off.

2.9.9 Snubbers (or Equalizers)

[Type 304L or Type 316L stainless steel] [70-30 copper-nickel] [70-30 nickel-copper] body with a rated working pressure not less than system design pressure. Snubber element: sintered stainless steel or other approved type.

2.9.10 Timed Solenoid Drain

Packaged solenoid drain with 6 mm, [20,682] [34,470] kPa (gage) 1/4 inch, [3000] [5000] psig, direct acting, normally closed solenoid valve, solid state timer, drain cycle adjustable from zero to 50 minutes, valve open duration adjustable from one to 14 seconds, power on light, valve open light, operation on 115 or 230 VAC, and housed in NEMA [1] [_____] enclosure.

2.9.11 Compressed Air Filters

Provide high pressure compressed air filter, single cartridge type, designed for operating pressures not less than the system design pressure. Filter housing of [Type [304L] [316L] stainless steel] [70-30

copper-nickel] [70-30 nickel-copper] construction. Provide a cellulose cartridge filter of graded density construction capable of removing liquids and solids of 5 microns and larger. Provide filter with a bottom drain and [manual drain valve] [timed solenoid drain].

2.9.12 Strainers

Y-pattern type with [cast stainless steel body, ASTM A351/A351M CF8M (Type 316), CF8 (Type 304), CF3 (Type 304L) or CF3M (Type 316L,] [70-30 copper-nickel,] [70-30 nickel-copper,] [forged alloy steel body ASTM A182/A182M, Grade F-22,] rated for the system design working pressure, with 20-mesh Monel or stainless steel screen. Net strainer area not less then 2.5 times the inlet connection area.

2.9.13 Unions

O-ring seal type compatible with union ends of QPL-24109 valves, material and end preparation compatible with pipe and fittings.

2.9.14 O-Ring Gaskets

SAE AMS7276.

2.9.15 Hangers and Supports

Provide pipe hangers and supports conforming to MSS SP-58, MSS SP-69, and ASME B31.1, except as specified or indicated otherwise. Hangers for high pressure air lines shall be rigid or braced and sufficiently strong to prevent "whipping" of a pipe if a break occurs while the line is under pressure. Furnish zinc plated pipe hangers and supports except for copper plated inserts for copper piping. Provide tubing supports of U-shaped steel bolts and nuts firmly secured to adequately support structures such as walls, columns, floors, or brackets. Clips shall fit closely around piping but shall have sufficient clearance to permit longitudinal movement of piping during normal expansion and contraction. Provide supports at valves, fittings, branch lines, outlets, changes in direction, equipment, and accessories.

2.10 MEDIUM PRESSURE COMPRESSED AIR PIPING AND ACCESSORIES

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NOTE: Components are listed based on operation at maximum temperature of 66 degrees C 150 degrees F. Class 300 steam rated components have water-oil-gas (WOG) ratings above 2758 kPa (gage) at 66 degrees C 400 psig at 150 degrees F. If higher operating temperatures are expected, change component descriptions to higher ratings as required after reviewing appropriate component specification.

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Medium pressure compressed air piping and accessories 869 to 2751 kPa (gage) at 66 degrees C 126 to 399 psig at 150 degrees F shall conform to the following:

2.10.1 Pipe

ASTM A53/A53M or ASTM A106/A106M, seamless carbon steel, Schedule 40, black.

2.10.2 Fittings, Size 50 Millimeters 2 Inches and Larger

ASME B16.9, carbon steel, butt welding, Schedule 40, or ASME B46.1, carbon steel welding neck flanges, Class 300, ASME B46.1, flanged fittings, carbon steel, Class 300, gaskets ASME B16.20, spiral wound metallic, Class 300, bolts ASTM A193/A193M, Grade B7, and nuts, ASTM A194/A194M, Grade 7. Butt welded joints shall be full penetration consumable insert or backing ring type.

2.10.3 Fittings, Size 40 Millimeters 1 1/2 Inches and Smaller

ASME B16.11, forged carbon steel, Class 3000 socket welding or Class 2000 threaded. Seal weld threaded joints not required to disassemble piping for maintenance. Joints may also be butt welded or flanged, as specified for sizes 50 mm 2 inches and larger.

2.10.4 Flat-faced Steel Flanges

Where connections are made to Class 250 cast iron flanges with steel flanges, use only flat-faced Class 300 steel flanges.

2.10.5 Unions

ASME B16.39, Class 2 (3447 kPa (gage) 500 psig WOG, cold, non-shock).

2.10.6 Valves

2.10.6.1 Globe and Angle Valves

Sizes 50 mm 2 inches and smaller, bronze, MSS SP-80, Type 3 (Metallic Disc, Renewable Seat), Class 300, threaded ends, or carbon steel, ASME B16.34, Class 300, threaded ends. Sizes larger than 50 mm 2 inches, ASME B16.34, carbon steel, tapered disk, Class 300, flanged ends.

2.10.6.2 Check Valves

ASME B16.34 or MSS SP-71, Class 300, steel, lift or swing type.

2.10.6.3 Pressure Reducing Valves

ANSI/NFLPA T3.12.3, with nominal pressure rating of not less than inlet system pressure indicated. Provide pressure reducing valves capable of being adjusted to specified flow and pressure, and suitable for intended service. Provide pilot valve for dome loaded type if required for proper operation.

2.10.6.4 Safety Valves

ASME BPVC SEC VIII D1 and ASME BPVC SEC IX, Code stamped safety valve, bronze body with bronze trim, for unfired pressure vessels, threaded or flanged connection; factory set and sealed.

2.10.7 Pressure Gages

ASME B40.100, Accuracy Grade A, for air, with steel or brass case, and nonshatterable safety glass, and a pressure blowout back to prevent glass from flying out in case of an explosion. Gages shall have a 90 mm 3 1/2 inch minimum diameter dial and a dial range of approximately twice working

pressure.

2.10.8 Pipe Hangers and Supports

MSS SP-58, MSS SP-69, and ASME B31.1, except as specified or indicated otherwise. Provide zinc plated pipe hangers and supports. Provide tubing supports of U-shaped steel bolts and nuts firmly secured to adequately support structures such as walls, columns, floors, or brackets. Clips shall fit closely around piping but shall have sufficient clearance to permit longitudinal movement of piping during normal expansion and contraction. Provide supports at valves, fittings, branch lines, outlets, changes in direction, equipment, and accessories.

2.10.9 Strainers

FS WW-S-2739, Class 250, Style Y, simplex type, with 20-mesh Monel or stainless steel screen.

2.10.10 Traps

CID A-A-60001, to drain water and other liquids from system. Type of traps, as indicated, and rated working pressure not less than system operating pressure.

2.10.11 Flexible Connections

Vibration isolation, wire braid reinforced corrugated metal hose type, line-sized, with bronze end connections, suitable for pressure indicated. Length as recommended by manufacturer but not less than [457] [_____] mm [18] [_____] inches.

2.10.12 Tetrafluoroethylene Tape

CID A-A-58092 for screw-jointed pipe.

2.11 SLEEVES

2.11.1 Floor Slabs, Roof Slabs, and Outside Walls Above and Below Grade

Galvanized-steel pipe having an inside diameter at least 15 mm 1/2 inch larger than the outside diameter of the pipe passing through it. Provide sufficient sleeve length to extend completely through floors, roofs, and walls, so that sleeve ends are flush with finished surfaces except that ends of sleeves for floor slabs shall extend 15 mm 1/2 inch above finished floor surface. Sleeves located in waterproofed construction shall include flange and clamping ring.

2.11.2 Partitions

Galvanized sheet steel, 26 gage or heavier, of sufficient length to completely extend through partition thickness with sleeve ends flush with partition finished surface.

2.12 VALVE BOX

Provide rectangular concrete design with words "Compressed Air" cast or otherwise marked on the cover. Size shall be large enough for removal of valve without removing box. Provide valve box for areas as follows:

a. Roads and traffic areas: Heavy Duty, cast iron cover

b. Other areas: Standard duty, heavy steel plate or concrete cover

2.13 IDENTIFICATION LABELS FOR PIPING

Labels for pipes 20 mm 3/4 inch O.D. and larger shall bear printed legends to identify contents of pipes and arrows to show direction of flow. Except that of pipes smaller than 20 mm 3/4 inch O.D., labels shall have color coded backgrounds to signify levels of hazard in accordance with PFI ES 22. Legends and type and size or characters shall also conform to PFI ES 22. Labels shall be made of plastic sheet in conformance with CID A-A-1689 with pressure-sensitive adhesive suitable for the intended applications or they may be premolded of plastic to fit over specific pipe outside diameters 20 mm 3/4 inch and larger. For pipes smaller than 20 mm 3/4 inch O.D., furnish brass identification tags 40 mm 1 1/2 inches in diameter with legends in depressed black-filled characters.

2.14 BURIED UTILITY WARNING AND IDENTIFICATION TAPE

Polyethylene plastic tape manufactured specifically for warning and identification of buried utility lines. Tape shall be of the type provided in rolls, 152 mm 6 inches minimum width, color codes for compressed air (gray) with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED COMPRESSED AIR LINE BELOW" or similar wording. Code and letter coloring shall be permanent, unaffected by moisture and other substances contained in trench backfill material.

2.15 FRESH WATER

Fresh water for cleaning, flushing, and testing shall be clean and potable.

2.16 BASIC PIPING AND COMPONENT MATERIALS

Conform to the following where material is specified by generic type and no specification is listed.

2.16.1 Stainless Steel

Austenitic type, annealed, ASTM A182/A182M.

2.16.2 Nickel-Copper

70-30 nickel-copper, annealed, ASTM B164, alloy N04400, ASTM B127.

2.16.3 Copper-Nickel

70-30 copper-nickel, soft temper, MIL-C-15726.

2.16.4 Other Materials

For materials where no specification is listed above, conform to material specifications listed in ASME B31.1 or ASME BPVC SEC VIII D1.

2.17 SOURCE QUALITY CONTROL

Test air compressors and compressed air dryers at the factory to assure

proper operation. Certify satisfactory accomplishment of tests.

PART 3 EXECUTION

3.1 INSTALLATION

Install materials and equipment as indicated and in accordance with manufacturer's recommendations.

3.1.1 Excavation and Backfilling

Section 31 00 00 EARTHWORK.

3.1.2 Corrosion Protection

Provide corrosion protection for buried steel [and corrosion resistant steel] piping in accordance with Section 09 97 13.28 PROTECTION OF BURIED STEEL PIPING AND STEEL BULKHEAD TIE RODS.

3.1.3 Piping

Provide Non-Destructive Examination (NDE) report for welding of piping. Unless specifically stated to the contrary, fabrication, assembly, welding, and brazing shall conform to ASME B31.1 for all piping of the air system. Piping shall follow the general arrangement shown. Cut piping accurately to measurements established for the work. Work piping into place without springing or forcing, except where cold-springing is specified. Piping and equipment within buildings shall be entirely out of the way of lighting fixtures and doors, windows, and other openings. Locate overhead piping in buildings in the most inconspicuous positions. Do not bury or conceal piping until it has been inspected, tested, and approved. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected and building structure shall not be weakened. Avoid interference with other piping, conduit, or equipment. Except where specifically shown otherwise, vertical piping shall run plumb and straight and parallel to walls. Piping connected to equipment shall be installed to provide flexibility for vibration. Adequately support and anchor piping so that strain from weight of piping is not imposed on the equipment.

3.1.3.1 Fittings

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NOTE: Delete bending of medium or high pressure pipe when not included in project.

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Use long radius ells where appropriate to reduce pressure drops. Pipe bends in lieu of fittings may be used for piping where space permits. Pipe bends shall have a uniform radius of at least five times the pipe diameter and must be free from any appreciable flattening, wrinkling, or thinning of the pipe. Mitering of pipe to form elbows, notching straight runs to form full sized tees, or any similar construction shall not be used. Make branch connections with welding tees, except factory made forged welding branch outlets or nozzles having integral reinforcements conforming to ASME B31.1 may be used.

Bending of High Pressure Pipe: Prior to bending pipe for high pressure systems, the Contractor shall submit for approval written fabrication and

inspection procedures and calculations showing the required minimum wall thickness of pipe after bending. Only cold bending shall be permitted. The fabrication procedure shall indicate the required pipe wall thickness prior to bending, equipment to be used, set up and bending procedures, and inspection and acceptance criteria. Inspection shall include verification of minimum wall thickness by ultrasonic or other methods if deemed necessary by the Contracting Officer. No wrinkles or other contour irregularities will be permitted in the bent pipe. Check flattening in accordance with ASME B31.1. Include required dimensional checks in inspection procedures and acceptable values tabulated for each pipe size to be bent. Qualified personnel shall perform nondestructive examinations required in accordance with qualified procedures.

3.1.3.2 Clearances for Welding

Provide clearances from walls, ceilings, and floors to permit the installation of joints. The clearances shall be at least 150 mm 6 inches for pipe sizes 100 mm 4 inches and less, 250 mm 10 inches for pipe sizes over 100 mm 4 inches, and sufficient in corners. However, the specified clearances shall not waive requirements for welders to be qualified for the positions to be welded.

3.1.3.3 Cleaning

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NOTE: Special cleaning requirements are mainly intended for high pressure systems. Special cleaning should also be considered for medium pressure systems over 1724 kPa (gage) 250 psig which may be subject to dieseling explosions when oil contamination is present. Objective cleaning standards are specified to simplify inspection and acceptance in the field.

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Before jointing and erection of piping or tubing, thoroughly clean interiors of pipe sections, tube, and components. In steel pipe, loosen scale and other foreign matter by rapping sharply and expel by wire brush and swab. Blow out both steel pipe and copper tube and components with compressed air at 690 kPa (gage) 100 psig or more. Maintain cleanliness by closure of pipe/tube openings with caps or plugs. Before making final terminal connections, blow out complete system with compressed air at 690 kPa (gage) 100 psig or more. Cleaning and cleanness of medium pressure systems over 1724 kPa (gage) 250 psig and high pressure systems shall conform to the paragraph entitled "Cleaning and Cleanness Requirements."

3.1.3.4 Changes in Pipe Size

Use reducing fittings for changes in pipe size. The use of bushings will not be permitted. In horizontal lines, 65 mm 2 1/2 inches and larger, reducing fittings shall be of the eccentric type to maintain the bottom of the lines in the same plane.

3.1.3.5 Drainage and Flexibility

Compressed air piping shall be free of unnecessary pockets and pitched approximately one mm per 400 mm 3 inches per 100 feet in the direction of flow to low points. Where pipes must be sloped so that condensate flows in opposite direction to air flow, slope one mm per 200 mm 6 inches per

100 feet or greater. Provide flexibility by use of fittings, loops, and offsets in piping. Install branches at top of a main to prevent carryover of condensate and foreign matter.

3.1.4 Threaded Joints

Where possible use pipe with factory cut threads, otherwise cut pipe ends square, remove fins and burrs, and cut taper pipe threads in accordance with ASME B1.20.1. Threads shall be smooth, clean, and full cut. Apply thread tape to male threads only. Work piping into place without springing or springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed.

3.1.5 Flanged Joints in High Pressure System

Install using calibrated torque wrenches or feeler gage methods to assure proper gasket compression. Calibrate torque wrench immediately prior to use.

3.1.6 Welding and Brazing

Perform welding and brazing in accordance with qualified procedures using qualified welders and welding operators and brazers. Do not perform welding and brazing when the quality of the completed weld or braze could be impaired by the prevailing working or weather conditions. The Contracting Officer will determine when weather or working conditions are unsuitable for welding. Welding of hangers, supports, and plates to structural members shall be in accordance with AWS D1.1/D1.1M. Mark welding and brazing detail drawings to identify the welder or brazer making the joint.

3.1.6.1 Cleaning for Welding and Brazing

Surfaces to be welded or brazed shall be free from loose scale, slag, rust, paint, oil, and other foreign material. Joint surfaces shall be smooth and free from defects which might affect proper welding. Clean each layer of weld metal thoroughly by wire brushing, grinding, or chipping prior to inspection or deposition of additional weld metal. Conform to paragraph entitled "Cleaning and Cleanness Requirements" [for medium pressure systems over 1724 kPa (gage) 250 psig] [and] [for high pressure] systems.

3.1.6.2 Stress Cracking During Brazing

For austenitic stainless steel and other material susceptible to stress corrosion cracking from molten brazing filler metal, avoid applying stress during brazing.

3.1.6.3 Welding or Brazing of Valves

Welding or Brazing of Valves: Disassemble valves subject to damage from heat during welding or brazing and reassemble after installation. Open valves two or three turns off the seat when not subject to heat damage during welding or brazing; do not backseat valve.

3.1.7 Valves

Install valves in conformance with ASME B31.1 at the locations indicated

and elsewhere as required for the proper functioning of the system.

3.1.7.1 Globe Valves

Install globe valves so that the pressure will be below the disk. Install globe valves with the stems vertical.

3.1.7.2 Pressure-Reducing Valves

Provide compressed air entering each pressure-reducing valve with a strainer. Provide each pressure-reducing valve unit with two block valves and with a globe or angle bypass valve and bypass pipe. Provide a bypass around a reducing valve of reduced size to restrict its capacity to approximately that of the reducing valve. Provide each pressure reducing valve unit with an indicating gage to show the reduced pressure, and a safety valve on the lower pressure side. These requirements do not apply to small pressure regulating valves used to adjust pressure for pneumatic equipment.

3.1.8 Hangers and Supports

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NOTE: See UFC 1-200-01, "General Building Requirements" and UFC 3-301-01, "Structural Engineering", for calculating pipe support spacing for schedules not shown. Also, space supports for high pressure air piping to provide restraint against whipping and damage to other piping if the high pressure line breaks; see DM 3.5, "Compressed Air and Vacuum Systems," Section 7, "Piping Systems." Delete Table I and reference to seismic requirements if not required.

****

Selection, fabrication, and installation of piping hangers and supports shall conform to MSS SP-58, MSS SP-69 [except that spacing of the hangers and supports shall be as per Table I].[Provide seismic restraints for piping in accordance with SMACNA 1981.]

TABLE I. MAXIMUM SPAN FOR PIPE

DIAMETER MM	STD. WT. STEEL PIPE SCHEDULE 40	EX. STRONG STEEL PIPE SCHEDULE 80
15	1.52	1.52
20	1.75	1.75
25	1.98	1.98
40	2.29	2.36
50	2.59	2.59
65	2.82	2.90

80	3.125	3.20
90	3.35	3.35
100	3.51	3.58
125	3.89	3.96
150	4.19	4.27
200	4.73	4.88
250	5.18	5.34
300	5.56	5.79

TABLE I. MAXIMUM SPAN FOR PIPE		
DIAMETER INCHES	STD. WT. STEEL PIPE SCHEDULE 40	EX. STRONG STEEL PIPE SCHEDULE 80
1/2	5'-0"	5'-0"
3/4	5'-9"	5'-9"
1	6'-6"	6'-6"
1-1/2	7'-6"	7'-9"
2	8'-6"	8'-6"
2-1/2	9'-3"	9'-6"
3	10'-3"	10'-6"
3-1/2	11'-0"	11'-0"
4	11'-6"	11'-9"
5	12'-9"	13'-0"
6	13'-9"	14'-0"
8	15'-6"	16'-0"
10	17'-0"	17'-6"
12	18'-3"	19'-0"

3.1.9 Pressure Gages

Provide pressure gauges with a shut-off valve or petcock installed between the gage and the line.

3.1.10 Strainers

Provide strainers with meshes suitable for the services where indicated, or where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

3.1.11 Equipment Foundations

Provide equipment foundations of sufficient size and weight and of proper design to preclude shifting of equipment under operating conditions or under any abnormal conditions which could be imposed upon the equipment. Provide foundations which meet the requirements of the equipment manufacturer, and when required by the Contracting Officer, obtain from the equipment manufacturer approval of the foundation design and construction for the equipment involved. Equipment vibration shall be maintained within acceptable limits, and shall be suitably dampened and isolated.

3.1.12 Equipment Installation

Install equipment strictly in accordance with these specifications, and the manufacturers' installation instructions. Grout equipment mounted on concrete foundations before piping is installed. Install piping in a manner that does not place a strain on any of the equipment. Do not bolt flanged joints tight unless they match properly. Extend expansion bends adequately before installation. Grade, anchor, guide and support piping without low pockets.

3.1.13 Cleaning of System

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NOTE: Special cleaning requirements are mainly intended for high pressure systems. Special cleaning should also be considered for medium pressure systems over 1724 kPa (gage) 250 psig which may be subject to dieseling explosions when oil contamination is present. Objective cleaning standards are specified to simplify inspection and acceptance in the field.

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Clean the various system components before final closing as the installations are completed. Remove foreign matter from equipment and surrounding areas. [Cleaning and cleanliness shall conform to paragraph entitled "Cleaning and Cleanliness Requirements" for pressures over 1724 kPa (gage) 250 psig.] Preliminary or final tests will not be permitted until the cleaning is approved by the Contracting Officer.

3.1.14 Pipe Sleeves

Provide pipe sleeves where pipes and tubing pass through masonry or concrete walls, floors, roofs, and partitions. Hold sleeves securely in proper position and location before and during construction. All sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Extend sleeves in floor slabs 50 mm 2 inches above the finished floor. Pack space between the pipe or tubing and the sleeve firmly with oakum and caulk both ends of the sleeve with elastic cement.

3.1.15 Floor, Wall, and Ceiling Plates

Provide chromium-plated steel or nickel-plated cast iron plates on pipes passing through floors and partitions of finished rooms. Provide painted cast-iron, malleable iron, or steel for other areas.

3.1.16 Flashing for Buildings

Provide flashing [as required] [in accordance with Section 07 60 00 FLASHING AND SHEET METAL] where pipes pass through building roofs and outside walls.

3.1.17 Unions and Flanges

Provide unions and flanges where necessary to permit easy disconnection of piping and apparatus, and as indicated. Provide a union for each connection having a screwed-end valve. [Provide unions or flanges not farther apart than 30 meters 100 feet.] [Provide unions or flanges as indicated.] Provide unions on piping under 50 mm 2 inches in diameter, and provide flanges on piping 50 mm 2 inches and over in diameter. Install dielectric unions or flanges between ferrous and non-ferrous piping, equipment, and fittings; except that bronze valves and fittings may be used without dielectric couplings for ferrous-to-ferrous or non-ferrous to non-ferrous connections.

3.1.18 Painting of Piping and Equipment

Paint piping and equipment in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.1.19 Identification of Piping

Identify piping in accordance with PFI ES 22. Use commercially manufactured piping identification labels. Space identification marking on runs not farther apart than 15 meters 50 feet. Provide two copies of the piping identification code framed under glass and install where directed.

3.1.20 Warning and Identification Tape

Coordinate installation of utility warning and identification tape with backfill operation. Provide tape above buried lines at a depth of 200 to 305 mm 8 to 12 inches below finish grade.

3.2 CLEANING AND CLEANNESS REQUIREMENTS

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NOTE: Special cleaning requirements are mainly intended for high pressure systems. Special cleaning should also be considered for medium pressure systems over 1724 kPa (gage) 250 psig which may be subject to dieseling explosions when oil contamination is present. Objective cleaning standards are specified to simplify inspection and acceptance in the field.

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Cleaning and cleanness requirements shall conform to ASTM A380/A380M and the following.

3.2.1 Substitution

The word "shall" shall be substituted for "should" in ASTM A380/A380M.

3.2.2 Prohibited Methods and Processes

The following methods and processes shall not be used.

a. Chemical descaling (acid pickling).

b. Abrasive blasting and vapor blasting.

c. Alkaline cleaning.

d. Emulsion cleaning.

e. Chelate cleaning.

f. Acid cleaning.

g. Passivation.

h. Corrosion inhibitors shall not be used.

3.2.3 Approval of Methods and Procedures

Prepare and submit written cleaning procedures for approval. Perform production cleaning in accordance with approved procedures.

3.2.4 Tools Used on Corrosion-Resistant Alloys

Tools used on corrosion-resistant alloys such as grinding, polishing, filing, deburring, and brushing tools shall be visually clean and shall not have been used on carbon or low alloy steels, aluminum, lead or materials containing lead or lead components, or other low melting point materials. Wire brushes shall be 300 series stainless steel. Unless otherwise approved, each tool shall be used on only one type of corrosion-resistant metal.

3.2.5 Cleaning Before Installation

Clean piping, components, and equipment before installation.

3.2.6 Cleaning Requirements

Clean surfaces containing no crevices or inaccessible areas by any of the procedures described herein. Clean surfaces containing crevices by immersion in unused or redistilled acetone, ethanol, or isopropanol only.

3.2.6.1 Vapor Degreasing

Vapor degreasing may be used on surfaces containing no crevices or inaccessible areas and shall be accomplished by the following procedures:

a. Dry all parts entering degreaser.

b. Load parts onto racks in the condensing zone so that they do not touch each other, and in such a manner to insure complete draining of

solvents.

c. Use perchloroethylene bath. Maintain bath at 121 to 127 degrees C 250 to 260 degrees F. The bath shall contain a neutral inhibitor to prevent acid formation due to hydrolysis. Other types of inhibitors are not permitted.

d. Change solvent when boiling point of perchloroethylene exceeds 127 degrees C 260 degrees F. Dump solvent earlier if cleanliness standards are not attained.

e. Lower or raise parts in the degreaser at a rate not to exceed 5 mm/s 12 inches per minute and immerse in vapor phase. Spray with clean solvent during immersion time. Keep the spray nozzle at least 305 mm one foot below the vapor line during spraying. Allow part to remain in vapor until condensation ceases (3 to 5 minutes). Dry parts completely before removing from degreaser.

3.2.6.2 Degreasing by Immersion or Wiping

Degreasing of parts having no inaccessible areas or crevices may be performed by immersion in solvent or by wiping with a clean lintless wiping cloth saturated with the solvent perchloroethylene, unused or redistilled acetone, ethanol, or isopropanol, or Stoddard solvent for preliminary degreasing. Dry in accordance with paragraph entitled "Drying Requirements."

3.2.6.3 Trisodium-Phosphate Detergent Cleaning (Degreasing)

Trisodium-phosphate detergent cleaning may be used on surfaces containing no crevices or inaccessible areas and shall be accomplished as follows:

a. Remove heavy dirt by either scrubbing with a non-shedding bristle brush using a solution of up to 112.2 mL one fluid ounce of nonionic detergent per liter gallon of tap water or immersing the parts in a hot (approximately 71 - 88 degrees C 160 - 190 degrees F) solution consisting of 207 to 296 mL 7 to 10 ounces of trisodium phosphate and up to 112.2 mL one fluid ounce of the nonionic detergent per liter gallon of tap water for about 20 minutes. Agitate and use brush as necessary.

b. Rinse parts thoroughly in hot water at a minimum of 49 degrees C 120 degree F.

c. Dry the parts in accordance with paragraph entitled "Drying Requirements."

3.2.6.4 Ultrasonic Cleaning

Cleaning methods using ultrasonic equipment may be used.

3.2.7 Drying Requirements

Accomplish drying by still or forced clean air or inert gas, drying oven, or by evacuation. When using evacuation, exercise care to prevent evacuating-pump lubricant from entering the equipment. Check compressed air used for drying to ensure cleanliness by blowing through a clean, white, cotton filter cloth for about 5 minutes at full drying velocity.

3.2.8 Inspection and Acceptance Criteria for Cleanliness

Conform to ASTM A380/A380M and the following:

3.2.8.1 Cleanness Criteria

All surfaces of piping material, equipment, instruments, and other components which will come in contact with compressed air shall be clean to the extent that no contamination is visible to a person with normal visual acuity (natural or corrected) under a lighting level of at least 1076 lux 100 footcandles on the surface being inspected. Cleanness of surface which cannot be visually inspected due to inaccessibility or geometry shall be determined by an interpretation of the discoloration or dirt obtained by wiping with a clean, white, wet or dry cloth. Free of contamination shall mean free of oil, dirt, metallic flakes, preservatives, paint, and any other substances which may present a safety hazard or impair the quality of the compressed air.

3.2.8.2 Critical Surfaces

No rust shall be allowed on valve seats, orifice plates or other critical surfaces. Thin films of rust are acceptable on other corrosion-resistant material surfaces provided there is no visible thickness or evidence of pitting and the total area involved does not exceed one percent of the total surface area of the component in contact with compressed air.

3.2.8.3 Carbon and Low Alloy Steels

A uniform light rust that can be removed by brushing or wiping is acceptable.

3.2.9 Maintaining Cleanness During Installation

Maintain cleanness of piping, components, and equipment during installation. Dirt and debris producing operations shall be performed so that dirt and debris fall away from system openings; otherwise, provide covers over openings to preclude contamination. Cap, plug, cover, or bag openings and pipe ends and secure with tape when they are not required to be open for the performance of work. Metal caps, plugs, and covers shall be austenitic stainless steel. Plastic items and tape shall be free of substances that can have a harmful effect on stainless steel and other corrosion-resistant metals in the system.

3.2.10 Cleanness Verification Flushes

After installation, check the systems for cleanness by flushing with water. Perform flushing so that the minimum velocity through any part of the system is not less than [1.1] [_____] meters [3.6] [_____] feet per second. Pass flush water through a filter for cleanness evaluation. Filter element shall be corrosion-resistant wire cloth with mesh size conforming to ASTM E11, No. 20 (850 micrometers), No. 25 (710 micrometers), or No. 30 (600 micrometers). Filter area shall be sufficient to limit pressure drop so that required flushing velocity can be attained.

3.2.10.1 Flush Acceptance Criteria

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NOTE: Select flush acceptance criteria based on how

critical the system is and the volume of system to be flushed. More particles may be expected and may be acceptable in larger systems.
****

The system shall be flushed until there is no more than [slight speckling] [[0.1] [0.5] [_____] cubic centimeters] of particulates on the filter screen. There shall be no particles larger than 0.79 by 1.59 mm 1/32 by 1/16 inch long. The flush water shall show no visual evidence of contamination such as oil particles, discoloration, or iridescent surface film characteristic of oil.

3.2.10.2 Recleaning of Systems

Systems which fail to meet acceptance flush criteria after flushing for more than 4 hours shall be recleaned by the Contractor at no additional cost to the Government. Prepare recleaning procedures and submit to the Contracting Officer for approval. Remove instruments, components, and any other items that may be damaged by recleaning. Perform recleaning by flushing with hot water at not less than 60 degrees C 140 degrees F.

3.3 CLEANING SILVERBRAZED PIPING

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NOTE: All silverbrazed piping, including low pressure systems, should be cleaned to preclude corrosion from residual brazing flux.
****

Clean silverbrazed piping to remove residual flux remaining in the system after fabrication. Use one of the procedures below. The hot flush and hot recirculating flush are preferred. Minimum flow rate through any part of the system in liters gallons per second minute shall be 0.0037 1.5 times the inside diameter of the pipe in mm inches. For any flushing method used, the system shall be full of water so that joints are completely submerged at all times.

3.3.1 Hot Flushing Method

Hot flush the system for one hour using heated fresh water. No part of the system shall go below 43 degrees C 110 degrees F.

3.3.2 Hot Recirculating Flush Method

Perform hot recirculating flush for one hour. Heat water during flushing so that no part of the system falls below 43 degrees C 110 degrees F. After completing the hot recirculating flush, flush the system with cold fresh water for 15 minutes.

3.3.3 Cold Soak Method

Cold soak the system using fresh water at not less than 15.50 degrees C 60 degrees F for 12 hours. Following the 12 hour soak, flush the system with fresh water at not less than 15.50 degrees C 60 degrees F for 4 hours.

3.4 FIELD QUALITY CONTROL

3.4.1 Examinations

3.4.1.1 Welding Examinations

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NOTE: The paragraphs will be edited and inserted if necessary to ensure proper implementation of the "CONTRACTOR QUALITY CONTROL PROGRAM." The specification writer or design engineer must indicate how much quality control of welding is needed for each project and who is to be responsible, i.e., primarily the Contractor or the Government. Rarely will a project require 100 percent testing of welds by NDE methods. The designer must determine the required methods and the extent of inspection and testing and must indicate the extent in this section of the project specifications or on the project drawings by notes, nondestructive test symbols, or other means. Table II at the end of this section was developed from MIL-STD-278, "Fabrication, Welding and Inspection, and Casting Inspection and Repair for Machinery, Piping, and Pressure Vessels in Ships of the United States Navy." The referenced applicable publications and Army Technical Manual, "WELDING DESIGN, PROCEDURES AND INSPECTION," TM-5-805-7, may be used for guidance in determining inspection and testing requirements. The specifications or drawings must clearly indicate which joints require 100 percent NDE inspection, which joints require random NDE inspection, and which NDE methods are to be employed for each joint. For random inspection, the drawings must indicate the location, number of joints, and minimum increment length of weld that will be subject to NDE inspection without predisclosing the exact spots to be examined. Joints not indicated to be tested by NDE methods shall be subject to visual inspection only. In cases where the nature of the welding is such as to require visual inspection only, the requirements for other nondestructive examinations should be deleted from these paragraphs and from paragraph entitled "QUALIFICATION OF INSPECTION AND NONDESTRUCTIVE PERSONNEL."

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NOTE: Information based on Table II must be developed and included in each project specification. Table must clearly define the systems to be inspected and the type of NDE required. Revise Table II if required for the project.

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[The Government will][The Contractor shall]perform visual and nondestructive examinations to detect surface and internal discontinuities

in completed welds, and submit a Non-Destructive Examination (NDE) report meeting the requirements specified in ASME B31.1.[The Contractor shall obtain the services of a qualified commercial inspection or testing laboratory or technical consultant, approved by the Contracting Officer.] Visually examine welds. Perform [radiographic,][liquid penetrant,][or][magnetic particle] examination as specified in Table II of this section. For systems operating at 6894 kPa (gage) 1000 psig or higher, all welds shall be examined. For high pressure systems operating less than 6894 kPa (gage) 1000 psig, perform random NDE. When examination and testing indicate defects in a weld joint, the weld shall be repaired by a qualified welder. Remove and replace defects as specified in ASME B31.1, unless otherwise specified. Repair defects discovered between weld passes before additional weld material is deposited. Whenever a defect is removed, and repair by welding is not required, blend the affected area into the surrounding surface, eliminating sharp notches, crevices, or corners. After defect removal is complete and before rewelding, examine the area by the same test methods which first revealed the defect to ensure that the defect has been eliminated. After rewelding, reexamine the repaired area by the same test methods originally used for that area. Any indication of a defect shall be regarded as a defect unless reevaluation by surface conditioning [and NDE] shows that no unacceptable defects are present. The use of any foreign material to mask, fill in, seal, or disguise welding defects will not be permitted.

3.4.1.2 Brazing Examinations

The Contractor shall perform brazing examinations.

a. Visual Examinations

Visually examine all compressed air systems as follows:

(1) Check brazed joint fit-up. Diametrical clearances shall conform to brazing procedure requirements.

(2) Check base material of pipe and fitting for conformance to the applicable drawing or specification.

(3) Check grade of brazing alloy for conformance to the brazing procedure before fit-up or brazing.

(4) Check completed brazed joint for a complete ring of brazing alloy between the outside surface of the pipe and the face of the fitting, and for a visible fillet.

(5) Check stainless steel and other susceptible material for evidence of stress cracks. Check inside of joint if possible with borescope or other aids.

b. Nondestructive Examination

For high pressure compressed air systems, any fitting, copper-nickel pipe, or stainless steel tubing which is reused after unsweating a brazed joint shall be liquid penetrant examined for cracks. Any crack detected shall be cause for rejection of the fitting or pipe. Liquid penetrant examination shall be performed by qualified personnel.

c. Repair of Brazed Joints

Defective joints may be repaired. However, no more than two attempts to repair by reheating and additional face feeding of brazing filler metal will be permitted, after which the defective joint shall be unsweated, reprepared as a new joint, examined for defects on pipe and fittings, and rebrazed. Perform required NDE.

3.4.2 Testing

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NOTE: If air (pressure) drop tests are used for system acceptance, assure that leakages at acceptable rates through valves (or other components) are not causing pressure drop. Most hard-seated valves have some allowable leakage rate (about 10 cubic centimeters 0.0026 gal per hour of water per 25 mm one inch valve size or 3 liters per hour 0.1 cubic feet per hourof gas per 25 mm one inch of valve size). Delete check for cross-connection if only one type of system is involved in project.

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3.4.2.1 General Requirements, Testing

Perform testing after cleaning and acceptance of cleanness. Contractor shall provide everything required for tests. Tests shall be subject to the approval of the Contracting Officer. Calibrate the test pressure gage with a dead weight tester within [15] [_____] days before use and certify by initial and date on a sticker applied to dial face. [Pressurize each piping system individually and check to assure that there are no cross-connections between different systems prior to hydrostatic and operational tests.]

Supervision of Testing

For [high] [and] [medium] pressure system, an experienced registered professional engineer responsible for safety and employed by the Contractor shall be present during testing.

3.4.2.2 Hydrostatic and Leak Tightness Tests

a. Preliminary Preparation

Remove or isolate from the system the compressor, air dryer, filters, instruments, and equipment which would be damaged by water during hydrostatic tests and reinstall after successful completion of tests.

b. Performance of Hydrostatic Tests

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NOTE: Specify or show on the drawings the design working pressure of each system in the project.

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Hydrostatically test piping systems in accordance with ASME B31.1. Vent or flush air from the piping system. Pressurize system for 10 minutes with water at one and one-half times design working pressure, then reduce to design working pressure and check for leaks and weeps.

c. Compressed Air Leak Tightness Test

After satisfactory completion of hydrostatic pressure test, blow systems dry with clean, oil-free compressed air, and test with clean, dry air at design working pressure. Brush joints with soapy water solution to check for leaks. Install a calibrated test pressure gage in piping system to observe any loss in pressure. Maintain required test pressure for a sufficient length of time to enable an inspection of joints and connections.

d. Compressed Air Pressure Test For High Pressure Systems

For high pressure systems, compressed air at system design pressure shall then stand in a system to equalize temperature. Pressure drop, corrected for temperature change, shall not be more than one percent in 24 hours for a test pressure 6894 kPa (gage) 1000 psig and above, and not over 5 percent in 6 hours for test pressures from 2758 to 6894 kPa (gage) 400 to 1000 psig. Use formula below to correct pressure for temperature change.

PF + 101.32 = (PI + 101.32)(TF + 273)/(TI + 273) PF + 14.7 = (PI + 14.7)(TF + 460)/(TI + 460)
Where PF = Final Pressure, (kPa (gage)) (psig)
Where PI = Initial Pressure, (kPa (gage)) (psig)
Where TF = Final Temperature, (degrees C F)
Where TI = Initial Temperature (degrees C F)

3.4.2.3 Operational Tests

Test equipment as in service to determine compliance with contract requirements and warranty. During the tests, test equipment under every condition of operation. Test safety controls to demonstrate performance of their required function. Completely test system for compliance with specifications.

3.5 INSTRUCTION TO GOVERNMENT PERSONNEL

Provide [2] [_____] man-days of instruction to [2] [_____] Government personnel in accordance with Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS for each type of compressor and compressed air dryer in the project.

TABLE II						
HP Piping (2758 kPa (Gage) Higher) Inspection Requirements 1/						
Required Nondestructive Examination						
Welded Joint type and pipe size, mm	VISUAL EXAMINATION		T/PT TEST		RADIOGRAPHY	
	Root Layer	Completed Weld	Root Layer	Completed Weld	Completed Weld	Extent Of
Butt 100 and greater	X2/	X	X2/	X3/	X	6.28 radian
Butt 65 to 90 incl	X2/	X	X2/	X3/	X4/5/	At least 105 radian
Butt less than 65	X2/	X	X2/	X3/	X4/5/6/	At least 105 radian
All socket and fillets	X2/	X	X2/	X	--	--

TABLE II						
HP Piping (400 psig and Higher) Inspection Requirements 1/						
Required Nondestructive Examination						
Welded Joint type and pipe size, inches	VISUAL EXAMINATION		T/PT TEST		RADIOGRAPHY	
	Root Layer	Completed Weld	Root Layer	Completed Weld	Completed Weld	Extent Of
Butt 4 and greater	X2/	X	X2/	X3/	X	360 degrees
Butt 2-1/2 to 3-1/2 incl.	X2/	X	X2/	X3/	X4/5/	At least 60 degrees
Butt less than 2-1/2	X2/	X	X2/	X3/	X4/5/6/	At least 60 degrees

TABLE II						
HP Piping (400 psig and Higher) Inspection Requirements 1/						
Required Nondestructive Examination						
Welded Joint type and pipe size, inches	VISUAL EXAMINATION		T/PT TEST		RADIOGRAPHY	
	Root Layer	Completed Weld	Root Layer	Completed Weld	Completed Weld	Extent Of
All socket and fillets	X2/	X	X2/	X	--	--

Legend: X - Indicates that test is required.

MT Magnetic Particle Inspection

PT Liquid Penetrant Inspection

RT Radiographic Examination

NOTES:

1/ Where new welds in piping intersects existing or older welds, the latter welds shall be inspected for a distance of 150 mm 6 inches or a distance equal to 50 percent of the pipe size diameter, whichever is less, as measured from points of intersection. The existing or older weld and adjacent base material shall be free from cracks. Where non-intersecting adjacent existing welds are inadvertently radiographed, only cracks shall be cause for rejection.

2/ MT/PT inspect the first or root pass of welds and when accessible, the reverse or back-chipped ground, gouged or machined side prior to depositing metal on the reverse side. Visual examination at 5X magnification may be substituted for MT/PT inspection. Linear discontinuities shall be unacceptable. Use 5X inspection where crevices cannot be cleaned thoroughly.

3/ MT/PT test shall be performed only when post-weld heat treatment is required and when specified on drawing. The test shall be conducted after heat treatment and shall include 6.28 radian 360 degrees of circumferential weld surface and adjacent base material. Where 6.28 radian 360 degrees RT is performed after heat treatment, MT/PT is not required, except where specified on drawing.

4/ RT of welds on piping in the horizontal fixed position shall represent a sector which was welded in the vertical or overhead position.
5/ In lieu of 1.05 radian 60 degree RT, PT or MT may be performed on the inside of a joint where weld is within 2 1/2 nominal pipe diameters from the open end is back welded, has backing ring removed or used consumable insert.
6/ RT is required where the working pressure exceeds 3964 kPa (gage) 575 psig. For working pressure 3964 kPa (gage) 575 psig and below, inspection may be performed in lieu of RT.

-- End of Section --