FMOC

Specification Section 15215 Compressed Gas Piping - Interior

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National Nuclear Security Administration

Sandia National Laboratories

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Change Log

Rev. No.	Changed By	Date	Change Description	Pages Changed
0	KLB DSW	5/31/11	Applied FMOC brand and format. Edited for punctuation, grammar, and general writing improvements and incorporated reviewer comments. Change the reference for cleaning and installing oxygen service piping from the Compressed Gas Association pamphlet G-4.1 "Pamphlet - Cleaning Equipment for Oxygen Service" to ASTM G 93 "Standard Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments" Require a submittal for welding and brazing procedures and welders similar to what is in the piping spec. For Argon, Helium, and Nitrogen systems delete the option to use steel piping. Change the specified ball valve from a Worcester to a Whitey Series 60. Use brass threaded adapters rather than copper in brazed joints to minimize heat distortion of threads resulting in potential leaks. Expand the pipe size for use of Swagelok fitting from less than 1/2 inch to 1/2 half inch and smaller. Require that soldered and brazed joints be installed per the Copper Development Association recommended practices manual. Change the pressure test requirements from 24 hours to 4 hours with zero pressure drop.	All

Part 1 - General

1.01 Summary

A. This section includes materials and operations required for the installation of interior, low-pressure (below 150-psig) compressed gas piping systems, including argon, helium, nitrogen, oxygen, hydrogen, chlorine, acetylene, and methane piping, fittings, valves, equipment, joints, and tests.

B. Related Sections: Refer to the following sections for related work:

1.02 References

The current editions of the following standards are a part of this specification:

A. Sandia National Laboratories (SNL) Construction Standards and Specifications

Number	Title
Section 01330	Submittal Procedures
Section 07270	Firestopping.
Section 09900	Painting.
Section 15050	Basic Mechanical Materials and Methods.
Section 15051	Piping Systems.

B. American National Standards Institute (ANSI)

Number	Title
B31.1	Power Piping
B2.1	Standard Welding Procedure Specification (WPS) Gas Metal Arc Welding of Austenitic Stainless Steel (M-8 or P-8), 10 through 18 Gage, in the As-Welded Condition, With or Without Backing
B1.2	Hose Coupling Screw Threads
B16.11	Forged Fittings, Socket-Welding and Threaded
B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
B31.3	Code for Pressure Piping, Chemical Plant and Petroleum
B1.1	Unified Inch Screw Threads

C. American Society of Mechanical Engineers (ASME)

Section IX, Boiler and Pressure Vessel Code, *Welding and Brazing Qualifications*

D. American Society of Testing and Materials (ASTM)

Number	Title
A53	Standard Specification for Pipe Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless
A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
A334M	Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
A420M	Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service
A632	Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Service
B88	Standard Specification for Seamless Copper Water Tube for Air Conditioning
A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
B819	Standard Specification for Seamless Copper Tube for Medical Gas Systems
G93	Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment Used in Oxygen-Enriched Environments

E. American Welding Society (AWS)

Number	Title
A5.8	Specification for Filler Metals for Brazing
	Brazing Manual, 3rd Edition, 1976
B2.2	Standard for Brazing Procedure and Performance Qualifications

F. National Fire Protection Association (NFPA)

Number	Title
50	Standard for Bulk Oxygen Systems
50a	Gaseous Hydrogen Systems
50b	Liquefied Hydrogen Systems
99	Health Care Facilities

G. Copper Development Association

1.03 Submittals

A. General: Submit the following in accordance with Conditions of Contract documents and Section 01330, "Submittal Procedures:"

B. Product Data: Submit product data for products used in Interior Compressed Gas Piping. Product data must indicate the maximum allowable operating pressure and temperature of each component and any related manufacturing standard.

C. As-Built Drawings

- On completion of the work, the Contractor must revise all drawings with a red marker to agree with the construction materials, capacities, locations, and routing as actually accomplished. The notation "As-Built" must be entered in the revision block, dated, and initialed.

D. All certifications for welders and brazers, and welding and brazing procedures must be submitted for verification of quality assurance at least two weeks before starting any work. The procedures and certifications are reviewed by the SNL-designated certified welding inspector.

1.04 Quality Assurance

A. Qualify welding/brazing processes and welder/brazer performance in accordance with AWS B2.2 or ASME Boiler and Pressure Vessel Code, Section IX. Certify that each welder/brazer has satisfactorily passed AWS or ASME qualification tests for welding/brazing processes involved and, if pertinent, has undergone recertification.

B. Welding and brazing procedures must address cleaning, joint clearance, overlaps, internal purge gas, purge gas flow rate, and filler metal.

C. Certification of procedures and operators applies for both shop and job site welding and brazing of pipe work.

D. Soldering is to conform to ANSI/American Society of Mechanical Engineers (ASME) B31.1, *Power Piping,* and the Copper Development Association recommended practices.

E. Operators must have completed the SNL Welding Safety Class.

F. Performance qualification of welders/brazers must remain in effect indefinitely unless the welder/brazer does not weld or braze with the qualified procedure for a period exceeding 12 months by proof of continuity logs, or there is a specific reason to question the ability of the welder/brazer.

1.05 Delivery, Storage, and Handling

A. Deliver materials to the job site in good condition and properly protected against damage to finished surfaces.

B. Storage on Site: Store materials in a location and in a manner to avoid damage. Stacking must be done so as to prevent bending.

- Store metal components and materials in a clean, dry location. Cover with waterproof paper, tarpaulin, or polyethylene sheeting so as to permit circulation of air inside the cover.

C. Keep handling onsite to a minimum. Exercise care to avoid damage to material finishes.

D. Pipe, fittings, and valves specified for "Cleaned and Packaged for Oxygen Service" must be capped and bagged until use.

Part 2 - Products

2.01 Materials

A. General: Materials must be as follows unless otherwise indicated on the applicable contract drawings (valves of equal quality and characteristics may be substituted for those listed in this specification):

B. Piping, fittings, valves, and other components that are required to be "Cleaned and Capped/Packaged for Oxygen Service" must be per ASTM G 93.

C. Pipe and fittings to be used for modifications or additions must be the same material (steel or copper) as the existing systems being modified but must conform to the following unless otherwise indicated on the applicable contract drawings:

1. Argon, Helium, and Nitrogen Systems (150-psig and under) over ½-inch diameter:
   a. Piping: Cleaned for oxygen service, Type L, hard drawn copper tubing, ASTM B88 or ASTM B819, and conforming to ANSI/ASME B31.3.
   b. Fittings: Wrought-copper brazed-joint, ANSI/ASME B16.22. Cast copper fittings in sizes over 3-inch diameter (where wrought copper is not available), ASTM B16.18. Use brass-threaded adapters on brazed joints to minimize distortion of threads. All fittings must be cleaned and packaged for oxygen service.
   c. Ball Valves: Whitey® Series 60, brass body, stainless steel ball and stem, Teflon® seat, cleaned and packaged for oxygen service, 250-psig maximum working pressure.
2. Argon, Helium, and Nitrogen Systems (150-psig and under) ½-inch diameter and smaller:
   a. Piping: Seamless, Type 304 stainless steel, ASTM A269, fully annealed with a hardness of Rockwell b (Rb 80 or less, cleaned and capped for oxygen service). Minimum tube wall thickness must be 1/8-inch outside diameter (OD) – 0.028-inch w.t., ¼-inch OD – 0.035-inch wall thickness (w.t.), 3/8-inch O.D. – 0.035-inch w.t., 1/2-inch O.D. – 0.035-inch w.t.
   b. Fittings: Stainless steel compression-type tube fittings, Swagelok. Compression tube fittings from different manufactures must not be used.
   c. Ball Valves: Whitey 60 Series, 316 stainless steel body with stainless steel ball and stem and Teflon seat, cleaned and packaged for oxygen service.
3. Oxygen Systems (50-psig and under):
   a. Piping: Type L hard drawn copper tubing, ASTM B88; cleaned and packaged for oxygen service.
   b. Fittings: Wrought copper and bronze brazed-joint, ANSI/ASME B16.22, cleaned and packaged for oxygen service.
   c. Ball Valves: Whitey Series 60, brass body, stainless steel ball and stem, Teflon seat, cleaned and packaged for oxygen service, 250-psig maximum working pressure.

Note: Oil and oxygen may combine with explosive violence. Comply with NFPA 50 and ASTM G 93.

4. Hydrogen Systems (50-psig and under):
    a. Piping: Schedule 40 seamless pipe, 316L stainless steel per ASTM A312. Comply with NFPA 50A and 50B.
    b. Fittings: 3,000-pound forged 316L stainless steel, socket welded per ANSI B16.11.
    c. Ball Valves: Whitey Series 60 316L stainless steel body, stainless steel ball and stem, socket weld ends, Teflon seat, forged schedule 80 carbon steel socket weld ends, 250-psig maximum working pressure.
    d. Globe Valves: Crane No. 222 H, bar stock, steel, 3000 psig.
5. Chlorine Systems (50-psig and under):
    a. Piping: Schedule 80 black steel, seamless Grades A or B, ASTM A53.
    b. Fittings: 2000-pound forged steel socket weld, ANSI/ASME B16.11.
    c. Needle Valves: Matheson No. 104, screwed, monel construction, 3000 psig.
6. Acetylene Systems (15-psig and under):
    a. Piping: Schedule 40 black steel, seamless Grades A or B, ASTM A53.
    b. Fittings: 2000-pound forged steel socket weld, ANSI/ASME B16.11 (cast iron not permitted).
    c. Valves: Crane No. 1652 (Underwriters' Approved) 15-psig rating, 180 degrees F maximum.

Note: Contact between acetylene and unalloyed copper should be avoided, since the explosive compound, copper acetylide, might be formed.

7. Methane Systems (50-psig and under):
    a. Piping: Schedule 40 black steel, seamless Grades A or B, ASTM A53.
    b. Fittings: 2000-pound forged steel socket weld, ANSI/ASME B16.11.
    c. Ball Valves: Whitey Series 60, carbon steel body, stainless steel ball and stem, Teflon seat, forged schedule 80 carbon steel socket weld ends, 250 psig, maximum working pressure.

2.02 Equipment

A. All major items of equipment required for installation on this contract must be as specified on the applicable contract drawings and must be furnished complete with all accessories normally supplied with the catalog item listed and all other accessories necessary for a complete and satisfactory operating system.

B. Relief Valves: Shall be ASME constructed and stamped. Size, capacity, and setting must be as indicated on the drawings. Discharge from relief valves must be piped full size and extended to the outside where required by code, standard, or drawings.

C. Identification and Labels: All piping systems must be labeled and identified in accordance with Section 15050, *Basic Mechanical Materials and Methods*.

D. Gages: Gages must be safety-type with rear blowout plug or panel, clear plastic cover, and sides and front consisting of one integral part. Range must be at least 1.2 times the system relief pressure. Gages must be installed with snubbers and ¼-inch bronze needle valves. All gages must be rated for the specific gas, pressure rating, and ambient conditions.

Part 3 - Execution

3.01 Preparation

A. Materials for copper and stainless steel piping systems that are required to be "cleaned for oxygen service", including pipe, valves, fittings, and components, must be cleaned and prepared in a facility equipped to clean, rinse, and purge the material in accordance with ASTM G 93, and must be delivered to the job site capped, bagged, or plugged as necessary to protect materials from contamination.

B. On-site cleaning of the interior surfaces of materials in copper and stainless piping systems must be limited to recleaning surfaces in the immediate vicinity of the joints that have become contaminated prior to brazing or welding.

- Surfaces must be cleaned by washing in a clean, hot water/alkaline solution of 1 lb. tri-sodium phosphate to 3 gallons of water (protective gloves required). Scrubbing must be employed as required to assure removal of dirt, metal filings, oil, and grease. After washing, materials must be rinsed in clear, hot water. Dry using Argon purge to <10 ppb moisture level. After drying, materials must be plugged or capped until assembly.

C. Black steel lines, before assembly, must be hammered to loosen scale, then wire-brushed inside as required. Following scale removal, pipe must be cleaned and stored as described for copper until assembly.

3.02 Installation – General

A. General: Piping installation must be coordinated with all trades with respect to space available with heating, ventilating, and electrical installation. In every instance where there is a conflict in the routing of the piping and the ducting, the routing of the ducting must govern. Installed piping must not interfere with the operation or accessibility of doors or windows; must not encroach on aisles, passageways, or equipment; and must not interfere with the servicing or maintenance of equipment.

1. Pipe must be cut accurately to measurements established at the construction site and must be worked into place without springing or forcing, properly clearing all openings and equipment.
2. Cutting or weakening of structural members to facilitate piping installation is not permitted.
3. Pipes must have burrs removed by reaming and must be so installed as to permit free expansion and contraction without damage to joints or hangers.
4. Piping above ground must be run parallel with the lines of the building unless otherwise noted on the drawings. Piping connections to equipment must be in accordance with details shown on the drawings. Service pipe, valves, and fittings must be kept a sufficient distance from other work to permit finished covering not less than ½ inch from such other work, and not less than ½-inch between finished covering on the different services.
5. Any penetrations through fire walls should be firestopped in accordance with Section 07270, *Fire Stop and Smoke Stop Systems.*

B. Reducers: Reduction in pipe sizes must be made with one-piece reducing fittings. Bushings reducing at least two pipe sizes will be acceptable only when there is no room for reducing couplings or swaged nipples.

C. Unions: All piping unions must be of the ground joint type constructed from materials equivalent in alloy composition and strength to other fittings specified with which they are used. Union pressure classes and end connections must be the same as the fitting used in the lines with the unions. Steel unions must have hardened stainless steel seating surfaces on both faces.

D. Valves: Valves must be installed at the locations shown on the drawings and where specified. All valves must be installed with their stems horizontal or above.

3.03 Hangers and Anchors

A. All piping must be rigidly supported from the building structure by means of adjustable ring-type hangers. (*Welding to the building structure is not permitted.*) Where pipes run side by side, support them on rod and angle iron or Unistrut® trapeze hangers. Hanger spacing must be as follows:

1. Horizontal:

Steel Piping	Maximum Spacing
½ inch and smaller	6 feet
¾ inch through 1 inch	8 feet
1¼ inch and larger	10 feet

Copper Piping	Maximum Spacing
½ inch	4 feet
¾ inch through 1 inch	6 feet
1 ¾ inch and larger	8 feet

2. Vertical: Steel and copper must be supported at 10-foot intervals, maximum, or at every floor level, whichever is less.
3. Round rods supporting the pipe hangers must be of the following dimensions:

Pipe Size	Rod Size
3/8-inch to 2-inch pipe	3/8-inch rod
2½-inch to 3-inch pipe	½-inch rod
4-inch to 5-inch pipe	5/8-inch rod

4. Rods for trapeze hangers must be a minimum of ⅜-inch and must have the equivalent cross section, listed in 3.03 A.3, per pipe supported. The use of pipe hooks, perforated iron strapping or wire for pipe supports will not be permitted.
5. Hanger rods must be galvanized carbon steel per ASTM A307, Grade B, threaded per ANSI B1.1 coarse thread series, Class 2A fit:
   a. Hanger rods must have minimum 6-inch threaded ends.
   b. All hanger rod connections must use double nut fastening.

6. Hanger rods must be installed vertically. Hanger rod offset **is not** permitted.
7. Place a hanger within 1 foot of each horizontal elbow.
8. Use hangers that are vertically adjustable 1½-inch minimum after piping is erected.
9. Use copper straps on copper pipe and ferrous hangers on ferrous pipe. Steel to copper contact is not allowed.
10. Soft copper tubing, where permitted, must be fastened to the building structure with Unistrut type clamps with cushion, spaced not more than 4 feet apart.
11. On 4-inch and larger piping, install hangers adjacent (within 1 foot on each side) to all horizontal elbows, strainers, check valves, valves, and all flanged items.

3.04 Joints

A. Screwed Joints: Screwed pipe joints must have American Standard Taper Pipe Threads ANSI/ASME B1.2. Burrs formed when cutting pipe must be removed by reaming. Care must be taken that the inside of the pipe is thoroughly clean and free of cutting oil and foreign matter before installation. Joints must be made perfectly tight by the use of Teflon tape or approved Teflon thread sealing and lubricating compound.

B. Solder Joints: (Soldered joints may only be used in existing systems where soldered joints were used originally.) Tubing must be cut square and burrs removed. Both inside of fittings and outside of tubing must be well cleaned with sand cloth or wire brush before sweating. Care must be taken to prevent annealing of fittings and hard drawn tubing when making connections. Joints for sweated fittings on low-pressure piping (150-psig and below) must be made with a noncorrosive paste flux and solid wire solder composed of 95 percent tin and 5 percent antimony or similar solder of equal characteristics. Cored solder will not be permitted. Conform to AWS A5.8. Joints must comply with ANSI/ASME B31.1, *Power Piping*, and the Copper Development Association recommended practices.

1. Solder containing antimony **must not** be used to join metals containing zinc (for example, galvanized iron, galvanized steel, and brass).
2. Solder end valve: Use two-piece gate or globe valve or three-piece ball valve for solder end valves. When joining a gate or glove solder end valve, ensure the valve is fully open. Apply heat to tube first. Transfer as much heat as possible through the tube to the valve. Avoid prolonged heating of valve. Use a noncorrosive paste flux and solid wire solder suitable for the service temperatures and pressures expected.
3. Use sand cloth or a stainless steel wire brush to clean surfaces to be joined. Steel wool **is not** permitted.

C. Brazed Joints: New copper systems must be installed per ASTM G 93, with brazed socket type fittings and with an argon or nitrogen purge applied. Flux must not be used except where joining specialty items and fittings that are not available in copper. Brazing filler metals must comply with ANSI/AWS A5.8, *Specification for Filler Metals for Brazing*. Copper-to-copper joints must be brazed using a copper-phosphorus or copper-phosphorous-silver brazing filler metal (BCuP) without flux. Dissimilar metals, such as copper and bronze or brass, must be brazed using an appropriate flux with a silver (BAg series) brazing filer metal.

1. Tube ends must be cut square using a sharp tubing cutter. The wheel must be free of grease, oil, or other lubricant not suitable for oxygen service. The cut end of the tubing must be deburred with a sharp, clean deburring tool, taking care to prevent chips from entering the tube or pipe.
2. The surfaces to be brazed must be mechanically cleaned with a stainless steel wire brush. The use of steel wool is prohibited due to the possible presence of oil. After mechanical cleaning, the surfaces must be wiped using a clean, lint-free white cloth. Joints must be recleaned if contaminated prior to brazing. Joints must be brazed within 1 hour of being cleaned.
3. Where dissimilar metals, such as copper and bronze or brass, are being brazed, flux must be applied sparingly to minimize contamination of the inside of the tube with flux. Where possible, short sections of copper tube must be brazed to the noncopper components and the interior of the subassembly must be cleaned of the flux prior to installation in the piping system. Flux-coated brazing rods may be used in lieu of the application of flux to the surfaces to be joined for tubes ¾-inch size and smaller.
4. While being brazed, joints must be continuously purged with oil-free dry nitrogen or argon to prevent the formation of copper oxide on the inside surface of the joint. The flow of the purge gas must be maintained until the joint is cool to the touch.

   Exception: A final connection to an existing system must be permitted to be made without the use of a purge gas.
5. During and after installation, openings in the piping system must be kept capped or plugged to avoid unnecessary loss of purge gas and to prevent contamination. While brazing, a discharge opening must be provided on the opposite side of the joint from where the purge gas is introduced. During brazing, the purge gas flow rate must be maintained at a level that will not produce a positive pressure in the piping system. While welding, the minimum purge rate must be 15 scfh for ¼-inch tubing, and 25 scfh for all tubing ⅜-inch and larger.
6. After brazing, the outside of all joints must be cleaned by washing with water and a stainless steel brush to remove any residue and permit clear visual inspection of the joint. Where flux has been permitted, hot water must be used.

D. Swagelok® Compression Fittings: Follow the manufacturer's installation instructions for assembly tubing and tube fittings. Use a sharp, clean, tube-cutter wheel to cut tubing. Remove burrs, chips, and scratches from the end of the tubing. Ensure that the tubing is fully bottomed in the fitting before final tightening. After assembly, check that the fitting is properly tightened by using a gap inspection gage.

E. Welded Joints: Joints between sections of pipe and between pipe and fittings may be welded using either gas or electric welding equipment. Stainless steel welding must conform to ANSI/AWS B2.1.005. All pipe surfaces must be thoroughly cleaned before welding. Each joint, except socket-weld joints, must be beveled before being welded. The Contractor must provide a nonflammable mat or blanket to protect the structure, and adequate fire protection equipment at all locations where welding is done. All elbows must be long radius where space conditions allow. Wherever tee connections are made to piping systems on the main run, welding sockets or weld-o-lets may be used in lieu of reducing outlet tees for branch connections up to one-half the size of the main run. On connections larger than one-half the size of the main run, welding tees must be used. The use of fittings formed from welded pipe sections will not be permitted. All welding must conform to the requirements of Section 15050, *Basic Mechanical Materials and Methods.*

Any welding work requires the following:

a. A Hot Work Permit from Fire Protection Engineering., located in MO119.

b. A dedicated fire watch during work through thirty (30) minutes after operation.

c. A minimum 2-A rated fire extinguisher located near the welding site.

d. Any other requirements listed on the permit.

3.05 Field Quality Control

A. General: All piping, equipment, and accessories installed under this contract must be inspected and tested by the Contractor in the presence of the Inspector and approved before acceptance. The Contractor must furnish all labor, material, and equipment required for testing. The Contractor must be responsible for all repairs and retesting as required. All instruments and other equipment whose safe pressure range is below that of the test pressure must be removed from the line or blanked off before applying the tests.

B. Brazed Joints: Each brazed joint must be visually examined after cleaning of the outside of the joint. The following conditions must be considered unacceptable:

1. Flux or flux residue
2. Excessive oxidation of the joint
3. Presence of unmelted filler metal
4. Failure of the filler metal to be clearly visible all the way around the joint at the interface between the socket and the tube
5. Cracks in the tube or component
6. Cracks in the braze filler metal
7. Failure of the joint to hold test pressure

Brazed joints that are found to be defective under conditions 1, 3, 4, 6, and 7 must be permitted to be repaired, except that no joint must be repaired more that once. Brazed joints that are defective under 2 and 5 must be replaced.

C. Blow Down and Purge Test: In order to remove particulate matter in the pipelines, a heavy, intermittent purging of each outlet must be performed with oil-free nitrogen. The outlet must be allowed to flow until the purge produces no discoloration in a white cloth.

D. Pressure Tests: Compressed gas piping must be tested at the test pressures specified and must not exceed the following drop in pressure (temperature compensated) in a 4-hour period. All system leaks must be located by soap testing.

Compressed Gas	Test Pressures	Test Gas	Max. Pressure Drop (4 Hrs)
Nitrogen Systems	225 psig	Nitrogen	0 psi
Argon Systems	225 psig	Nitrogen	0 psi
Helium Systems	225 psig	Nitrogen	0 psi
Oxygen Systems	150 psig	Nitrogen	0 psi
Hydrogen Systems	200 psig	Nitrogen	0 psi
Chlorine Systems	200 psig	Nitrogen	0 psi
Acetylene Systems	200 psig	Nitrogen	0 psi
Methane Systems	150 psig	Nitrogen	0 psi

1. The pressure test must be conducted as follows:
   a. Equipment that is not to be tested such as relief valves and gauges must be removed and the openings plugged or capped.
   b. The system must be filled with the test gas to 25 psig and held while all joints are visually inspected for leaks.
   c. The pressure must be slowly increased to 150 psig and held while all joints are soap tested.
   d. The system must be increased to the test pressure and held for 4 hours and the pressure drop recorded for acceptance.
   e. Pressure must be relieved from the system and equipment that was removed must be reinstalled. The system must be pressurized to the operating pressure and joints at previously removed equipment must be soap tested.
   f. Leaks, if any, must be located, repaired, and retested.
   g. For the test, the contractor must provide a calibrated 4-inch diameter pressure gauge of maximum 1% full scale accuracy, maximum 300 psig range, and maximum 2 psig graduations. A digital pressure gauge of similar accuracy may also be used. If the system is in an area where the temperature will fluctuate more than 10 degrees F over the test period, then the contractor must also furnish an 8-inch temperature chart recorder or a combination temperature/pressure chart recorder. The pressure gauge must be calibrated annually.

- END OF SECTION -