- (1) Area and local alarms shall not be required.
- (2) Warning systems shall be permitted to have a single alarm panel.
- (3) The alarm panel shall be located in an area of continuous surveillance while the facility is in operation.
- (4) Pressure switches/sensors that monitor main line pressure shall be mounted at the source equipment with a pressure indicator(s) (lamp or LED) at the alarm panel. The audible and noncancelable alarm visual signals shall indicate if the pressure in the main line increases or decreases 20 percent from the normal operating pressure. Visual indicators shall remain until the situation that caused the alarm is resolved.
- (5) When automatic changeover of source gases is required, the changeover alarm shall have a secondary indicator to suit the arrangement of the source equipment.
- (6) A cancelable audible indication of each alarm condition that produces a sound at the alarm panel shall re-initiate the audible signal if another alarm condition occurs while the audible is silenced.
- (7) Pressure switches/senses shall be installed downstream from any emergency shutoff valves required by 5.3.4.1 and shall comply with 5.3.9.1(4) and 5.3.9.1(5)

5.3.9.2 Systems for gases such as compressed air or nitrogen used to power devices, as well as Level 3 vacuum systems, shall not be required to have warning systems.

5.3.10 Level 3 Distribution.

5.3.10.1 Piping Materials for Field-Installed Level 3 Positive-Pressure Gas Systems.

5.3.10.1.1 Piping for Medical Gases. Piping for Level 3 positive-pressure nonflammable medical gases (i.e., oxygen and nitrous oxide) shall meet the requirements in 5.3.10.1.1.1 through 5.3.10.1.1.5.

5.3.10.1.1.1 Tubes, valves, fittings, station outlets, and other piping components in medical gas systems shall have been cleaned for oxygen service by the manufacturer prior to installation in accordance with CGA G-4.1 *Cleaning Equipment for Oxygen Service.*

5.3.10.1.1.2 Each length of tube shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation.

5.3.10.1.1.3 Fittings, valves, and other components shall be delivered sealed and labeled by the manufacturer and kept sealed until prepared for installation.

5.3.10.1.1.4 Tubes shall be hard-drawn seamless copper ASTM B 819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, medical gas tube, Type L or K.

5.3.10.1.1.5 ASTM B 819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, medical gas tube shall be identified by the manufacturer's markings "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue (Type L) or green (Type K).

5.3.10.1.2 Piping for Level 3 Gas-Powered Devices. Tubes shall be hard-drawn seamless copper and one of the following:

- (1) ASTM B 819, Standard Specification for Seamless Copper Tube for Medical Gas Systems, medical gas tube (Type K or L)
- (2) ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, water tube (Type K or L)

(3) ASTM B 280, Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service, ACR tube (O.D. size), except that tube installed underground or within floor slabs shall be permitted to be soft annealed temper.

5.3.10.2 Piping Materials for Field-Installed Level 3 Vacuum Systems.

5.3.10.2.1 In copper piping systems, the tubes shall be hard-drawn seamless copper and one of the following:

- (1) ASTM B 819, Standard Specification for Seamless Copper Tube for Medical Gas Systems, medical gas tube (Type K or L)
- (2) ASTM B 88, Standard Specification for Seamless Copper Water Tube, water tube (Type K, L, or M)
- (3) ASTM B 280, Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service, ACR tube (O.D. size), except that tube installed underground or within floor slabs shall be permitted to be soft annealed temper.

5.3.10.2.2 Copper tube installed underground or within floor slabs shall be permitted to be soft annealed temper.

5.3.10.2.3 In plastic piping systems, the pipe shall be polyvinylchoride (PVC) plastic, Schedule 40 minimum.

5.3.10.3 Fittings.

5.3.10.3.1 Turns, offsets, and other changes in direction in medical gas piping, copper Level 3 vacuum piping, and piping for gas-powered devices shall be made with brazed wrought copper capillary fittings complying with ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*, or brazing fittings complying with ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*.

5.3.10.3.2 Cast copper alloy fittings shall not be used where joints are brazed.

5.3.10.3.3 Branch connections in copper vacuum piping systems shall be permitted to be made using mechanically formed, drilled, and extruded tee-branch connections that are formed in accordance with the tool manufacturer's instructions, and brazed.

5.3.10.3.4 Turns, offsets, and other changes in direction in plastic Level 3 vacuum piping shall be made with solvent-cemented PVC plastic pressure fittings, Schedule 40 minimum.

5.3.10.4 Threaded Joints. Threaded joints in Level 3 gaspowered systems and vacuum distribution piping shall meet the following requirements:

- (1) Be limited to connections to pressure/vacuum indicators, alarm devices, and source equipment
- (2) Have tapered threads complying with ASME B1.20.1, *Pipe Threads, General Purpose, Inch*
- (3) Be made up with polytetrafluoroethylene (such as TeflonTM) tape or other thread sealant recommended for oxygen service, with the sealant applied to the male threads only

5.3.10.5 Soldered Joints. Soldered joints in copper Level 3 vacuum and Level 3 gas-powered systems piping shall be made in accordance with ASTM B 828, *Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings*, using a "lead-free" solder filler metal containing not more than 0.2 percent lead by volume.

5.3.10.6 Solvent-Cemented Joints. Solvent-cemented joints in plastic Level 3 vacuum piping shall be in accordance with

ASTM D 2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.

5.3.10.7 Brazed Joints.

5.3.10.7.1 General Requirements.

5.3.10.7.1.1 Brazed joints shall be made using a brazing alloy that exhibits a melting temperature in excess of 538° C (1000° F) to retain the integrity of the piping system in the event of fire exposure.

5.3.10.7.1.2 Brazed tube joints shall be the socket type.

5.3.10.7.1.3 Filler metals shall bond with and be metallurgically compatible with the base metals being joined.

5.3.10.7.1.4 Filler metals shall comply with ANSI/AWS A5.8, *Specification for Filler Metals for Brazing and Braze Welding.*

5.3.10.7.1.5 Copper-to-copper joints shall be brazed using a copper–phosphorus or copper–phosphorus–silver brazing filler metal (BCuP series) without flux.

5.3.10.7.1.6 Joints to be brazed in place shall be accessible for necessary preparation, assembly, heating, filler application, cooling, cleaning, and inspection.

5.3.10.7.2 Cutting Tube Ends.

5.3.10.7.2.1 Tube ends shall be cut square using a sharp tubing cutter to avoid deforming the tube.

5.3.10.7.2.2 The cutting wheels on tubing cutters shall be free from grease, oil, or other lubricant not recommended for oxygen service.

5.3.10.7.2.3 The cut ends of the tube shall be deburred with a sharp, clean deburring tool, taking care to prevent chips from entering the tube.

5.3.10.7.3 Cleaning Joints for Brazing.

5.3.10.7.3.1 The interior surfaces of tubes, fittings, and other components that are cleaned for oxygen service shall be stored and handled to avoid contamination prior to assembly and brazing.

5.3.10.7.3.2 The exterior surfaces of tube ends shall be cleaned prior to brazing to remove any oxides and surface dirt and to roughen the surfaces to prepare them for brazing.

5.3.10.7.3.3 If the interior surfaces of fitting sockets that were cleaned for oxygen become contaminated prior to brazing, they shall be re-cleaned for oxygen in accordance with 5.3.10.7.3.9 and be cleaned for brazing with a clean, oil-free wire brush.

5.3.10.7.3.4 Nonabrasive pads shall be used to clean the exterior surfaces of tube ends.

5.3.10.7.3.5 The use of steel wool or sand cloth shall be prohibited.

5.3.10.7.3.6 The cleaning process shall not result in grooving of the surfaces to be joined.

5.3.10.7.3.7 After being abraded, the surfaces shall be wiped using a clean, lint-free white cloth.

5.3.10.7.3.8 Tubes, fittings, valves, and other components shall be visually examined internally before being joined to verify that they have not become contaminated for oxygen service (if so required) and that they are free of obstructions or debris.

5.3.10.7.3.9 The interior surfaces of tube ends, fittings, and other components that were cleaned for oxygen service by the manufacturer, but become contaminated prior to being installed, shall be permitted to be re-cleaned on-site by the installer by thoroughly scrubbing the interior surfaces with a clean, hot water/alkaline solution, such as sodium carbonate or trisodium phosphate, mixed 450 g to 11 L (1 lb to 3 gal) of potable water and thoroughly rinsing them with clean, hot potable water.

5.3.10.7.3.10 Other aqueous cleaning solutions shall be permitted to be used for the on-site re-cleaning permitted in 5.3.10.7.3.9, provided that they are as recommended in CGA G-4.1, *Cleaning Equipment for Oxygen Service*, and are listed in CGA O2-DIR, *Directory of Cleaning Agents for Oxygen Service*.

5.3.10.7.3.11 Material that has become contaminated internally and is not clean for oxygen service (if so required) shall not be installed.

5.3.10.7.3.12 Joints shall be brazed within 1 hour after the surfaces are cleaned for brazing.

5.3.10.7.4 Brazing Dissimilar Metals.

5.3.10.7.4.1 Flux shall only be used when brazing dissimilar metals, such as copper and bronze or brass, using a silver (BAg series) brazing filler metal.

5.3.10.7.4.2 Surfaces shall be cleaned for brazing in accordance with 5.3.10.7.3.

5.3.10.7.4.3 Flux shall be applied sparingly to minimize contamination of the inside of the tube with flux.

5.3.10.7.4.4 The flux shall be applied and worked over the cleaned surfaces to be brazed using a stiff, stainless steel bristle brush to ensure complete coverage and wetting of the surfaces with flux.

5.3.10.7.4.5 Where possible, short sections of copper tube shall be brazed onto the noncopper component and the interior of the subassembly shall be cleaned of flux prior to installation in the piping system.

5.3.10.7.4.6 On joints DN20 (NPS ³/₄) (⁷/₈ in. O.D.) size and smaller, flux-coated brazing rods shall be permitted to be used in lieu of applying flux to the surfaces being joined.

5.3.10.7.5* Nitrogen Purge.

5.3.10.7.5.1 While being brazed, joints shall be continuously purged with oil-free, dry Nitrogen NF to prevent the formation of copper oxide on the inside surfaces of the joint.

5.3.10.7.5.2 The source of the purge gas shall be monitored and the installer shall be audibly alerted when the content is low.

5.3.10.7.5.3 The purge gas flow rate shall not produce a positive pressure in the piping system.

5.3.10.7.5.4 The purge gas flow rate shall be controlled by the use of a pressure regulator and flowmeter, or combination thereof.

5.3.10.7.5.5 Pressure regulators alone shall not be used to control purge gas flow rates.

5.3.10.7.5.6 During and after installation, openings in the piping system shall be kept capped or plugged to maintain a nitrogen atmosphere within the piping and to prevent debris or other contaminants from entering the system.

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5.3.10.7.5.7 While a joint is being brazed, a discharge opening shall be provided on the opposite side of the joint from where the purge gas is being introduced.

5.3.10.7.5.8 The flow of purge gas shall be maintained until the joint is cool to the touch.

5.3.10.7.5.9 After the joint has cooled, the purge discharge opening shall be plugged or capped to prevent contamination of the inside of the tube and maintain the nitrogen atmosphere within the piping system.

5.3.10.7.5.10 The final connection of new piping to an existing in-use pipeline shall be permitted to be made without the use of a nitrogen purge.

5.3.10.7.5.11 After a final connection in a Level 3 positivepressure gas pipeline is made without a nitrogen purge, an outlet in the immediate downstream zone of the affected portion(s) of both the new and existing in-use piping shall be tested in accordance with 5.3.12.3.8, Verifier Final Tie-In Test.

5.3.10.7.6 Assembling and Heating Joints.

5.3.10.7.6.1 Tube ends shall be inserted fully into the socket of the fitting.

5.3.10.7.6.2 Where flux is permitted, the joint shall be heated slowly until the flux has liquefied.

5.3.10.7.6.3 After flux is liquefied, or where flux is not permitted to be used, the joint shall be heated quickly to the brazing temperature, taking care not to overheat the joint.

5.3.10.7.6.4 Techniques for heating the joint; applying the brazing filler metal; and making horizontal, vertical, and large-diameter joints shall be as stated in sections on Applying Heat and Brazing and Horizontal and Vertical Joints in Chapter VII, Brazed Joints in the CDA *Copper Tube Handbook*.

5.3.10.7.7 Inspection of Brazed or Soldered Joints.

5.3.10.7.7.1 After brazing or soldering, the outside of all joints shall be cleaned by washing with water and a wire brush to remove any residue and permit clear visual inspection of the joint.

5.3.10.7.7.2 Where flux has been used, the wash water shall be hot.

5.3.10.7.7.3 Each joint shall be visually inspected after cleaning the outside surfaces.

5.3.10.7.7.4 Joints exhibiting the following conditions shall not be permitted:

- (1) Flux or flux residue (when flux or flux-coated BAg rods are used with dissimilar metals)
- (2) Base metal melting or erosion
- (3) 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 or solder filler metal
- (7) Failure of the joint to hold the test pressure or vacuum under the installer-performed initial pressure or vacuum test (5.3.12.2.3 or 5.3.12.2.4) and standing pressure or vacuum test (5.3.12.2.7 or 5.3.12.2.8).

5.3.10.7.7.5 Joints that are identified as defective under conditions 5.3.10.7.7.4(2) or 5.3.10.7.7.4(5) shall be replaced.

5.3.10.7.7.6 Joints that are found to be defective under conditions 5.3.10.7.7.4(1), 5.3.10.7.7.4(3), 5.3.10.7.7.4(4), 5.3.10.7.7.4(6), or 5.3.10.7.7.4(7) shall be permitted to be repaired, except that no joint shall be reheated more than once before being replaced.

5.3.10.8 Special Joints.

5.3.10.8.1 The following joints shall be prohibited throughout Level 3 medical gas (i.e., oxygen and nitrous oxide) pipeline systems:

- (1) Flared and compression connections, including connections to station outlets and inlets, alarm devices, and other components
- (2) Other straight-threaded connections, including unions

5.3.10.8.2 Flared and compression connections shall be permitted in piping for Level 3 gas-powered devices and Level 3 vacuum in junction boxes, and where exposed at station outlets/inlets and source equipment.

5.3.10.9 Special Fittings. The following special fittings shall be permitted to be used in lieu of brazed joints:

- (1) Memory-metal couplings having temperature and pressure ratings joints not less than that of a brazed joint
- (2) Listed or approved metallic gas tube fittings that, when made up, provide a permanent joint having the mechanical, thermal, and sealing integrity of a brazed joint
- (3) Axially swaged, elastic strain preload fittings providing metal to metal seal having pressure and temperature ratings not less than that of a brazed joint and when complete are permanent and nonseparable.

5.3.10.10 Installation of Level 3 Piping and Equipment.

5.3.10.10.1 Qualification of Installers.

5.3.10.10.1.1 The installation of Level 3 gas and vacuum systems shall be made by qualified, competent technicians who are experienced in making such installations.

5.3.10.10.1.2 The installers of Level 3 medical gas systems (i.e., oxygen and nitrous oxide) shall be qualified under the requirements of ASSE 6010, *Professional Qualifications Standard for Medical Gas Systems Installers*.

5.3.10.10.1.3 Brazing on medical gas system pipelines shall be performed by individuals who are qualified under the provisions of 5.3.10.10.15.

5.3.10.10.1.4 Prior to any installation work involving brazing, the installer of Level 3 medical gas piping shall provide documentation for the qualification of brazing procedures and individual brazers that is required under 5.3.10.10.15.

5.3.10.10.2 Pipe Sizing. Piping systems shall be designed and sized to deliver the required flow rates at the utilization pressures.

5.3.10.10.3* Minimum Pipe Sizes.

5.3.10.10.3.1 Mains, branches, and drops to individual service outlets in Level 3 oxygen piping systems shall be not less than DN10 (NPS % in.) ($\frac{1}{2}$ in. O.D.) size, but at least one size larger than the piping for nitrous oxide.

5.3.10.10.3.2 Mains, branches, and drops to individual service outlets in Level 3 nitrous oxide and inlets in the following piping systems shall be not less than DN8 (NPS ¹/₄ in.) (³/₈ in. O.D.) size.

5.3.10.10.3.3 Mains, branches, and drops to individual service outlets/inlets in Level 3 piping systems for gas powered devices and vacuum shall not be the same as the sizes used for oxygen and nitrous oxide.

5.3.10.10.3.4 Runouts to alarm panels and connecting tubing for pressure/vacuum indicators and alarm devices shall be permitted to be DN8 (NPS ¹/₈) (¹/₄ in. O.D.) size.

5.3.10.10.4 Protection of Piping. Piping shall be protected against freezing, corrosion, and physical damage.

5.3.10.10.4.1 Piping exposed in corridors and other areas where subject to physical damage from the movement of carts, stretchers, portable equipment, or vehicles shall be protected.

5.3.10.10.4.2 Tubing for Level 3 medical gas (i.e., oxygen and nitrous oxide) tubing that is underground within buildings or embedded in concrete floors or walls shall be installed in a continuous conduit.

5.3.10.10.5 Location of Piping.

5.3.10.10.5.1 Piping for Level 3 medical gases (i.e., oxygen and nitrous oxide) shall be located in accordance with 5.3.10.10.5.1(A) through 5.3.10.10.5.1(C):

(A) Piping shall be permitted to be installed overhead wherever possible.

(B) Piping shall not be installed in electrical switchgear rooms, elevator shafts, and areas having open flames.

(C) Medical gas piping (i.e., oxygen and nitrous oxide) shall not be located where subject to contact with oil.

5.3.10.10.5.2 Piping for Level 3 gas-powered devices, and Level 3 vacuum systems shall be located in accordance with 5.3.10.10.5.2(A) and 5.3.10.10.5.2(B):

(A) Piping shall be permitted to be installed at the following locations:

- (1) Under floor or underground
- (2) Underground within buildings
- (3) Aboveground, within walls, within ceilings

(B) Piping shall not be installed in electrical switchgear rooms, elevator shafts, and areas having open flames, except for the following locations:

- (1) Room locations for Level 3 gas-powered devices and Level 3 vacuum systems.
- (2) Room locations for secondary distribution circuit panels and breakers having a maximum voltage rating of 600 volts.

5.3.10.10.6 Pipe Support.

5.3.10.10.6.1 Piping shall be supported from the building structure in accordance with MSS SP-69, *Pipe Hangers and Supports* — *Selection and Application.*

5.3.10.10.6.2 Hangers and supports shall comply with MSS SP-58, *Pipe Hangers and Supports — Materials, Design, and Manufacture.*

5.3.10.10.6.3 Hangers for copper tube shall be sized for copper tube and have a copper finish.

5.3.10.10.6.4 In potentially damp locations, copper tube hangers and supports that are in contact with the tube shall be plastic-coated or otherwise be electrically insulated from the tube.

5.3.10.10.6.5 Maximum support spacing for copper tubing shall be in accordance with Table 5.3.10.10.6.5.

Table 5.3.10.10.6.5 Maximum Pipe Support Spacing

Pipe Size	Hanger Spacing	
	mm	ft
DN8 (NPS ¼) (¾ in. O.D.)	1520	5
DN10 (NPS 3/8) (1/2 in. O.D.)	1830	6
DN15 (NPS 1/2) (5% in. O.D.)	1830	6
DN20 (NPS ¾) (7% in. O.D.)	2130	7
DN25 (NPS 1) (1 ¹ / ₈ in. O.D.)	2440	8
DN 32 (NPS 11/4) (13% in. O.D.)	2740	9
DN40 (NPS 1½) (15% in. O.D.) and larger	3050	10
Vertical risers, all sizes		
Every floor, but not to exceed:	4570	15

5.3.10.10.6.6 PVC plastic piping for Level 3 vacuum systems shall be supported at a maximum spacing of 1.22 m (4 ft), except that vertical piping shall be supported at every floor and with mid-story guides.

5.3.10.10.6.7 Where required, Level 3 gas and vacuum piping shall be seismically restrained against earthquakes in accordance with the applicable building code.

5.3.10.10.7 Piping Within Floor Slabs and Underground Within Buildings.

5.3.10.10.7.1 The tube(s) shall be installed in one (or more) continuous conduits that are of sufficient size to permit subsequent installation, removal, and replacement of the gas and/or vacuum lines.

5.3.10.10.7.2 Each tube pulled into the conduit shall be a continuous length having no joints within the conduit.

5.3.10.10.8 Underground Piping Outside of Buildings.

5.3.10.10.8.1 Buried piping outside of buildings shall be installed below the local level of frost penetration.

5.3.10.10.8.2 The installation procedure for underground piping shall protect the piping from physical damage while being backfilled.

5.3.10.10.8.3 If underground piping is protected by a conduit, cover, or other enclosure, the following requirements shall be met:

- (1) Access during construction shall be provided at the joints for visual inspection and leak testing.
- (2) The conduit, cover, or enclosure shall be self-draining and not retain groundwater in prolonged contact with the pipe.

5.3.10.10.8.4 Buried piping that will be subject to surface loads shall be buried at a depth that will protect the piping and or its enclosure from excessive stresses.

5.3.10.10.8.5 The minimum backfilled cover above the top of the pipe or its enclosure for buried piping outside of buildings shall be 900 mm (36 in.), except that the minimum cover shall be permitted to be reduced to 450 mm (18 in.) where physical damage is otherwise prevented.

5.3.10.10.8.6 Trenches shall be excavated so that the pipe or its enclosure has firm, substantially continuous bearing on the bottom of the trench.

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5.3.10.10.8.7 Backfill shall be clean and compacted so as to protect and uniformly support the pipe or its enclosure.

5.3.10.10.8.8 A continuous tape or marker placed immediately above the pipe or its enclosure shall clearly identify the pipeline by specific name.

5.3.10.10.8.9 A continuous warning means shall also be provided above the pipeline at approximately one-half the depth of bury.

5.3.10.10.8.10 Where buried piping is installed through a wall sleeve, the ends of the sleeve shall be sealed to prevent the entrance of ground water into the building.

5.3.10.10.9 Branch Takeoffs. Runouts from horizontal piping for medical gas (i.e., oxygen and nitrous oxide) shall be taken off above the centerline of the main or branch pipe and rise vertically at an angle of not more than 45 degrees from vertical.

5.3.10.10.10 Special Requirements for Level 3 Vacuum Piping.

5.3.10.10.10.1 Horizontal piping in Level 3 vacuum systems shall be sloped a minimum of 7 mm per 3.05 m ($\frac{1}{4}$ in. per 10 ft) toward the vacuum source equipment.

5.3.10.10.10.2 Horizontal piping shall include no sags or low points that will permit fluids or debris to accumulate.

5.3.10.10.10.3 Accessible cleanouts that are limited to vertical downflow shall be provided where necessary to clear the piping of obstructions.

5.3.10.10.11 Hose and Flexible Connectors.

5.3.10.10.11.1 Hose and flexible connectors, both metallic and nonmetallic, shall be no longer than necessary and shall not penetrate or be concealed in walls, floors, ceilings, or partitions.

5.3.10.10.11.2 Flexible connectors, metallic or nonmetallic, shall have a minimum burst pressure, with a gauge pressure of 6895 kPa (1000 psi).

5.3.10.10.12 Prohibited System Interconnections.

5.3.10.10.12.1 Two or more piping systems for medical gases, gas-powered devices, and Level 3 vacuum shall not be interconnected for testing or any other reason.

5.3.10.10.12.2 Leak testing shall be accomplished by separately charging and testing each individual piping system.

5.3.10.10.13 System Manufacturer's Instructions.

5.3.10.10.13.1 The installation of individual components shall be made in accordance with the instructions of the system manufacturer.

5.3.10.10.13.2 Such instructions shall include directions and information deemed by the system manufacturer to be necessary for attaining proper operation, testing, and maintenance of the system.

5.3.10.10.13.3 Copies of system manufacturer's instructions shall be left with the system owner.

5.3.10.10.14 Changes in System Use.

5.3.10.10.14.1 Where a Level 3 positive-pressure gas piping distribution system originally used or constructed for use at one pressure or for one gas is converted for operation at another pressure or for another gas, all provisions of 5.3.10 shall apply as if the system were new.

5.3.10.10.14.2 Piping for Level 3 gas-powered devices or Level 3 vacuum shall not be permitted to be converted for use as a medical gas piping system (i.e., oxygen or nitrous oxide).

5.3.10.10.15 Qualification of Brazing Procedures and Brazing.

5.3.10.10.15.1 Brazing procedures and brazer performance for the installation of Level 3 brazed piping shall be qualified the same as for Level 1 piping, in accordance with either Section IX, Welding and Brazing Qualifications, of the ASME *Boiler and Pressure Vessel Code*, or AWS B2.2, *Standard for Brazing Procedure and Performance Qualification*, both as modified by 5.3.10.10.15.2 through 5.3.10.10.15.5.

5.3.10.10.15.2 Brazers shall be qualified by visual examination of the test coupon followed by sectioning.

5.3.10.10.15.3 The brazing procedure specification shall address cleaning, joint clearance, overlap, internal purge gas, purge gas flow rate, and filler metal.

5.3.10.10.15.4 The brazing procedure qualification record and the record of brazer performance qualification shall document filler metal used, cleaning, joint clearance, overlap, internal purge gas and flow rate during brazing of coupon, and the absence of internal oxidation in the completed coupon.

5.3.10.10.15.5 Brazing procedures qualified by a technically competent group or agency shall be permitted under the following conditions:

- The brazing procedure specification and the procedure qualification record meet the requirements of this standard.
- (2) The employer obtains a copy of both the brazing procedure specification and the supporting qualification records from the group or agency and signs and dates these records, thereby accepting responsibility for the qualifications that were performed by the group or agency.
- (3) The employer qualifies at least one brazer following each brazing procedure specification used.

5.3.10.10.15.6 An employer shall be permitted to accept brazer qualification records of a previous employer under the following conditions:

- (1) The brazer has been qualified following the same or an equivalent procedure that the new employer uses.
- (2) The new employer obtains a copy of the record of brazer performance qualification tests from the previous employer and signs and dates these records, thereby accepting responsibility for the qualifications performed by the previous employer.

5.3.10.10.15.7 Performance qualifications of brazers shall remain in effect indefinitely unless the brazer does not braze with the qualified procedure for a period exceeding 6 months, or there is a specific reason to question the ability of the brazer.

5.3.11 Labeling and Identification.

5.3.11.1 Pipe Labeling.

5.3.11.1.1 Piping shall be labeled by stenciling or adhesive markers that identify the system.

5.3.11.1.2 Pipe labels shall show the name of the gas/vacuum system or the chemical symbol.

5.3.11.1.3 Where positive-pressure gas piping systems operate at pressures other than the standard gauge pressure of 345 kPa to 380 kPa (50 psi to 55 psi) or gauge pressure of 1100 kPa to 1275 kPa (160 psi to 185 psi) for nitrogen, the pipe labels shall

include the nonstandard operating pressure in addition to the name or symbol of the gas.

5.3.11.1.4 Pipe labels shall be located as follows:

- (1) At intervals of not more than 6.1 m (20 ft)
- (2) At least once in or above every room
- (3) On both sides of walls or partitions penetrated by the piping
- (4) At least once in every story height traversed by risers

5.3.11.2 Shutoff Valves.

5.3.11.2.1 Shutoff valves shall be identified as to the following:

- (1) The name or chemical symbol for the specific system
- (2) The name of the room(s) or area(s) served
- (3) A caution to not close (or open) the valve except in an emergency

5.3.11.2.2 Where positive-pressure gas systems operate at pressures other than the standard gauge pressure of 345 kPa to 380 kPa (50 psi to 55 psi) or gauge pressure of 1100 kPa to 1275 kPa (160 psi to 185 psi) for nitrogen, the valve identification shall also include the nonstandard operating pressure.

5.3.11.3 Service Outlets and Inlets.

5.3.11.3.1 Service outlets and inlets shall be identified as to the name or chemical symbol for the specific gas or vacuum provided.

5.3.11.3.2 Where positive-pressure gas systems operate at pressures other than the standard gauge pressure of 345 kPa to 380 kPa (50 psi to 55 psi) or gauge pressure of 1100 kPa to 1275 kPa (160 psi to 185 psi) for nitrogen, the station outlet identification shall include the nonstandard operating pressure.

5.3.12 Performance Criteria and Testing — Level 3 (Medical Gas, Gas-Powered Devices, Vacuum).

5.3.12.1 General.

5.3.12.1.1 Inspection and testing shall be performed on all new piped gas systems, additions, renovations, temporary installations, or repaired systems, to assure the facility, by a documented procedure, that all applicable provisions of this document have been adhered to and system integrity has been achieved or maintained.

5.3.12.1.2 Inspection and testing shall include all components of the system or portions thereof including, but not limited to, medical gas source(s), compressed air source systems (e.g., compressors, dryers, filters, regulators), alarms and monitoring safeguards, pipelines, isolation valves, and service outlets and inlets.

5.3.12.1.3 All systems that are breached and components that are subjected to additions, renovations, or replacement (e.g., new medical gas sources, compressors, dryers, alarms) shall be inspected and tested.

5.3.12.1.4 Systems shall be deemed breached at the point of pipeline intrusion by physical separation or by system component removal, replacement, or addition.

5.3.12.1.5 Breached portions of the systems subject to inspection and testing shall be confined to only the specific altered zone and components in the immediate zone or area that is located upstream for vacuum systems and downstream for pressure gases at the point or area of intrusion.

5.3.12.1.6 The inspection and testing reports shall be submitted directly to the party that contracted for the testing, who shall submit the report through channels to the responsible authority and any others that are required.

5.3.12.1.7 Reports shall contain detailed listings of all findings and results.

5.3.12.1.8 The responsible facility authority shall review these inspection and testing records prior to the use of any systems to assure that all findings and results of the inspection and testing have been successfully completed.

5.3.12.1.9 All documentation pertaining to inspections and testing shall be maintained on-site within the facility.

5.3.12.1.10 Before piping systems are initially put into use, the Level 3 health care facility authority shall be responsible for ascertaining that the gas/vacuum delivered at each outlet/ inlet is that shown on the outlet/inlet label and that the proper connecting fittings are installed for the specific gas/ vacuum. (*See 5.3.12.1.11.*)

5.3.12.1.11 Acceptance of the verifier's reports required under 5.3.12.3, System Verification, shall be permitted to satisfy the requirements of 5.3.12.1.10.

5.3.12.2 Initial Tests.

5.3.12.2.1 General.

5.3.12.2.1.1 The tests required by 5.3.12.3.1 through 5.3.12.3.12 shall be performed prior to the tests listed in 5.3.12.3, System Verification, by one or more of the following:

- (1) The installer
- (2) A representative of the system supplier
- (3) A representative of the system manufacturer

5.3.12.2.1.2 The test gas for positive-pressure gas systems shall be oil-free, dry Nitrogen NF.

5.3.12.2.1.3 Where manufactured assemblies are to be installed, the tests required under 5.3.12.2 shall be performed as follows:

- (1) After completion of the distribution piping
- (2) Prior to installation or connection of manufactured assemblies supplied through flexible hoses or flexible tubing
- (3) At all station outlets/inlets on manufactured assemblies supplied through copper tubing

5.3.12.2.2 Initial Blow Down. Piping in Level 3 positive-pressure gas distribution systems shall be blown clear by means of oil-free, dry Nitrogen NF as follows:

- (1) After installation of the distribution piping
- (2) Before installation of station outlets and other system components (i.e., pressure alarm devices, pressure indicators, pressure relief valves, manifolds, source equipment)

5.3.12.2.3 Initial Pressure Test for Positive-Pressure Gas Systems and Copper Level 3 Vacuum Piping.

5.3.12.2.3.1 Each section of the piping in Level 3 positive-pressure gas piping systems and copper Level 3 vacuum systems shall be pressure tested using oil-free, dry Nitrogen NF.

5.3.12.2.3.2 Initial pressure tests shall be conducted as follows:

(1) After installation of station outlets/inlets rough-in assemblies. Test caps shall be permitted to be used.

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(2) Prior to the installation of components of the distribution piping system that would be damaged by the test pressure (i.e., pressure/vacuum alarm devices, pressure/vacuum indicators, line pressure relief valves).

5.3.12.2.3.3 Where Level 3 vacuum piping systems include plastic piping, they shall be inspected to assure that there are no visible cross-connections to positive-pressure gas piping systems prior to applying test pressures to the positive-pressure systems.

5.3.12.2.3.4 The source shutoff valves for all piping systems shall remain closed during these tests.

5.3.12.2.3.5 The test pressure for positive-pressure gas piping shall be 1.5 times the system working pressure, but not less than a gauge pressure of 1035 kPa (150 psi).

5.3.12.2.3.6 The test pressure for copper Level 3 vacuum piping shall be a gauge pressure of 105 kPa (15 psi).

5.3.12.2.3.7 The test pressure shall be maintained until each joint has been examined for leakage by means of soapy water or other equally effective means of leak detection.

5.3.12.2.3.8 Leaks, if any, shall be located, replaced (if permitted) or repaired (if required), and retested.

5.3.12.2.4 Initial Leak Tests — **PVC Level 3 Vacuum Piping.** Plastic Level 3 vacuum piping shall be leak-tested under vacuum conditions.

5.3.12.2.4.1 Plastic Level 3 vacuum piping shall not be tested with compressed gas.

5.3.12.2.4.2 Leak tests shall be conducted after installation of station inlets.

5.3.12.2.4.3 The piping being tested shall be subjected to a vacuum of not less than 485 mm (19 in.) gauge HgV, using either the vacuum source equipment or a vacuum test pump.

5.3.12.2.4.4 The test vacuum shall be maintained until each joint has been examined for leakage.

5.3.12.2.5 Initial Cross-Connection Test. The installer shall determine that no cross-connections exist between the various Level 3 gas and vacuum piping systems.

5.3.12.2.5.1 All Level 3 gas and vacuum piping systems shall be at atmospheric pressure.

5.3.12.2.5.2 Face plates for outlets/inlets shall be installed.

5.3.12.2.5.3 Level 3 vacuum piping systems shall be subjected to a vacuum of not less than 485 mm (19 in.) gauge HgV, using either the vacuum source equipment or a test pump.

5.3.12.2.5.4 Each individual system gas outlet and vacuum inlet in each piping system shall be checked to determine that the vacuum is present only at the inlets for the vacuum system being tested.

5.3.12.2.5.5 The vacuum piping system shall be relieved to atmospheric pressure.

5.3.12.2.5.6 The test gas for all positive-pressure gas piping systems shall be oil-free, dry Nitrogen NF.

5.3.12.2.5.7 Sources of test gas and vacuum shall be disconnected from all piping systems except for the one system being tested.

5.3.12.2.5.8 The positive-pressure gas system being tested shall be pressurized to a gauge pressure of 345 kPa (50 psi) with oil-free, dry Nitrogen NF.

5.3.12.2.5.9 Each individual system gas outlet and vacuum inlet in each installed piping system shall be checked to determine that the test gas is being dispensed only from the outlets in the piping system being tested.

5.3.12.2.5.10 The cross-connection test shall be repeated for each installed positive-pressure gas piping system.

5.3.12.2.5.11 The proper labeling and identification of system outlets/inlets shall be confirmed during these tests.

5.3.12.2.6 Initial Piping Purge Test. The outlets in each Level 3 positive-pressure gas piping system shall be purged to remove any particulate matter from the distribution piping.

5.3.12.2.6.1 The test gas shall be oil-free, dry Nitrogen NF.

5.3.12.2.6.2 Using appropriate adapters, each outlet shall be purged with an intermittent high-volume flow of test gas until the purge produces no discoloration in a clean white cloth.

5.3.12.2.6.3 The purging shall be started at the furthest outlet in the system and proceed towards the source equipment.

5.3.12.2.7 Initial Standing Pressure Test for Positive-Pressure Gas Piping. After successful completion of the initial pressure tests under 5.3.12.2.3, Level 3 positive-pressure gas distribution piping shall be subjected to a standing pressure test.

5.3.12.2.7.1 Tests shall be conducted after the installation of station outlet valve bodies and face plates, and other distribution system components (i.e., pressure alarm devices, pressure indicators, and line pressure relief valves).

5.3.12.2.7.2 The source valve shall be closed during this test.

5.3.12.2.7.3 The piping systems shall be subjected to a 24-hour standing pressure test using oil-free, dry Nitrogen NF.

5.3.12.2.7.4 Test pressures shall be 20 percent above the normal system operating line pressure.

5.3.12.2.7.5 At the conclusion of the tests, there shall be no change in the test pressure greater than a gauge pressure of 35 kPa (5 psi).

5.3.12.2.7.6 Leaks, if any, shall be located, repaired (if permitted), replaced (if required), and retested.

5.3.12.2.8 Initial Standing Vacuum Test for Vacuum Systems. Level 3 vacuum systems, with either plastic or copper piping, shall be subjected to a standing vacuum test.

5.3.12.2.8.1 The piping system shall be subjected to a vacuum of not less than 485 mm (19 in.) gauge HgV for 24 hours, using either the vacuum source equipment or a test source.

5.3.12.2.8.2 During the test, the source of test vacuum shall be disconnected from the piping system.

5.3.12.2.8.3 At the conclusion of the test, the vacuum shall not have reduced to less than 300 mm (12 in.) HgV.

5.3.12.2.8.4 Leaks, if any, shall be located, repaired (if permitted), replaced (if required), and retested.

5.3.12.3 System Verification.

5.3.12.3.1 General.

5.3.12.3.1.1 Verification tests shall be conducted on Level 3 medical gases (e.g., oxygen and nitrous oxide).

5.3.12.3.1.2 Verification tests shall be performed only after all tests required in 5.3.12.2, Initial Tests, have been completed on all positive-pressure and vacuum piping systems.

5.3.12.3.1.3 The test gas shall be oil-free, dry Nitrogen NF or the system gas where permitted.

5.3.12.3.1.4 Verification testing shall be conducted by a party technically competent and experienced in the field of medical gas and vacuum system verification and meeting the requirements of ASSE 6030, *Professional Qualifications Standard for Medical Gas Systems Verifiers.*

5.3.12.3.1.5 Verification testing shall be performed by a party other than the installing contractor.

5.3.12.3.1.6 All verification tests required under 5.3.12.3 shall be performed after installation of any manufactured assemblies supplied through flexible hose or tubing.

5.3.12.3.1.7 Where manufactured assemblies include multiple possible connection points for terminals, each possible position shall be tested independently.

5.3.12.3.1.8 For small projects affecting a limited number of areas where the use of nitrogen is impractical, the system gas shall be permitted to be used for the following tests:

- (1) Standing pressure (5.3.12.3.2)
- (2) Cross-connection (5.3.12.3.3)
- (3) Warning system (5.3.12.3.4)
- (4) Piping purge (5.3.12.3.5)
- (5) Piping particulate (5.3.12.3.6)
- (6) Piping purity (5.3.12.3.7)
- (7) Operational pressure (5.3.12.3.9)

5.3.12.3.1.9 All verification test results shall be reported as required in 5.3.12.1.

5.3.12.3.2 Verifier Standing Pressure Test. Level 3 medical gas piping systems (i.e., oxygen and nitrous oxide) shall be subjected to a 10-minute standing pressure test at operating line pressure using the following procedures:

- (1) After the system is filled with oil-free, dry Nitrogen NF or the system gas, the source valve and any zone valves shall be closed.
- (2) The piping system downstream of the valves shall show no decrease in pressure after 10 minutes.
- (3) Any leaks found shall be located, repaired (if permitted), replaced (if required), and retested.

5.3.12.3.3 Verifier Cross-Connection Test. After closing of walls and completion of the requirements of 5.3.12.2, Initial Tests, it shall be determined that no cross-connections exist between the Level 3 medical gas systems and any of the other positive-pressure and vacuum piping systems by use of the following method:

- (1) Shut off the source of test gas for all positive-pressure gas piping systems and reduce systems to atmospheric pressure.
- (2) Using oil-free, dry Nitrogen NF, or the system gas, pressurize one of the Level 3 medical gas piping systems to a gauge pressure of 345 kPa (50 psi).
- (3) Test each positive-pressure gas outlet and Level 3 vacuum inlet using appropriate adapters to verify that the test gas pressure is present only at the outlets in the Level 3 medical gas piping system being tested.
- (4) After it has been verified that a Level 3 medical gas piping system is free of cross-connections, disconnect the source of test gas and reduce the piping to atmospheric pressure.
- (5) Proceed to test each Level 3 medical gas piping system until each is verified to be free of cross-connections.

5.3.12.3.4 Verifier Level 3 Warning System Tests.

5.3.12.3.4.1 All warning systems that are installed for Level 3 medical gases shall be verified to ensure that all components function correctly prior to placing the system into service.

5.3.12.3.4.2 Permanent records of these tests shall be maintained.

5.3.12.3.4.3 Warning systems that are part of an addition to an existing piping system shall be tested prior to connection of the new piping to the existing system.

5.3.12.3.4.4 Tests of warning systems for new installations shall be performed after the verifier's cross-connection testing (5.3.12.3.3), but before purging the piping (5.3.12.3.5) and performing the remaining verification tests (5.3.12.3.6 through 5.3.12.3.12).

5.3.12.3.4.5 Test gases shall be either oil-free, dry Nitrogen NF, or the gas of system designation.

5.3.12.3.4.6 The audible and noncancelable alarm signals in each single treatment facility shall be checked to verify that they are in a location that will be continuously attended while the facility is in operation.

5.3.12.3.4.7 The operation of the Level 3 line pressure alarms required by 5.3.9.1(4) shall be verified.

5.3.12.3.4.8 Audible and noncancelable visual signals in each single treatment facility shall indicate if the pressure in the Level 3 medical gas main line being monitored increases or decreases 20 percent from the normal operating pressure.

5.3.12.3.4.9 The operation of the Level 3 changeover alarms required by 5.3.9.1(5) shall be verified.

5.3.12.3.4.10 Audible and noncancelable visual signals shall indicate whenever automatic changeover occurs or is about to occur.

5.3.12.3.4.11 Where Level 3 medical gas systems include other alarm features that are not mandatory under 5.3.9, they shall be functionally tested in accordance with their intended purpose and the equipment manufacturer's recommendations.

5.3.12.3.5 Verifier Piping Purge Test. In order to remove any traces of particulate matter deposited in the pipelines as a result of construction, a heavy, intermittent purging of each Level 3 medical gas (i.e., oxygen and nitrous oxide) pipeline shall be done.

5.3.12.3.5.1 The appropriate adapter shall be obtained from the facility or manufacturer, and high purge rates of at least 230 SLPM (8 SCFM) shall be put on each outlet.

5.3.12.3.5.2 After the purge is started, it shall be rapidly interrupted several times until the purge produces no discoloration in a white cloth loosely held over the adapter during the purge.

5.3.12.3.5.3 In order to avoid possible damage to the outlet and its components, this test shall not be conducted using any implement other than the correct adapter.

5.3.12.3.6 Verifier Piping Particulate Test. The cleanliness of the piping in each Level 3 medical gas (i.e., oxygen and nitrous oxide) system shall be verified as follows:

(1) The test shall be performed using oil-free, dry Nitrogen NF or the system gas.

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- (2) A minimum of 1000 L (35 ft^3) of gas shall be filtered through a clean, white 0.45-micron filter at a minimum flow rate of 100 SLPM (3.5 SCFM).
- (3) Each zone shall be tested at the outlet most remote from the source.
- (4) The filter shall accrue no more than 0.001 g (1 mg) of matter from any outlet tested.

5.3.12.3.7 Verifier Piping Purity Test. For each Level 3 medical gas (i.e., oxygen and nitrous oxide) system, the purity of the piping system shall be verified as follows:

- These tests shall be performed with oil-free, dry Nitrogen NF or the system gas.
- (2) The tests shall be for total hydrocarbons (as methane) and halogenated hydrocarbons, and compared with the source gas.
- (3) This test shall be performed at the outlet most remote from the source.
- (4) The difference between the two tests shall in no case exceed the following:
 - (a) Total hydrocarbons, 1 ppm
 - (b) Halogenated hydrocarbons, 2 ppm
- (5) A test shall be conducted at the outlet most remote from the source and the moisture concentration shall not exceed 500 ppm or an equivalent pressure dew point of -12°C (10°F) at 345 kPa (50 psig).

5.3.12.3.8 Verifier Final Tie-In Test.

5.3.12.3.8.1 Prior to the connection of any new Level 3 medical gas piping to its source of supply, including extensions or additions to an existing piping system, the verification tests in 5.3.12.3.1 through 5.3.12.3.7 shall be successfully performed on the new work.

5.3.12.3.8.2 Each joint in the final connection between the new work and the existing system shall be leak-tested with the gas of system designation by means of soapy water or other means effective for use with oxygen.

5.3.12.3.8.3 For Level 3 medical gases, immediately after the final connection is made and leak-tested, the specific altered zone and components in the immediate zone or area that is downstream from the point or area of intrusion shall be purged per 5.3.12.3.5.

5.3.12.3.8.4 Before the new work is used for patient care, the following tests shall be performed for all Level 3 medical gas (i.e., oxygen and nitrous oxide) systems:

- (1) Operational pressure (5.3.12.3.9)
- (2) Gas concentration (5.3.12.3.10)

5.3.12.3.8.5 Permanent records of these tests shall be maintained in accordance with 5.3.13.7.1.

5.3.12.3.9 Verifier Operational Pressure Test. Operational pressure tests shall be performed at each station outlet in Level 3 medical gas piping systems (i.e., oxygen and nitrous oxide) where the user makes connections and disconnections.

5.3.12.3.9.1 Tests shall be performed using either oil-free, dry Nitrogen NF or the gas of system designation.

5.3.12.3.9.2 Medical gas outlets (i.e., oxygen and nitrous oxide) shall deliver 100 SLPM (3.5 SCFM) with a pressure drop of no more than 35 kPa (5 psi) and static pressure of 345 kPa to 380 kPa (50 psi to 55 psi).

5.3.12.3.10 Verifier Gas Concentration Test. After purging each Level 3 medical gas piping system with the gas of system designation, the following shall be performed:

- (1) Each medical gas outlet (i.e., oxygen and nitrous oxide) shall be analyzed for concentration of gas, by volume.
- (2) Analysis shall be conducted with instruments designed to measure the specific gas dispensed.
- (3) Allowable concentrations shall be as follows:(a) Oxygen ≥ 99 percent oxygen
 - (b)*Nitrous oxide ≥ 99 percent nitrous oxide

5.3.12.3.11 Labeling. The presence and correctness of labeling required by this standard for all Level 3 medical gas components (i.e., station outlets/inlets, shutoff valves, and alarm panels) shall be verified.

5.3.12.3.12 Source Equipment Verification.

5.3.12.3.12.1 General. Source equipment verification for Level 3 medical gases shall be performed following the installation of the interconnecting pipelines, accessories, and source equipment.

5.3.12.3.12.2 Use of Source Equipment for Pipeline Verification Tests. Where the source equipment and system gas is used for verification testing of the distribution piping, the source equipment shall be verified prior to verification of the distribution piping.

5.3.12.3.12.3 Source Equipment for Level 3 Medical Gases (Oxygen and Nitrous Oxide). The system apparatus shall be tested for proper function, including the changeover from primary to secondary supply (with its changeover signal), before the system is put into service.

5.3.12.4 Final Testing of Level 3 Systems for Gas-Powered Devices and Vacuum.

5.3.12.4.1 General.

5.3.12.4.1.1 Final testing of gas-powered device systems and vacuum systems shall be performed only after all tests required by 5.3.12.2, Initial Tests, have been performed.

5.3.12.4.1.2 The tests required by 5.3.12.4.2 through 5.3.12.4.8 shall be performed by one or more of the following:

- (1) The installer
- (2) A representative of the system supplier
- (3) A representative of the system manufacturer
- (4) A system verifier per 5.3.12.3.1.5

5.3.12.4.1.3 The test gas shall be oil-free, dry Nitrogen NF or the system gas where permitted.

5.3.12.4.2 Final Standing Pressure Test (Level 3 Gas-Powered Devices). Each gas-powered device piping system shall be subjected to a 10-minute standing pressure test at operating line pressure using the following procedures:

- (1) After the system is filled with oil-free, dry Nitrogen NF or the system gas, the source valve and any zone valves shall be closed.
- (2) The piping system downstream of the valves shall show no decrease in pressure after 10 minutes.
- (3) Any leaks found shall be located, repaired (if permitted), replaced (if required), and retested.

5.3.12.4.3 Final Standing Vacuum Test (Level 3 Vacuum). Each Level 3 vacuum piping system shall be subjected to a 10-minute standing vacuum test at operating line vacuum using the following procedures:

- (1) After the system has stabilized at the operating line vacuum, the source valve and any zone valves shall be closed.
- (2) The piping system upstream of the valves shall show no decrease in vacuum after 10 minutes.
- (3) Leaks, if any, shall be located, repaired (if permitted), replaced (if required), and retested.

5.3.12.4.4 Final Cross-Connection Test (Level 3 Gas-Powered Devices and Vacuum). After closing of walls and completion of the requirements of 5.3.12.2, Initial Tests, it shall be determined that no cross-connections exist between the piping systems for gas-powered devices and Level 3 vacuum using the following method:

- (1) Where facilities have more than one gas or vacuum system, test each system separately.
- (2) Shut off the source of test gas for all gas-powered device piping systems and reduce them to atmospheric pressure.
- (3) Operate each Level 3 vacuum system at the normal system vacuum, using the source equipment.
- (4) Each gas-powered device gas outlet and Level 3 vacuum inlet shall be tested with appropriate adapters to verify that vacuum is present only at the vacuum inlets in the system being tested and not at any gas-powered device gas outlets or inlets of other vacuum systems.
- (5) Shut down the vacuum source equipment and slowly break the vacuum in the vacuum piping system, increasing its pressure to atmospheric.
- (6) Test each Level 3 vacuum system until all are determined to be free of cross-connections.
- (7) Using oil-free, dry Nitrogen NF or the system gas, pressurize the gas-powered device piping system to a gauge pressure of 345 kPa (50 psi).
- (8) Test each gas-powered device gas outlet using appropriate adapters to verify that the test gas pressure is present only at the outlets in the gas-powered device system being tested.
- (9) After it has been determined that a gas-powered device piping system is free of cross-connections, disconnect the source of test gas and reduce the piping to atmospheric pressure.
- (10) Proceed to test each gas-powered device piping system until all are determined to be free of cross-connections.

5.3.12.4.5 Final Piping Purge Test (for Level 3 Gas-Powered Devices). In order to remove any traces of particulate matter deposited in the pipelines as a result of construction, a heavy, intermittent purging of each gas-powered device pipeline shall be done.

5.3.12.4.5.1 The appropriate adapter shall be obtained from the facility or manufacturer, and high purge rates shall be put on each outlet.

5.3.12.4.5.2 After the purge is started, it shall be rapidly interrupted several times until the purge produces no discoloration in a white cloth loosely held over the adapter during the purge.

5.3.12.4.5.3 In order to avoid possible damage to the outlet and its components, this test shall not be conducted using any implement other than the correct adapter.

5.3.12.4.6 Final Tie-In Test (Piping for Gas-Powered Devices and Level 3 Vacuum).

5.3.12.4.6.1 Prior to the connection of any new piping to its source of supply, including extensions or additions to an existing piping system, the final tests in 5.3.12.4.1 through 5.3.12.4.5 shall be successfully performed on the new work.

5.3.12.4.6.2 Each joint in the final connection between new work and an existing system shall be leak-tested with the gas of system designation or vacuum at the normal operating pressure by means of soapy water or other means effective for use with oxygen.

5.3.12.4.6.3 For gas-powered device piping, immediately after the final connection is made and leak-tested, the specific altered zone and components in the immediate zone or area that is downstream from the point or area of intrusion shall be purged per 5.3.12.4.5.

5.3.12.4.7 Labeling. The presence and correctness of labeling required by this standard for all Level 3 gas-powered device and vacuum system components (e.g., station outlets/inlets and shutoff valves) shall be checked.

5.3.12.4.8 Source Equipment Testing.

5.3.12.4.8.1 General. Source equipment checks for Level 3 gas-powered devices and Level 3 vacuum shall be performed following the installation of the interconnecting pipelines, accessories, and source equipment.

5.3.12.4.8.2 Use of Source Equipment for Pipeline Verifica-tion Tests. Where the source equipment and system gas or vacuum is used for final testing of the distribution piping, the source equipment shall be checked out and placed in operation prior to testing the distribution piping.

5.3.12.4.8.3 Level 3 Gas-Powered Devices Source Equipment. The source equipment for Level 3 gas-powered device system(s) shall be checked out and placed in operation according to the manufacturer's instructions.

5.3.12.4.8.4 Level 3 Vacuum Source Equipment. The source equipment for Level 3 vacuum systems shall be checked out and placed in operation according to the manufacturer's instructions.

5.3.13 Level 3 Operation and Management.

5.3.13.1 Special Precautions for Handling Oxygen Cylinders and Manifolds. Handling of oxygen cylinders and manifolds shall be based on CGA G-4, *Oxygen.*

5.3.13.1.1 Oxygen cylinders, containers, and associated equipment shall be protected from contact with oil or grease. Specific precautions shall include the following:

- (1) Oil, grease, or readily flammable materials shall never be permitted to come in contact with oxygen cylinders, valves, regulators, gauges, or fittings.
- (2) Regulators, fittings, or gauges shall never be lubricated with oil or any other flammable substance.
- (3) Oxygen cylinders or apparatus shall never be handled with oily or greasy hands, gloves, or rags.

5.3.13.1.2 Equipment associated with oxygen shall be protected from contamination. Specific precautions shall include the following:

(1) Particles of dust and dirt shall be cleared from cylinder valve openings by slightly opening and closing the valve before applying any fitting to the cylinder.