

CHAPTER 13

HEALTH CARE FACILITIES AND MEDICAL GAS AND VACUUM SYSTEMS

Part I – Special Requirements for Health Care Facilities.

1301.0 Application.

1301.1 Construction and equipment requirements shall be applied only to new construction and new equipment, except as modified in individual chapters. Only the altered, renovated, or modernized portion of an existing system or individual component shall be required to meet the installation and equipment requirements stated in this standard. If the alteration, renovation, or modernization adversely impacts existing performance requirements of a system or component, additional upgrading shall be required. [NFPA 99:1.3.2 – 1.3.2.2]

1301.2 This chapter applies to the special fixtures and systems in health care facilities and to the special plumbing requirements for such facilities. Other plumbing in such facilities shall comply with other applicable sections of this code.

1301.3 This chapter shall not apply to breathing air replenishment (BAR) systems.

1302.0 Medical Gas and Vacuum Piping Systems – Installation Requirements.

The installation of medical gas and vacuum piping systems shall be in accordance with the requirements of this chapter and/or the appropriate standards adopted by the Authority Having Jurisdiction. For additional standards, see Table 14-1.

1302.1 The installation of individual components shall be made in accordance with the instructions of the manufacturer. Such instructions shall include directions and information deemed by the manufacturer to be adequate for attaining proper operation, testing, and maintenance of the medical gas and vacuum systems. Copies of the manufacturer's instructions shall be left with the system owner. [NFPA 99:5.1.10.10.9.1 – 5.1.10.10.9.3]

1302.2 The installation of medical gas and vacuum systems shall be made by qualified, competent technicians who are experienced in making such installations. Installers of medical gas and vacuum systems shall meet the requirements of ASSE Standard 6010, *Professional Qualification Standard for Medical Gas and Vacuum System Installers*. [NFPA 99:5.1.10.10.11.1 – 5.1.10.10.11.2]

1302.3 Brazing shall be performed by individuals who are qualified under the provisions of Section 1311.6. [NFPA 99:5.1.10.10.11.3]

1302.4 Prior to any installation work, the installer of medical gas and vacuum piping shall provide and maintain documentation on the job site for the qualification of brazing procedures and individual brazers that are required under Section 1311.6. [NFPA 99:5.1.10.10.11.4]

1303.0 Protrusions from Walls.

1303.1 Drinking fountain control valves shall be flush-mounted or fully recessed when installed in corridors or other areas where patients are transported on a gurney, bed, or wheelchair.

1303.2 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. [NFPA 99:5.1.10.10.2.1]

1304.0 Psychiatric Patient Rooms.

Piping and drain traps in psychiatric patient rooms shall be concealed. Fixtures and fittings shall be resistant to vandalism.

1305.0 Locations for Ice Storage.

Ice makers or ice storage containers shall be located in nursing stations or similarly supervised areas to minimize potential contamination.

1306.0 Sterilizers.

1306.1 General. The requirements of this section apply to sterilizers and bedpan steamers. Such equipment shall be installed in accordance with this code and the manufacturer's installation instructions.

1306.2 Indirect Waste Connections. Waste drainage from sterilizers and bedpan steamers shall be connected to the sanitary drainage system through an airgap in accordance with this chapter and Chapter 8. The size of indirect waste piping shall be not less than the size of the drain connection on the fixture. Each such indirect waste pipe shall not exceed fifteen (15) feet (4,572 mm) in length and shall be separately piped to a receptor. Such receptors shall be located in the same room as the equipment served. Except for bedpan steamers, such indirect waste pipes shall not require traps. A trap having a seal of not less than three (3) inches (76 mm) shall be provided in the indirect waste pipe for a bedpan steamer.

1307.0 Vapor Vents and Stacks for Sterilizers.

1307.1 General. When a sterilizer has provision for a vapor vent and such a vent is required by the manufacturer, the vent shall be extended to the outdoors above the roof. Sterilizer vapor vents shall be installed in accordance with the manufacturer's instructions and shall not be connected to any drainage system vent.

1308.0 Aspirators.

1308.1 (See Section 603.4.9, Water Inlets to Water Supplied Aspirators.) Provisions for aspirators or other water-supplied suction devices shall be installed only with the specific approval of the Authority Having Jurisdiction. Where aspirators are used for removing body fluids, they shall include a collection container to collect liquids and solid particles. Aspirators shall indirectly discharge to the sanitary drainage system through an airgap in accordance with Chapter 8. The potable water supply to an aspirator shall be protected by a vacuum breaker or equivalent backflow protection device in accordance with Section 603.0.

Part II – Medical Gas and Vacuum Systems.**1309.0 Application.**

1309.1 The provisions herein shall apply to the installation, testing, and verification of medical gas and vacuum piping in hospitals, clinics, and other health care facilities.

1309.2 The purpose of this chapter is to provide requirements for the installation, testing, and verification of medical gas and medical vacuum systems, from the central supply system to the station outlets or inlets.

1309.3 Wherever the terms *medical gas* or *vacuum* occur, the provisions shall apply to piped systems for oxygen, nitrous oxide, medical air, carbon dioxide, helium, medical-surgical vacuum, waste anesthetic gas disposal, and mixtures thereof. Wherever the name of a specific gas or vacuum service occurs, the provision shall apply only to that gas. [NFPA 99:5.1.1.2]

1309.4 This chapter does not apply to portable compressed gas systems.

1309.5 This chapter does not apply to:

- (A) Cylinder and container management, storage, and reserve requirements.
- (B) Gas central supply and bulk supply systems, except as addressed in this chapter.

- (C) Electrical connections and requirements.
- (D) Motor requirements and controls.
- (E) Systems having nonstandard operating pressures, except as addressed in this chapter.
- (F) Waste anesthetic gas disposal (WAGD) systems.
- (G) Surface-mounted medical gas rail systems

1309.6 The requirements of this chapter shall not be interpreted to conflict with the requirements of NFPA 99, *Standard for Health Care Facilities*. For requirements of portions of medical gas and medical vacuum systems not addressed in this chapter or medical gas and medical vacuum systems beyond the scope of this chapter refer to NFPA 99, *Standard for Health Care Facilities*.

1309.7 An existing system that is not in strict compliance with the provisions of the standard (Code) shall be permitted to be continued in use as long as the Authority Having Jurisdiction has determined that such use does not constitute a distinct hazard to life. [NFPA 99:5.1.1.4]

1310.0 Definitions.

1310.1 Building Supply – The pipe from the source of supply to a building or structure.

1310.2 Critical Care Area – Those special care units, intensive care units, coronary care units, angiography laboratories, cardiac catheterization laboratories, delivery rooms, operating rooms, post anesthesia recovery rooms, emergency departments, and similar areas in which patients are intended to be subjected to invasive procedures and connected to line-operated, patient-care-related electrical appliances. [NFPA 99:3.3.138.1]

1310.3 General Care Areas – General care areas are patient bedrooms, examining rooms, treatment rooms, clinics, and similar areas in which it is intended that the patient will come in contact with ordinary appliances such as a nurses-call system, electric beds, examining lamps, telephones, and entertainment devices. [NFPA 99:3.3.138.2]

1310.4 Manifold – A device for connecting outlets of one (1) or more gas cylinders to the central piping system for that specific gas. [NFPA 99:3.3.103]

1310.5 Medical Air – For purposes of this standard, medical air is air supplied from cylinders, bulk containers, medical air compressors, or has been reconstituted from oxygen USP and oil-free, dry nitrogen NF. [NFPA 99:3.3.106] Medical air shall be required to have the following characteristics:

- (1) Be supplied from cylinders, bulk containers, medical air compressor sources, or be reconstituted from oxygen USP and oil-free dry nitrogen NF.

- (2) Meet the requirements of medical air USP.
- (3) Have no detectable liquid hydrocarbons.
- (4) Have less than twenty-five (25) ppm gaseous hydrocarbons.
- (5) Have equal to or less than five (5) mg/m³ of permanent particulates sized one (1) micron or larger in the air at normal atmospheric pressure. [NFPA 99:5.1.3.5.1(1)-(5)]

1310.6 Medical Gas – Gas used in a medical facility, including oxygen, nitrous oxide, carbon dioxide, helium, medical air, and mixtures of these gases. Standards of purity apply.

1310.7 Medical Gas System – Complete system consisting of a central supply system (manifold, bulk, or compressors), including control equipment and piping extending to station outlets at the points where medical gases are required.

1310.8 Medical Vacuum System – See 1310.19, Vacuum System – Level 1.

1310.9 Nitrogen, NF (Oil-Free, Dry) (Nitrogen for Brazing and Testing) – Nitrogen complying, at a minimum, with oil-free, dry nitrogen NF. [NFPA 99:3.3.120.1]

1310.10 Patient Care Area – Any portion of a health care facility wherein patients are intended to be examined or treated. [NFPA 99:3.3.138]

1310.11 Purge, Flow – The removal of oxygen from a system by oil-free dry nitrogen during brazing.

1310.12 Purge, System – The removal of nitrogen from a system with the medical gas required for that system.

1310.13 SCFM – Standard cubic feet per minute. [NFPA 99:3.3.163]

1310.14 Special Hazard Area – An area such as a kitchen or electrical switch-gear room.

1310.15 Station Inlet – An inlet point in a medical-surgical piped vacuum distribution system at which the user makes connections and disconnections. [NFPA 99:3.3.171]

1310.16 Station Outlet – An inlet point in a piped medical/surgical vacuum distribution system at which the user makes connections and disconnections. [NFPA 99:3.3.172]

1310.17 Use Point – A room or area of a room where medical gases are dispensed to a single patient for medical purposes. A use point is permitted to be comprised of a number of station outlets of different gases.

1310.18 User Outlet – See Station Outlet.

1310.19 Vacuum System – Level 1 – A system consisting of central vacuum-producing equipment with pressure and operating controls, shutoff valves,

alarm warning systems, gauges, and a network of piping extending to and terminating with suitable station inlets at locations where patient suction could be required. [NFPA 99:3.3.91]

1310.20 Valve, Isolation – A valve that isolates one (1) piece of equipment from another.

1310.21 Valve, Riser – A valve at the base of a vertical riser that isolates that riser.

1310.22 Valve, Service – A valve serving horizontal piping extending from a riser to a station outlet or inlet.

1310.23 Valve, Source – A single valve at the source that controls a number of units that make up the source.

1310.24 Valve, Zone – A valve that controls the gas or vacuum to a particular area.

1310.25 Waste Anesthetic Gas Disposal – The process of capturing and carrying away gases vented from the patient breathing circuit during the normal operation of gas anesthesia or analgesia equipment. [NFPA 99:3.3.184]

1311.0 General Requirements.

1311.1 Oxygen Compatibility. 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 4.1, *Cleaning Equipment for Oxygen Service*, except that fittings shall be permitted to be cleaned by a supplier or agency other than the manufacturer. [NFPA 99:5.1.10.1.1]

1311.1.1 Components include but are not limited to containers, valves, valve seats, lubricants, fittings, gaskets, and interconnecting equipment including hose. Easily ignitable materials should be avoided.

Compatibility involves both combustibility and ease of ignition. Materials that burn in air will burn violently in pure oxygen at normal pressure and explosively in pressurized oxygen. Also, many materials that do not burn in air will do so in pure oxygen, particularly under pressure. Metals for containers and piping have to be carefully selected, depending on service conditions. The various steels are acceptable for many applications, but some service conditions can call for other materials (usually copper or its alloys) because of their greater resistance to ignition and lower rate of combustion. Similarly, materials that can be ignited in air have lower ignition energies in oxygen. Many such materials can be ignited by friction at a valve seat, stem packing or by adiabatic compression

produced when oxygen at high pressure is rapidly introduced into a system initially at low pressure.

1311.1.2 Materials used in central supply systems shall meet the following requirement [NFPA 99:5.1.3.4.4]:

In those portions of systems intended to handle oxygen or nitrous oxide at gauge pressures of less than three-hundred (300) psi (2,070 kPa), material construction shall be compatible with oxygen under the temperatures and pressures to which the components can be exposed in the containment and use of oxygen, nitrous oxide, mixtures of these gases, or mixtures containing more than 23.5 percent oxygen. [NFPA 99:5.1.3.4.4(1), (2)]

1311.2 Certification of medical gas and medical vacuum systems shall conform to the requirements of Section 1328.0 of this code, the Authority Having Jurisdiction, and NFPA 99, *Standard for Health Care Facilities*, Section 5.1.12.

1311.3 Prior to any installation work, the installer of medical gas and vacuum piping shall provide and maintain documentation on the job site for the qualification of brazing procedures and individual brazers that are required under Section 1311.6. [NFPA 99:5.1.10.10.11.4]

1311.3.1 Each length of tube shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation. Fittings, valves, and other components shall be delivered sealed, labeled, and kept sealed until prepared for installation. [NFPA 99:5.1.10.1.2 and 5.1.10.1.3]

1311.4 Medical gas and medical vacuum systems shall be supplied from a source consisting of not less than two (2) units – primary and secondary, e.g., a manifold consisting of two (2) cylinder banks with not less than two (2) cylinders in each bank, not less than two (2) air compressors, or not less than two (2) vacuum pumps. However, two (2) supply pipelines are not required.

1311.5 Health Care Organization personnel shall be permitted to install piping systems if the requirements of this chapter are met during installation. [NFPA 99:5.1.10.10.11.5]

1311.6 Brazing procedures and brazer performance for the installation of medical gas and vacuum piping shall be qualified 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 Qualifications*, both as modified below. [NFPA 99:5.1.10.10.12.1]

1311.6.1 Brazers shall be qualified by visual examination of the test coupon followed by sectioning. [NFPA 99:5.1.10.10.12.2]

1311.6.2 The Brazing Procedure Specification (BPS) shall address cleaning, joint clearance, overlap, internal purge gas purge gas flow rate, and filler metal. [NFPA 99:5.1.10.10.12.3]

1311.6.3 The brazing procedure specification 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. [NFPA 99:5.1.10.10.12.4]

1311.6.4 Brazing procedures qualified by a technically competent group or agency shall be permitted under the following conditions:

- (1) The brazing procedure specification and the procedure qualification record meets 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 not less than one (1) brazer following each brazing procedure specification used. [NFPA 99:5.1.10.10.12.5]

1311.6.5 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. [NFPA 99:5.1.10.10.12.6]

1311.6.6 Performance qualifications of brazers shall remain in effect indefinitely unless the brazer does not braze with the qualified procedure for a period exceeding six (6) months, or there is a specific reason to question the ability of the brazer. [NFPA 99:5.1.10.10.12.7]

1312.0 Plan Review.

1312.1 Before any medical gas or medical vacuum system is installed or altered in any hospital,

medical facility, or clinic, duplicate plans and specifications shall be filed with the Authority Having Jurisdiction. Approval of the plans shall be obtained prior to issuance of any permit by the Authority Having Jurisdiction.

1312.2 Plans and specifications shall show the following, in detail:

1312.2.1 Plot plan of the site, drawn to scale, indicating the location of existing or new cylinder storage areas, property lines, drive-ways, and existing or proposed buildings.

1312.2.2 Piping layout of the proposed piping system or alteration, including alarms, valves, origin of gases, and user outlets/inlets. The demand and loading of any piping, existing or future, shall also be indicated.

1312.2.3 Complete specification of materials.

1312.3 Plans and specifications submitted to the Authority Having Jurisdiction shall clearly indicate the nature and extent of the work proposed and shall show in detail that such work will conform to the provisions of this code.

1312.4 A record of as-built plans and valve identification records shall remain on the site at all times.

1313.0 System Performance.

1313.1 Required Operating Pressures. Medical gas and medical vacuum systems shall be capable of delivering service in the pressure ranges listed in Table 13-1.

1313.2 Minimum Flow Rates. Medical gas and medical vacuum systems shall be capable of supplying the flow rates listed in Table 13-2.

1313.3 Minimum Station Outlets/Inlets. Station outlets and inlets for medical gas and medical vacuum systems shall be provided as listed in Table 13-3.

1314.0 Required Pipe Sizing.

1314.1 Where the maximum demand for each medical gas or vacuum system and the maximum length of piping between the source equipment and the most distant station outlet/inlet do not exceed the values in Table 13-6, the size of pipe of each section of the system shall be determined using Tables 13-4 and 13-6. The size for systems beyond the range of Table 13-6 shall be determined by using the methods set forth in Section 1314.3 of this chapter.

1314.2 To determine the size of each section of pipe in any system within the range of Table 13-6, proceed as follows:

1314.2.1 Measure the length of the pipe from the source equipment location to the most remote station inlet/outlet on the system.

1314.2.2 In Table 13-6, select the column showing that distance, or the next longer distance if the table does not give the exact length.

1314.2.3 Starting at the most remote outlet/inlet, find in the vertical column just selected the medical gas or vacuum demand for that inlet/outlet. If the exact figure of demand is not shown, choose the next larger figure below in the column.

1314.2.4 Opposite this demand figure, in the first column at the left in Table 13-6, will be found the correct size of pipe.

1314.2.5 Using this same vertical column, proceed in a similar manner for each section of pipe serving this inlet/outlet. For each section of pipe, determine the total gas or vacuum demand supplied by the section, using Table 13-4.

1314.2.6 Size each section of branch piping not previously sized by measuring the distance from the source equipment location to the most remote inlet/outlet in that branch, and follow the procedures of Sections 1314.2.2 through 1314.2.5.

Note: Size branch piping in the order of the distance from the source location, beginning with the most distant outlet not previously sized.

1314.3 For conditions other than those covered by Section 1314.1 of this section, such as longer runs of greater gas or vacuum demands, the size of each gas or vacuum piping system shall be determined by standard engineering methods acceptable to the Authority Having Jurisdiction, and each system shall be so designed that the total pressure drop or gain between the source equipment and any inlet/outlet shall not exceed the allowable pressures shown in Table 13-1.

1315.0 Workmanship.

1315.1 Design, construction, and workmanship shall be in conformity with accepted engineering practices and shall meet the requirements of this code.

1315.2 Cracks, holes, or other imperfections in materials shall not be concealed by welding, brazing, or soldering, or by using paint, wax, tar, other leak-sealing or repair agents.

1315.3 Burred ends of all tubing shall be deburred using a deburring tool to the full bore of the tube, and all chips shall be removed.

1316.0 Materials.

The provisions of this section apply to the field-installed piping for the distribution of medical piped gases.

1316.1 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 4.1, *Cleaning Equipment for Oxygen Service*, except that fittings shall be permitted to be cleaned by a supplier or agency other than the manufacturer. [NFPA 99:5.1.10.1.1]

1316.2 Each length of tube shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation. Fittings, valves, and other components shall be delivered sealed, labeled, and kept sealed until prepared for installation. [NFPA 99:5.1.10.1.2, 5.1.10.1.3]

1316.3 Tubes shall be hard-drawn seamless copper ASTM B 819 medical gas tube, Type L, except that where operating pressures are exceeding a gauge pressure of one-hundred and eighty-five (185) psi (1,275 kPa), Type K shall be used for sizes exceeding DN80 (NPS 3) (3-1/8 in. O.D.).

ASTM B 819 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). [NFPA 99:5.1.10.1.4, 5.1.10.1.5]

Piping for vacuum systems shall be constructed of any of the following:

- (1) Hard-drawn seamless copper tube:
 - (a) ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, (Types K, L, M).
 - (b) ASTM B 280, *Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service* (copper ACR tube).
 - (c) ASTM B 819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, copper medical gas tubing (Type K or L).
- (2) Stainless steel tube. [NFPA 99:5.1.10.2.1]:

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

Mains and branches in medical gas-piping systems shall be not less than DN15 (NPS 1/2) (5/8 in. O.D.) size.

Mains and branches in medical-surgical vacuum systems shall be not less than DN20 (NPS 3/4) (7/8 in. O.D.) size.

Drops to individual station outlets and inlets shall be not less than DN15 (NPS 1/2) (5/8 in. O.D.) size.

Runouts to alarm panels and connecting tubing for gauges and alarm devices shall be permitted to be DN8 (NPS 1/4) (3/8 in. O.D.) size. [NFPA 99:5.1.10.10.1.1 – 5.1.10.10.1.5]

1316.4 Turns, offsets, and other changes in direction in welded or brazed medical gas and vacuum piping shall be made with wrought-copper capillary fittings complying with ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*, or brazed fittings complying with ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*. [NFPA 99:5.1.10.3.1]

1316.4.1 Cast-copper alloy fittings shall not be permitted. [NFPA 99:5.1.10.3.2]

1316.4.2 Branch connections in 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. [NFPA 99:5.1.10.3.3]

1316.5 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) Dielectric fittings, where required by the manufacturer of special medical equipment to electrically isolate the equipment from the piping distribution system.
- (4) 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. [NFPA 99:5.1.10.7]

1316.6 The following joints shall be prohibited throughout medical gas and vacuum distribution pipeline systems:

- (1) Flared and compression-type connections, including connections to station outlets and inlets, alarm devices, and other components.
- (2) Other straight-threaded connections, including unions.
- (3) The use of pipe-crimping tools to permanently stop the flow. [NFPA 99:5.1.10.8]

1316.6.1 Threaded joints in medical gas and vacuum distribution piping shall meet the following requirements:

- (1) Be limited to connections to pressure/vacuum indicators, alarm devices, and source equipment.
- (2) Be tapered pipe threads complying with ASME B1.20.1, *Pipe Threads General Purpose, Inc.*

- (3) Be made up with polytetrafluoroethylene (such as Teflon™) tape or other thread sealant recommended for oxygen service, with the sealant applied to the male threads only. [NFPA 99:5.1.10.4]

1316.7 New or replacement shutoff valves shall be as follows:

- (1) Quarter turn, full ported ball type.
- (2) Brass or bronze construction.
- (3) Have extensions for brazing.
- (4) Have a handle indicating open or closed.
- (5) Consist of three pieces permitting in-line service-ability. [NFPA 99:5.1.4.3]

1316.8 Soldered joints in copper Level 3 vacuum and Level 3 gas-powered systems piping shall be made in accordance with ASTM B 828, *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. [NFPA 99:5.3.10.5]

1317.0 Cleaning for Medical Gas Piping Systems.

1317.1 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 recleaned 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 one (1) pound to three (3) gallons (450 g to 11 L) of potable water and thoroughly rinsing them with clean, hot potable water. Other aqueous cleaning solutions shall be permitted to be used for on-site recleaning permitted above, provided that they are as recommended in CGA Pamphlet G-4.1, *Cleaning Equipment for Oxygen Service*, and are listed in CGA Pamphlet O2-DIR, *Directory of Cleaning Agents for Oxygen Service*. [NFPA 99:5.1.10.5.3.10 and 5.1.10.5.3.11]

1317.2 Material that has become contaminated internally and is not clean for oxygen service shall not be installed. [NFPA 99:5.1.10.5.3.12]

1318.0 Installation of Piping.

1318.1 Piping shall be protected against freezing, corrosion, and physical damage. [NFPA 99:5.1.10.10.2]

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. [NFPA 99:5.1.10.10.2.1]

Piping underground within buildings or embedded in concrete floors or walls shall be installed in a continuous conduit. [NFPA 99:5.1.10.10.2.2]

1318.2 Piping risers shall be permitted to be installed in pipe shafts if protected from physical damage, effects of excessive heat, corrosion, or contact with oil. [NFPA 99:5.1.10.10.3.1]

Piping shall not be installed in kitchens, elevator shafts, elevator machine rooms, areas with open flames, electrical service equipment exceeding 600 volts, and areas prohibited under NFPA 70, *National Electrical Code*, except for the following locations:

- (1) Room locations for medical air compressor supply systems and medical-surgical vacuum pump supply systems.
- (2) Room locations for secondary distribution circuit panels and breakers having a maximum voltage rating of 600 volts. [NFPA 99:5.1.10.10.3.2]

Medical gas piping shall be permitted to be installed in the same service trench or tunnel with fuel gas lines, fuel oil lines, electrical lines, steam lines, and similar utilities provided that the space is ventilated (naturally or mechanically) and the ambient temperature around the medical gas piping shall not exceed 130°F (54°C). [NFPA 99:5.1.10.10.3.3]

Medical gas piping shall not be located where subject to contact with oil, including a possible flooding area in the case of a major oil leak. [NFPA 99:5.1.10.10.3.4]

1318.3 Buried piping outside of buildings shall be installed below the local level of frost penetration. [NFPA 99:5.1.10.10.5.1]

1318.4 The installation procedure for underground piping shall protect the piping from physical damage while being backfilled. [NFPA 99:5.1.10.10.5.2]

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

- (1) Access 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. [NFPA 99:5.1.10.10.5.3]

Buried piping that will be subject to surface loads shall be buried at a depth that will protect the piping and its enclosure from excessive stresses. [NFPA 99:5.1.10.10.5.4]

The minimum backfilled cover above the top of the pipe or its enclosure for buried piping outside of buildings shall be thirty-six (36) inches (900 mm), except that the minimum cover shall be permitted to

be reduced to eighteen (18) inches (450 mm) where physical damage is otherwise prevented. [NFPA 99:5.1.10.10.5.5]

Trenches shall be excavated so that the pipe enclosure has firm, substantially continuous bearing on the bottom of the trench. [NFPA 99:5.1.10.10.5.6]

Backfill shall be clean and compacted so as to protect and uniformly support the pipe enclosure. [NFPA 99:5.1.10.10.5.7]

A continuous tape or marker placed immediately above the enclosure shall clearly identify the pipeline by specific name. [NFPA 99:5.1.10.10.5.8]

A continuous warning means shall also be provided above the pipeline at approximately one-half (1/2) the depth of bury. [NFPA 99:5.1.10.10.5.9]

Where underground piping is installed through a wall sleeve, the ends of the sleeve shall be sealed to prevent the entrance of groundwater into the building. [NFPA 99:5.1.10.10.5.10]

1318.5 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. Flexible connectors, metallic or nonmetallic, shall have a minimum burst pressure, with a gauge pressure of one-thousand (1,000) psi (6,895 kPa). [NFPA 99:5.1.10.10.7.1 – 5.1.10.10.7.2]

1318.6 Where a positive-pressure medical gas-piping distribution system, originally used or constructed for the use at one (1) pressure and for one (1) gas, is converted for operation at another pressure or for another gas, the provisions of Section 1316.0 shall apply as if the system were new. [NFPA 99:5.1.10.10.10.1]

A vacuum system shall not be permitted to be converted for use as a gas system. [NFPA 99:5.1.10.10.10.2]

1318.7 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. [NFPA 99:5.1.10.10.2.1]

1318.8 Piping shall be supported from the building structure in accordance with MSS Standard Practice SP-69, *Piping Hangers and Supports – Selection and Application*. [NFPA 99:5.1.10.10.4.1]

Hangers and supports shall comply with MSS Standard Practice SP-58, *Pipe Hangers and Supports - Materials, Design, and Manufacture*. [NFPA 99:5.1.10.10.4.2]

Hangers for copper tube shall have a copper finish and be sized for copper tube. [NFPA 99:5.1.10.10.4.3]

In potentially damp locations, copper tube hangers or supports that are in contact with the tube shall be plastic-coated or otherwise be insulated from the tube. [NFPA 99:5.1.10.10.4.4]

Maximum support spacing shall be in accordance with Table 13-7. [NFPA 99: Table 5.1.10.10.4.5]

1318.9 Where required, medical gas and vacuum piping shall be seismically restrained against earthquakes in accordance with the applicable building code. [NFPA 99:5.1.10.10.4.6] Seismic considerations shall conform to the requirements of this code and the Authority Having Jurisdiction.

1318.10 Two (2) or more medical gas-piping systems shall not be interconnected for testing or any other reason. Leak testing shall be accomplished by separately charging and testing the individual piping system. [NFPA 99:5.1.10.10.8.1 – 5.1.10.10.8.2]

1318.11 Piping shall be labeled by stenciling or adhesive markers that identify the patient medical gas, the support gas, or vacuum system, and include:

- (1) The name of the gas/vacuum system or the chemical symbol per NFPA 99: Table 5.1.11.
- (2) The gas or vacuum system color code per NFPA 99: Table 5.1.11.
- (3) Where positive-pressure gas piping systems operate at pressures other than the standard gauge pressure in NFPA 99: Table 5.1.11, the pipe labeling shall include the operating pressure in addition to the name of the gas. [NFPA 99:5.1.11.1.1]

1319.0 Joints.

This section sets forth the requirements for pipe joint installation for positive-pressure medical gas systems.

1319.1 Brazed joints shall be made using a brazing alloy that exhibits a melting temperature in excess of 1,000°F (538°C) to retain the integrity of the piping system in the event of fire exposure. [NFPA 99:5.1.10.5.1.1]

Braze tube joints shall be the socket type. [NFPA 99:5.1.10.5.1.2]

Filler metals shall bond with and be metallurgically compatible with the base metals being joined. [NFPA 99:5.1.10.5.1.3]

Filler metals shall comply with AWS A.5.8, *Specification for Filler Metals for Brazing and Braze Welding*. [NFPA 99:5.1.10.5.1.4]

Copper-to-copper joints shall be brazed using a copper-phosphorus or copper-phosphorus-silver brazing filler metal (BCuP series) without flux. [NFPA 99:5.1.10.5.1.5]

Flux shall only be used when brazing dissimilar metals, such as copper and bronze or brass, using a silver (BAg series) brazing filler material. [NFPA 99:5.1.10.5.4.1]

Joints to be brazed in place shall be accessible for necessary preparation, assembly, heating, filler application, cooling, cleaning, and inspection. [NFPA 99:5.1.10.5.1.7]

1319.2 Tube ends shall be cut square using a sharp tubing cutter to avoid deforming the tube. [NFPA 99:5.1.10.5.2.1]

The cutting wheels on tubing cutters shall be free from grease, oil, or other lubricant not suitable for oxygen service. [NFPA 99:5.1.10.5.2.2]

The cut ends of the tube shall be deburred with a sharp, clean deburring tool, taking care to prevent chips from entering the tube. [NFPA 99:5.1.10.5.2.3]

1319.3 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. [NFPA 99:5.1.10.5.3.1]

The exterior surfaces of tube ends shall be cleaned prior to brazing to remove any surface oxides. [NFPA 99:5.1.10.5.3.2]

When cleaning the exterior surfaces of tube ends, no matter shall be permitted to enter the tube. [NFPA 99:5.1.10.5.3.3]

If the interior surfaces of fitting sockets become contaminated prior to brazing, they shall be recleaned for oxygen in accordance with Section 1317.1 and be cleaned for brazing with a clean, oil-free wire brush. [NFPA 99:5.1.10.5.3.4]

Clean, nonshedding, abrasive pads shall be used to clean the exterior surfaces of tube ends. [NFPA 99:5.1.10.5.3.5]

The use of steel wool or sand cloth shall be prohibited. [NFPA 99:5.1.10.5.3.6]

The cleaning process shall not result in grooving of the surfaces to be joined. [NFPA 99:5.1.10.5.3.7]

After being abraded, the surfaces shall be wiped using a clean, lint-free white cloth. [NFPA 99:5.1.10.5.3.8]

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 and that they are free of obstructions or debris. [NFPA 99:5.1.10.5.3.9]

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 recleaned 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 one (1) pound to three (3) gallons (450 g to 11 L) of potable water and thoroughly rinsing them with clean, hot potable water. [NFPA 99:5.1.10.5.3.10]

Other aqueous cleaning solutions shall be permitted to be used for on-site recleaning permitted in NFPA 99:5.1.10.5.3.10, provided that they are as recommended in CGA Pamphlet G-4.1, *Cleaning Equipment for Oxygen Service*, and are listed in CGA Pamphlet O2-DIR, *Directory of Cleaning Agents for Oxygen Service*. [NFPA 99:5.1.10.5.3.11]

Material that has become contaminated internally and is not clean for oxygen service shall not be installed. [NFPA 99:5.1.10.5.3.12]

Joints shall be brazed within eight (8) hours after the surfaces are cleaned for brazing. [NFPA 99:5.1.10.5.3.13]

1319.4 Flux shall only be used when brazing dissimilar metals such as copper and bronze or brass, using a silver (BAg series) brazing filler metal. [NFPA 99:5.1.10.5.4.1]

Surfaces shall be cleaned for brazing in accordance with Section 1319.3. [NFPA 99:5.1.10.5.4.2]

Flux shall be applied sparingly to minimize contamination of the inside of the tube with flux. [NFPA 99:5.1.10.5.4.3]

The flux shall be applied and worked over the cleaned surfaces to be brazed using a stiff bristle brush to ensure complete coverage and wetting of the surfaces with flux. [NFPA 99:5.1.10.5.4.4]

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. [NFPA 99:5.1.10.5.4.5]

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. [NFPA 99:5.1.10.5.4.6]

1319.5 Tube ends shall be inserted fully into the socket of the fitting. [NFPA 99:5.1.10.5.6.1]

Where flux is permitted, the joint shall be heated slowly until the flux has liquefied. [NFPA 99:5.1.10.5.6.2]

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. [NFPA 99:5.1.10.5.6.3]

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*. [NFPA 99:5.1.10.5.6.4]

1319.6 When 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. [NFPA 99:5.1.10.5.5.1]

The source of the purge gas shall be monitored, and the installer shall be audibly alerted when the source content is low. [NFPA 99:5.1.10.5.5.2]

The purge gas flow rate shall be controlled by the use of a pressure regulator and flow meter or combination thereof. [NFPA 99:5.1.10.5.5.3]

Pressure regulators alone shall not be used to control purge gas flow rates. [NFPA 99:5.1.10.5.5.4]

In order to assure that all ambient air has been removed from the pipeline prior to brazing, an oxygen analyzer shall be used to verify the effectiveness of the purge. The oxygen analyzer shall read below 1 percent oxygen concentration before brazing is to begin. [NFPA 99:5.1.10.5.5.5]

During and after installation, openings in the piping system shall be kept sealed to maintain a nitrogen atmosphere within the piping to prevent debris or other contaminants from entering the system. [NFPA 99:5.1.10.5.5.6]

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. [NFPA 99:5.1.10.5.5.7]

The flow of purge gas shall be maintained until the joint is cool to the touch. [NFPA 99:5.1.10.5.5.8]

After the joint has cooled, the purge discharge opening shall be sealed to prevent contamination of the inside of the tube and maintain the nitrogen atmosphere within the piping system. [NFPA 99:5.1.10.5.5.9]

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. [NFPA 99:5.1.10.5.5.10]

After a final connection in a positive-pressure medical gas pipeline is made without a nitrogen purge, an outlet in the immediate downstream zone of the affected portions of both the new and existing in-use piping shall be tested in accordance with NFPA 99:5.1.12.3.9, *Final Tie-In Test*. [NFPA 99:5.1.10.5.5.11]

When using the autogenous orbital welding process, joints shall be continuously purged inside

and outside with inert gas(es) in accordance with the qualified welding procedure. [NFPA 99:5.1.10.5.5.12]

1319.7 After brazing, 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. [NFPA 99:5.1.10.5.7.1]

Where flux has been used, the wash water shall be hot. [NFPA 99:5.1.10.5.7.2]

Each brazed joint shall be visually inspected after cleaning the outside surfaces. [NFPA 99:5.1.10.5.7.3]

Joints exhibiting the following conditions shall not be permitted:

- (1) Flux or flux residue (when flux or flux-coated BAg series 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 brazed filler metal.
- (7) Failure of the joint to hold the test pressure under the installer-performed initial pressure test (Section 1327.10) and standing pressure test (Section 1327.11). [NFPA 99:5.1.10.5.7.4]

Brazed joints that are identified as defective under conditions of Section 1319.7(2) or (5) shall be replaced. [NFPA 99:5.1.10.5.7.5]

Brazed joints that are identified as defective under Sections 1319.7(1), (3), (4), (6), or (7) shall be permitted to be repaired, except that no joint shall be reheated more than once before being replaced. [NFPA 99:5.1.10.5.7.6]

1320.0 Valves – Requirements, Locations, and Labeling.

1320.1 General Requirements. Shutoff valves accessible to other than authorized personnel shall be installed in valve boxes with frangible or removable windows large enough to permit manual operation of valves. [NFPA 99:5.1.4.2.1]

Shutoff valves for use in certain areas, such as psychiatric or pediatric, shall be permitted to be secured with the approval of the Authority Having Jurisdiction to prevent inappropriate access. [NFPA 99:5.1.4.2.2]

1320.1.1 Where valves are concealed in any enclosure, the door or entry to the enclosure shall be identified and color coded with the type of gas service installed, as described in Section

1323.0. Enclosures shall be of sufficient size to permit valve operation. Valve handles in the off position shall prevent closure of the access panel or door.

1320.2 In-line shutoff valves intended for use to isolate piping for maintenance or modification shall meet the following requirements:

- (1) Be located in a restricted area.
- (2) Be locked or latched open.
- (3) Be identified in accordance with Section 1323.0 [NFPA 99:5.1.4.9.1]

1320.3 Shutoff valves provided for the connection of future piping shall meet the following requirements:

- (1) Be located in a restricted area.
- (2) Be locked or latched closed.
- (3) Be identified in accordance with Section 1323.0 [NFPA 99:5.1.4.10]

1320.3.1 Future connection valves shall be labeled as to gas content. [NFPA 99:5.1.4.10.1]

1320.3.2 Downstream piping shall be closed with a brazed cap with tubing allowance for cutting and rebrazing. [NFPA 99:5.1.4.10.2]

1320.3.3 A zone valve shall be located immediately outside each vital life-support, critical care, and anesthetizing location in each medical gas and/or vacuum line, and located so as to be readily accessible in an emergency. [NFPA 99:5.1.4.8.7]

1320.3.4 Gas-delivery columns, hose reels, ceiling tracks, control panels, pendants, booms, or other special installations shall be located downstream of the zone valve. [NFPA 99:5.1.4.8.7.1]

1320.3.5 Zone valves shall be so arranged that shutting off the supply of gas to any one (1) operating room or anesthetizing location will not affect the others. [NFPA 99:5.1.4.8.7.2]

1320.4 Source Valve. A shutoff valve shall be placed at the immediate connection of each source system to the distribution piping to permit the entire source, including all accessory devices (such as air dryers, final line regulators, etc.), to be isolated from the facility. [NFPA 99:5.1.4.4]

1320.4.1 The source valve shall be located in the immediate vicinity of the source equipment. [NFPA 99:5.1.4.4.1]

1320.4.2 The source valve shall be labeled in accordance with Section 1323.0, Source Valve for the (Source Name). [NFPA 99:5.1.4.4.2]

1320.5 Main Valve. A shutoff valve shall be provided in the main supply line inside of the

building, except where one or more of the following conditions exist:

- (1) The source and source valve are located inside the building served.
- (2) The source system is physically mounted to the wall of the building served and the pipeline enters the building in the immediate vicinity of the source valve. [NFPA 99:5.1.4.5]

1320.5.1 The main line valve shall be located to permit access by authorized personnel only (i.e., by locating above a ceiling or behind a locked access door). [NFPA 99:5.1.4.5.1]

1320.5.2 The main line valve shall be located on the facility side of the source valve and outside of the source room, enclosure, or where the main line first enters the building. [NFPA 99:5.1.4.5.2]

1320.5.3 The main line shall be labeled in accordance with Section 1323.0. [NFPA 99:5.1.4.5.3]

1320.6 Riser Valve. Each riser supplied from the main line shall be provided with a shutoff valve adjacent to the riser connection. Riser valves shall be permitted to be located above ceilings, but shall remain accessible and not be obstructed. [NFPA 99:5.1.4.6, 5.1.4.6.1]

1320.7 Zone Valve. Station outlets/inlets shall be supplied through a zone valve as follows:

- (1) The zone valve shall be placed such that a wall intervenes between the valve and outlets/inlets that it controls.
- (2) The zone valve shall serve only outlets/inlets located on that same story. [NFPA 99:5.1.4.8]

1320.7.1 Zone valves shall be readily operable from a standing position in the corridor on the same floor they serve. [NFPA 99:5.1.4.8.1]

1320.7.2 Zone valves shall be so arranged that shutting off the supply of medical gas or vacuum to one (1) zone will not affect the supply of medical gas or vacuum to another zone or the rest of the system. [NFPA 99:5.1.4.8.2]

1320.8 Service Valves. Service valves shall be placed in the branch piping prior to any zone valve box assembly on that branch. [NFPA 99:5.1.4.7.2]

1320.8.1 Only one (1) service valve shall be required for each branch off of a riser regardless of how many zone valve boxes are installed on that lateral. [NFPA 99:5.1.4.7.1]

1320.8.2 Service valves shall be installed to allow servicing or modification of lateral branch piping from a main or riser without shutting down the entire main, riser, or facility. [NFPA 99:5.1.4.7]

1321.0 Pressure-Regulating Equipment.

1321.1 Pressure-regulating equipment shall be installed in the supply main upstream of the final line-pressure valve. Where multiple piping systems for the same gas at different operating pressures are required, separate pressure-regulating equipment, relief valves, and source shutoff valves shall be provided for each pressure.

1321.2 Each central supply system shall have a pressure-relief valve set at 50 percent above normal line pressure, installed downstream of the pressure regulator and upstream of any shutoff valve. This pressure-relief valve shall be permitted to be set at a higher pressure, provided another pressure-relief valve set at 50 percent above normal line pressure is installed in the main supply line.

1321.2.1 Pressure-relief valves shall close automatically when excess pressure has been released.

1321.2.2 Pressure-relief valves set at 50 percent shall be vented to the outside from gas systems, except medical air, or if the total capacity of the supply system is in excess of three-thousand (3,000) cubic feet (85 m³) of gas.

1321.2.3 Pressure-relief valves shall be of brass or bronze and specially designed for the gas service involved.

1321.2.4 A pressure-relief valve shall not be isolated from its intended use by any valve.

1321.3 Pressure Gauges. Pressure and vacuum indicators shall be readable from a standing position. Pressure/vacuum indicators shall be provided at the following locations, as a minimum:

- (1) Adjacent to the alarm-initiating device for source main-line pressure and vacuum alarms in the master alarm system.
- (2) At or in area alarm panels to indicate the pressure/vacuum at the alarm activating device for each system that is monitored by the panel.
- (3) On the station outlet/inlet side of zone valves. [NFPA 99:5.1.8.2.1, 5.1.8.2.2]

1322.0 Station Outlets/Inlets.

Station outlets and inlets shall be installed in strict accordance with the manufacturers instructions.

1322.1 After installation of the piping, but before installation of the station outlets/inlets and other medical gas and medical gas system components (e.g., pressure-actuating switches for alarms, manifolds, pressure gauges, or pressure relief valves), the line shall be blown clear by means of oil-free, dry nitrogen.

1323.0 Labeling and Identification.

The gas content of medical gas piping systems shall be readily identifiable by appropriate labeling with the name and pressure contained. Such labeling shall be by means of metal tags, stenciling, stamping, or adhesive markers, in a manner that is not readily removable. Where supplementary color identification of piping is used, it shall be in accordance with the gases and colors indicated in CGA Pamphlet C-9, *Standard Color-Marking of Compressed Cylinders Intended for Medical Gas Use*, See Table 13-1.

1323.1 Piping shall be labeled by stenciling or adhesive markers that identify the medical gas, support gas, or vacuum system and include:

- (1) The name of the gas/vacuum system or the chemical symbol per Table 13-1.
- (2) The gas or vacuum system color code per Table 13-1.
- (3) Where positive-pressure gas piping systems operate at pressures other than the standard gauge in Table 13-1, the pipe labeling shall include the operating pressure in addition to the name of the gas. [NFPA 99:5.1.11.1.1]

Pipe labels shall be located as follows:

- (1) At intervals of not more than twenty (20) feet (6,100 mm).
- (2) Not less than once in or above every room.
- (3) On both sides of walls or partitions penetrated by the piping.
- (4) Not less than once in every story height traversed by risers. [NFPA 99:5.1.11.1.2]

1323.2 Shutoff valves shall be identified as follows:

- (1) The name or chemical symbol for the specific medical gas or vacuum system.
- (2) The room or areas served.
- (3) A caution to not close or open valve except in emergency. [NFPA 99:5.1.11.2.1]

1323.3 Station outlets and inlets shall be identified as to the name or chemical symbol for the specific medical gas or vacuum provided. [NFPA 99:5.1.11.3.1]

1323.4 The shutoff valves described in Sections 1320.4, 1320.5, and 1320.6 shall be labeled to reflect the rooms that are controlled by such valves. Labeling shall be kept current from initial construction through acceptance. Valves shall be labeled in substance as follows:

In-line shutoff valves shall be labeled in substance as follows:

CAUTION
(NAME OF MEDICAL GAS) VALVE
DO NOT CLOSE EXCEPT IN EMERGENCY
THIS VALVE CONTROLS SUPPLY TO...

Source valves shall be labeled in substance as follows:

**SOURCE VALVE
FOR THE (SOURCE NAME).**

Main line valves shall be labeled in substance as follows:

**MAIN LINE VALVE FOR THE
(GAS/VACUUM NAME) SERVING THE
(NAME OF BUILDING).**

Riser valve(s) shall be labeled in substance as follows:

**RISER FOR THE (GAS/VACUUM NAME)
SERVING (NAME OF THE AREA/BUILDING
SERVED BY THE PARTICULAR RISER).**

Service valve(s) shall be labeled in substance as follows:

**SERVICE VALVE FOR THE
(GAS/VACUUM NAME) SERVING
(NAME OF THE AREA/BUILDING
SERVED BY THE PARTICULAR VALVE).**

[NFPA 99:5.1.11.2.3 – 5.1.11.2.6]

1324.0 Alarms.

Master, area, and local alarm systems used for medical gas and vacuum systems shall include the following :

- (1) Separate visual indicators for each condition monitored, except as permitted for local alarms that are displayed on master alarm panels.
- (2) Visual indicators that remain in alarm until the situation that has caused the alarm is resolved.
- (3) A cancelable audible indication of each alarm condition that produces a sound with a minimum level of not less than eighty (80) decibels at three (3) feet (920 mm).
- (4) A means to visually identify a lamp or LED failure.
- (5) Visual and audible indication that the wiring to an alarm initiating device is disconnected.
- (6) Labeling of each indicator, indicating the condition monitored.
- (7) Labeling of each alarm panel for its area of surveillance.
- (8) Reinitiation of the audible signal if another alarm condition occurs while the audible alarm is silenced.
- (9) Power for master and area alarms from the life safety branch of the emergency electrical system as described in NFPA 99 Chapter 4, Electrical Systems.

- (10) Power for local alarms, dew point sensors, and carbon monoxide sensors permitted to be from the same essential electrical branch as is used to power the air compressor system.
- (11) Wiring from switches or sensors that is supervised or protected as required by Section 517.30(C)(3) of NFPA 70, *National Electrical Code*, for emergency system circuits.
- (12) Assurance by the responsible authority of the facility that the labeling of alarms, where room numbers or designations are used, is accurate and up-to-date.
- (13) Provisions for automatic restart after a power loss of ten (10) seconds (e.g., during generator startup) without giving false signals or requiring manual reset. [NFPA 99:5.1.9.1]

1324.1 Functioning of alarm components shall be verified in accordance with testing and monitoring requirements of the manufacturer and the Authority Having Jurisdiction.

1325.0 Medical Air System.

Medical air compressors shall be installed in a well-lit, ventilated, and clean location and shall be accessible. The location shall be provided with drainage facilities. The medical air compressor area shall be located separately from medical gas cylinder system sources, and shall be readily accessible for maintenance.

1325.1 Medical air compressors shall be sufficient to serve the peak calculated demand with the largest single compressor out of service. In no case shall there be less than two (2) compressors. [NFPA 99:5.1.3.5.11.2]

Medical air compressor systems shall consist of the following:

- (1) Components complying with NFPA 99:5.1.3.5.4 through NFPA 99:5.1.3.5.10, arranged per NFPA 99:5.1.3.5.11. [NFPA 99:5.1.3.5.3.2(1)]
- (2) An automatic means to prevent backflow from on-cycle compressors through off-cycle compressors. [NFPA 99:5.1.3.5.3.2(2)]
- (3) A manual shutoff valve to isolate each compressor from the centrally piped system and from other compressors for maintenance or repair without loss of pressure in the system. [NFPA 99:5.1.3.5.3.2(3)]
- (4) Intake filter-mufflers of the dry type. [NFPA 99:5.1.3.5.3.2(4)]
- (5) Pressure relief valves set at 50 percent above line pressure. [NFPA 99:5.1.3.5.3.2(5)]
- (6) Piping between the compressor and the source shutoff valve compatible with oxygen that does not contribute to contaminant levels. [NFPA 99:5.1.3.5.3.2(6)]

(7) Except as defined in NFPA 99:5.1.3.5.3.2(1) through NFPA 99:5.1.3.5.3.2(6), materials and devices used between the medical air intake and the medical air source valve shall be permitted to be of any design or construction appropriate for the service, as determined by the manufacturer. [NFPA 99:5.1.3.5.3.2(7)]

1325.2 The medical air compressors shall draw their air from a source of clean air located where no contamination is anticipated from engine exhausts, fuel storage vents, medical-surgical vacuum system discharges, particulate matter, or odor of any type. [NFPA 99:5.1.3.5.13.1]

1325.3 Compressor intake piping shall be hard-drawn seamless copper, and one of the following:

- (1) ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, (Types K or L).
- (2) ASTM B 280, *Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service* (Copper ACR tube).
- (3) ASTM B 819, *Standard Specification for Seamless Copper Tube for medical Gas Systems*, (Types K or L). [NFPA 99:5.1.3.5.13.4]

The compressor air intake shall be located outdoors above roof level, at a minimum distance not less than of ten (10) feet (3,050 mm) from any door, window, exhaust, other intake, or opening in the building and a distance of not less than twenty (20) feet (6,100 mm) above ground. [NFPA 99:5.1.3.5.13.2]

If an air source equal to or better than outside air (e.g., air already filtered for use in operating room ventilating systems) is available, it shall be permitted to be used for the medical air compressors with the following provisions:

- (1) This alternate source of supply air shall be available on a continuous twenty-four (24) hours-per-day, seven (7) days-per-week basis.
- (2) Ventilating systems having fans with motors or drive belts located in the air stream shall not be used as a source of medical air intake. [NFPA 99:5.1.3.5.13.3]

Air intakes for separate compressors shall be permitted to be joined together to one (1) common intake where the following conditions are met:

- (1) The common intake is sized to minimize back pressure in accordance with the manufacturer's recommendations.
- (2) Each compressor can be isolated by manual or check valve, blind flange, or tube cap to prevent open inlet piping when compressors are removed from service and consequent backflow of room air into the other compressor(s). [NFPA 99:5.1.3.5.13.5]

1325.3.1 Each medical air compressor shall have an isolation valve installed so that shutting off or failure of the largest unit will not affect the operation of the other unit(s).

1325.4 Drains shall be installed on dryers, after-coolers, separators, and receivers.

1325.5 Medical air receivers shall be provided with proper valves to allow the flow of compressed air to enter and exit out of separator receiver ports during normal operation and allow the receiver to be bypassed during service, without shutting down the medical air system. [NFPA 99:5.1.3.5.11.4]

1325.6 Medical Air Receivers. Receivers for medical air shall meet the following requirements:

- (1) Be made of corrosion-resistant materials or otherwise be made corrosion resistant.
- (2) Comply with Section VIII, Unfired Pressure Vessels, of the ASME Boiler and Pressure Vessel Code.
- (3) Be equipped with a pressure-relief valve, automatic drain, manual drain, sight glass, and pressure indicator.
- (4) Be of a capacity sufficient to prevent the compressor from short cycling. [NFPA 99:5.1.3.5.6]

Piping within compressor systems upstream of the source shutoff valve shall comply with Sections 1316.0 and 1319.0, except that stainless steel shall be permitted to be used as a piping material.

1326.0 Medical Vacuum Pump System.

The vacuum plant shall be installed in a well-lit, ventilated, and clean location with ample accessibility. The location shall be provided with drainage facilities. The vacuum plant, when installed as a source, shall be located separately from other medical vacuum system sources, and shall be readily accessible for maintenance.

1326.1 Medical-surgical vacuum sources shall consist of the following:

- (1) Two (2) or more vacuum pumps sufficient to serve the peak calculated demand with the largest single vacuum pump out of service.
- (2) An automatic means to prevent backflow from any on-cycle vacuum pumps through any off-cycle vacuum pumps.
- (3) A shutoff valve or other isolation means to isolate each vacuum pump from the centrally piped system and other vacuum pumps for maintenance or repair without loss of vacuum in the system.

- (4) A vacuum receiver.
- (5) Piping between the vacuum pump(s), discharge(s), receiver(s), and the vacuum source shutoff valve shall be in accordance with 1316.3, except that stainless, galvanized, or black steel pipe shall be permitted to be used.
- (6) Except as defined in NFPA 99:5.1.3.6.1.2(1) through NFPA 99:5.1.3.6.1.2(5), materials and devices used between the medical vacuum exhaust and the medical vacuum source shall be permitted to be of any design or construction appropriate for the service, as determined by the manufacturer. [NFPA 99 5.1.3.6.1.2(1), (2), (3), (4), (5), (6)]

1326.1.1 Additional pumps shall automatically activate when the pumps in operation are incapable of adequately maintaining the required vacuum.

Automatic or manual alternation of pumps shall allow division of operating time. If automatic alternation of pumps is not provided, the facility staff shall arrange a schedule for manual alternation. [NFPA 99:5.1.3.6.6.1, 5.1.3.6.6.2]

1326.2 The medical–surgical vacuum pumps shall exhaust in a manner and location that will minimize the hazards of noise and contamination to the facility and its environment.

The exhaust shall be located as follows:

- (1) Outdoors.
- (2) Not less than ten (10) feet (3,050 mm) from any door, window, air intake, or other openings in buildings.
- (3) At a level different from air intakes.
- (4) Where prevailing winds, adjacent buildings, topography, or other influences that would not divert the exhaust into occupied areas or prevent dispersion of the exhaust.

The end of the exhaust shall be turned down and screened or otherwise be protected against the entry of vermin, debris, or precipitation by screening fabricated or composed of a non-corroding material.

The exhaust shall be piped of materials approved for medical–surgical vacuum piping under Section 1316.3 (Vacuum tubes).

The exhaust shall be free of dips and loops that might trap condensate or oil. Where such low points are unavoidable, a drip leg and valved drain shall be installed. [NFPA 99:5.1.3.6.7.1 - 5.1.3.6.7.5]

1326.2.1 Vacuum exhausts from multiple pumps shall be permitted to be joined together to one (1) common exhaust where the following conditions are met:

- (1) The common exhaust is sized to minimize back-pressure in accordance with the pump manufacturer's recommendations.
- (2) Each pump can be isolated by manual or check valve, blind flange, or tube cap to prevent open exhaust piping when pumps are removed for service and consequent flow of exhaust air into the room. [NFPA 99:5.1.3.6.7.6]

1326.3 Receivers for vacuum shall meet the following requirements:

- (1) Be made of ferrous and/or nonferrous materials.
- (2) Comply with Section VIII, Unfired Pressure Vessels, of the *ASME Boiler and Pressure Vessel Code*.
- (3) Be capable of withstanding a gauge pressure of sixty (60) psi (415 kPa) and twenty-nine and nine-tenths (29.9) inch (760 mm) gauge HgV.
- (4) Be equipped with a manual drain.
- (5) Be of a capacity based on the technology of the pumps. [NFPA 99:5.1.3.6.3]

1326.4 Piping between vacuum pumps, discharges, receivers, and the vacuum main line valve shall be in accordance with Section 1316.3, except that stainless, galvanized, or black steel pipe shall be permitted to be used. [NFPA 99:5.1.3.6.1.2(5)]

1326.5 Drains shall be installed and terminate in an approved location.

1327.0 Testing and Inspection.

1327.1 Inspection and testing shall be performed on new piped gas systems, additions, renovations, temporary installations, or repaired systems, to ensure the facility, by a documented procedure, that the applicable provisions of this document have been adhered to and system integrity has been achieved or maintained. [NFPA 99:5.1.12.1.1.]

1327.1.1 Tests and inspections required by this section shall not be interpreted to conflict with the requirements of NFPA 99, *Standard for Health Care Facilities*. Final certification or verification shall require the completion of tests and inspections required by Sections 4-3.4.1.1, 4-3.4.1.2, and 4-3.4.1.3 of NFPA 99, *Standard for Health Care Facilities*. For requirements of the portions of medical gas and medical vacuum systems testing and inspection not addressed in this chapter or medical gas and medical vacuum systems testing and inspection beyond the scope of this chapter, refer to NFPA 99, *Standard for Health Care Facilities*.

1327.2 Systems that are breached and components that are subject to additions, renovations, or replacement (e.g., new gas sources: bulk, manifolds, compressors, dryers, alarms) shall be inspected and appropriately tested. [NFPA 99:5.1.12.1.3]

1327.2.1 Systems shall be deemed breached at the point of pipeline intrusion by physical separation, by system component removal, replacement, or addition.

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 down stream for pressure gases at the point or area of intrusion. [NFPA 99:5.1.12.1.4, 5.1.12.1.5]

1327.3 Advance Notice. It shall be the duty of the person doing the work authorized by the permit to notify the Authority Having Jurisdiction, orally or in writing, that said work is ready for inspection. Such notification shall be given not less than twenty-four (24) hours before the work is to be inspected.

1327.4 Responsibility. The equipment, material, and labor necessary for inspection and testing shall be furnished by the permit holder or by the person who is requiring the inspection.

1327.5 Testing. The test shall be conducted in the presence of the Authority Having Jurisdiction or a duly appointed representative.

1327.6 Retesting. If the Authority Having Jurisdiction finds that the work does not pass tests, necessary corrections shall be made and the work shall then be resubmitted for test or inspection.

1327.7 Initial Pressure Test – Piped Gas Systems. Before attachment of system components (e.g., pressure-actuating switches for alarms, manifolds, pressure gauges, or pressure-relief valves), but after installation of the station outlets and inlets, with test caps in place, each section of the piping system shall be subjected to a test pressure of one and one-half (1-1/2) times the working pressure [minimum one-hundred and fifty (150) psig (1 Mpa gauge)] with oil-free dry nitrogen. This 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 safe for use with oxygen. The source shutoff valve shall be closed. Leaks, if any, shall be located, repaired, and retested in accordance with this paragraph. [NFPA 99:5.1.12.2.3.7]

1327.8 Cross-Connection Test – Piped Gas Systems. It shall be determined that no cross-connections exist between the various medical gas and vacuum piping systems. [NFPA 99:5.1.12.2.4]

Piping systems shall be reduced to atmospheric pressure. [NFPA 99:5.1.12.2.4.1]

Sources of test gas shall be disconnected from piping systems except for the one (1) system being tested. [NFPA 99:5.1.12.2.4.2]

The system under test shall be charged with oil-free, dry nitrogen NF to a gauge pressure of fifty (50) psi (345 kPa). [NFPA 99:5.1.12.2.4.3]

After the installation of the individual faceplates with appropriate adapters matching outlet/inlet labels, each individual outlet/inlet in each installed medical gas and vacuum piping system shall be checked to determine that the test gas is being dispensed only from the piping system being tested. [NFPA 99:5.1.12.2.4.4]

1327.8.1 The source of test gas shall be disconnected, and the system tested shall be reduced to atmospheric pressure. [NFPA 99:5.1.12.3.3.1(E)] The cross-connection test referenced in NFPA 99:5.1.12.2.4 shall be repeated for each installed medical gas and vacuum piping system. [NFPA 99:5.1.12.2.4.5]

1327.8.2 Where a medical vacuum system is installed, the cross-connection testing shall include that piped vacuum system with medical gas-piping systems.

1327.8.3 Medical-surgical vacuum systems shall be in operation so that these vacuum systems are tested at the same time the medical gas systems are tested. [NFPA 99:5.1.12.3.3.2(D)] The proper labeling and identification of system outlets/inlets shall be confirmed during these tests. [NFPA 99:5.1.12.2.4.6]

1327.9 Final Testing Standing Pressure Test – Piped Gas Systems. After successful completion of the initial pressure tests under Section 1327.7, medical gas distribution piping shall be subject to a standing pressure test. [NFPA 99:5.1.12.2.6]

Tests shall be conducted after the final installation of station outlet valve bodies, face plates, and other distribution system components (e.g., pressure alarm devices, pressure indicators, line pressure-relief valves, manufactured assemblies, hose, etc.). [NFPA 99:5.1.12.2.6.1]

The source valve shall be closed during this test. [NFPA 99:5.1.12.2.6.2]

The piping systems shall be subjected to a twenty-four (24) hour standing pressure test using oil-free, dry nitrogen NF. [NFPA 99:5.1.12.2.6.3]

Test pressures shall be 20 percent above the normal system operating line pressure. [NFPA 99:5.1.12.2.6.4]

1327.9.1 After the piping system is filled with test gas, the supply valve and all outlets shall be

closed and the source of test gas disconnected. Tests shall be conducted after the final installation of station outlet valve bodies, face plates, and other distribution system components (e.g., pressure alarm devices, pressure indicators, line pressure-relief valves, manufactured assemblies, hose, etc.). [NFPA 99:5.1.12.2.6.1]

The source valve shall be closed during this test. [NFPA 99:5.1.12.2.6.2]

The piping systems shall be subjected to a twenty-four (24) hour standing pressure test using oil-free, dry nitrogen NF. [NFPA 99:5.1.12.2.6.3]

Test pressures shall be 20 percent above the normal system operating line pressure. [NFPA 99:5.1.12.2.6.4]

Leaks, if any, shall be located, repaired (if permitted), or replaced (if required), and retested. [NFPA 99:5.1.12.2.6.6]

At the conclusion of the tests, there shall be no change in the test pressure other than that attributed to changes of ambient temperature. [NFPA 99:5.1.12.2.6.5]

1327.10 Initial Pressure Test – Piped Vacuum Systems. Each section of the piping in medical gas and vacuum systems shall be pressure-tested. [NFPA 99:5.1.12.2.3.1]

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.
- (2) Prior to the installation of components of the distribution piping system that would be damaged by the test pressure (e.g., pressure/vacuum alarm devices, pressure/vacuum indicators, line pressure-relief valves, manufactured assemblies with flexible hose, etc.). [NFPA 99:5.1.12.2.3.2]

The source shutoff valve shall remain closed during these tests. [NFPA 99:5.1.12.2.3.3]

The test pressure for pressure gases shall be one and one-half (1.5) times the system working pressure not less than a gauge pressure of one-hundred and fifty (150) psi (1,035 kPa). [NFPA 99:5.1.12.2.3.4]

The test pressure for vacuum shall be not less than a gauge pressure of sixty (60) psi (415 kPa). [NFPA 99:5.1.12.2.3.5]

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 that is safe for use with oxygen. [NFPA 99:5.1.12.2.3.6]

Leaks, if any, shall be located, repaired (if permitted), replaced (if required), and retested. [NFPA 99:5.1.12.2.3.7]

1327.11 Standing Pressure Test – Piped Vacuum Systems. After successful completion of the initial pressure tests under Section 1327.10, vacuum distribution piping shall be subjected to a standing vacuum test. [NFPA 99:5.1.12.2.7]

Tests shall be conducted after installation of components of the vacuum system. [NFPA 99:5.1.12.2.7.1]

The piping systems shall be subjected to a twenty-four (24) hour standing vacuum test. [NFPA 99:5.1.12.2.7.2]

Test pressure shall be between twelve (12) inch (300 mm) gauge HgV and full vacuum. [NFPA 99:5.1.12.2.7.3]

During the test, the source of test vacuum shall be disconnected from the piping system. [NFPA 99:5.1.12.2.7.4]

At the conclusion of the test, there shall be no change in the vacuum other than that attributed to changes of ambient temperature, as permitted in the following [NFPA 99:5.1.12.2.7.5]:

Test vacuum changes due to expansion or contraction shall be permitted to be determined by means of the following pressure temperature relationship:

- (1) The calculated final absolute pressure equals the initial absolute pressure times the final absolute temperature, divided by the initial absolute temperature.
- (2) Absolute pressure is the gauge pressure reading plus fourteen and seven-tenths (14.7) psi (101.4 kPa).
- (3) Absolute temperature is the temperature reading plus 460°F (238°C).
- (4) The final allowable gauge pressure reading equals the final allowable absolute pressure minus a gauge pressure of fourteen and seven-tenths (14.7) psi (101.4 kPa). [NFPA 99:5.1.12.2.7.6]

Leaks, if any, shall be located, repaired (if permitted), or replaced (if required), and retested. [NFPA 99:5.1.12.2.7.7]

1327.12 Corrections. Notices of correction or violation shall be written by the Authority Having Jurisdiction and posted at the site of the work, mailed or delivered to the permittee or an authorized representative. Refusal or failure to comply with any such notice or order within ten (10) days of receipt thereof shall be considered a violation of this code, and shall be subject to the penalties set forth elsewhere in this code for violations.

1327.13 Approval. Upon satisfactory completion of all tests and certification of the medical gas and medical vacuum systems, a certificate of approval shall be issued by the Authority Having Jurisdiction to the permittee.

1327.14 Covering or Use. No medical gas or medical vacuum system or part thereof shall be covered, concealed, or put into use until it has been tested, inspected, and accepted as required in this code.

1327.15 Uncovering. Any medical gas and vacuum system or part thereof that is covered or concealed before testing and inspected as required in this code shall be uncovered for inspection, after notice to uncover the work has been issued to the permittee or his authorized representative by the Authority Having Jurisdiction.

1328.0 System Certification.

1328.1 Prior to any medical gas system being placed in service, each and every system shall be certified, as described in Section 1328.2.

1328.1.1 Verification tests shall be performed only after all tests required in Section 1327.0, Installer-Performed Tests, have been completed. [NFPA 99:5.1.12.3.1.1]

Testing shall be conducted by a party technically competent and experienced in the field of medical gas and vacuum pipeline testing and meeting the requirements of ASSE Standard 6030, *Medical Gas Verifiers Professional Qualifications Standard*. [NFPA 99:5.1.12.3.1.3]

Testing shall be performed by a party other than the installing contractor. [NFPA 99:5.1.12.3.1.4]

When systems have been installed by in-house personnel, testing shall be permitted by personnel of that organization who meet the requirements of this section. [NFPA 99:5.1.12.3.1.5]

1328.2 Certification tests, verified and attested to by the certification agency, shall include the following:

1328.2.1 Verifying compliance with the installation requirements.

1328.2.2 Testing and checking for leakage, correct zoning, and identification of control valves.

1328.2.3 Checking for identification and labeling of pipelines, station outlets, and control valves.

1328.2.4 Testing for cross-connection, flow rate, system pressure drop, and system performance.

1328.2.5 Functional testing of pressure relief valves and safety valves.

1328.2.6 Functional testing of all sources of supply.

1328.2.7 Functional testing of alarm systems, including accuracy of system components.

1328.2.8 Purge flushing of system and filling with specific source gases.

1328.2.9 Testing for purity and cleanliness of source gases.

1328.2.10 Testing for specific gas identity at each station outlet.

1328.3 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 facility authority and any others that are required. [NFPA 99:5.1.12.1.6]

Reports shall contain detailed listings of all findings and results. [NFPA 99:5.1.12.1.7]

1328.4 A report that includes the specific items mentioned in Section 1328.2 and other information required by NFPA 99, *Standard for Health Care Facilities* shall be delivered to the Authority Having Jurisdiction prior to acceptance of the system.

TABLE 13-1
Standard Designation Colors and Operating Pressures for Gas and Vacuum Systems
[NFPA 99: Table 5.1.11]

Gas Service	Abbreviated Name	Colors (Background/Text)	Standard Gauge Pressure
Medical air	Med Air	Yellow/black	50–55 psi (345–380 kPa)
Carbon dioxide	CO ₂	Gray/black or gray/white	50–55 psi (345–380 kPa)
Helium	He	Brown/white	50–55 psi (345–380 kPa)
Nitrogen	N ₂	Black/white	160–185 psi (1,100–1,275 kPa)
Nitrous oxide	N ₂ O	Blue/white	50–55 psi (345–380 kPa)
Oxygen	O ₂	Green/white or white/green	50–55 psi (345–380 kPa)
Oxygen/carbon dioxide mixture	O ₂ /CO ₂ n (n is % of CO ₂)	Green/white	50–55 psi (345–380 kPa)
Medical–surgical vacuum	Med Vac	White/black	15 in. to 30 in. HgV (360 mm to 760 mm)
Waste anesthetic gas disposal	WAGD	Violet/white	Varies with system type
Other mixtures	Gas A% / Gas B%	Colors as above Major gas for background/ minor gas for text	None
Nonmedical air (level 3 gas-powered device)		Yellow-and-white diagonal stripe/black	None
Nonmedical and Level 3 vacuum		White-and-black diagonal stripe/black boxed	None
Laboratory air		Yellow-and-white checkerboard/black	None
Laboratory vacuum		White-and-black checkerboard/black boxed	None
Instrument air		Red/white	160–185 psi (1,100–1,275 kPa)

TABLE 13-2
Minimum Flow Rates

Oxygen	.71 CFM per outlet ¹ (20 LPM)
Nitrous Oxide	.71 CFM per outlet ¹ (20 LPM)
Medical Compressed Air	.71 CFM per outlet ¹ (20 LPM)
Nitrogen	15 CFM (0.42 m ³ /min.) free air per outlet
Vacuum	1 SCFM (0.03 sm ³ /min.) per inlet ²
Carbon Dioxide	.71 CFM per outlet ¹ (20 LPM)
Helium	.71 CFM per outlet (20 LPM)

¹ Any room designed for a permanently located respiratory ventilator or anesthesia machine shall have an outlet capable of a flow rate of 180 LPM (6.36 CFM) at the station outlet.

² For testing and certification purposes, individual station inlets shall be capable of a flow rate of 3 SCFM, while maintaining a system pressure of not less than 12 inches (305 mm) at the nearest adjacent vacuum inlet.

TABLE 13-3
Minimum Outlets/Inlets per Station

Location	Oxygen	Medical Vacuum	Medical Air	Nitrous Oxide	Nitrogen	Helium	Carbon Dioxide
Patient rooms for medical/surgical, obstetrics, and pediatrics	1/bed	1/bed	1/bed	—	—	—	—
Examination/treatment for nursing units	1/bed	1/bed	—	—	—	—	—
Intensive care (all)	3/bed	3/bed	2/bed	—	—	—	—
Nursery ¹	2/bed	2/bed	1/bed	—	—	—	—
General operating rooms	2/room	3/room ⁴	2/room	1/room	1/room	—	—
Cystoscopic and invasive special procedures	2/room	3/room ⁴	2/room	—	—	—	—
Recovery delivery and labor/delivery/recovery rooms ²	2/bed 2/room	2/bed 3/room ⁴	1/bed 1/room	— —	— —	— —	— —
Labor rooms	1/bed	1/bed	1/bed	—	—	—	—
First aid and emergency treatment ³	1/bed	1/bed ⁴	1/bed	—	—	—	—
Autopsy	—	1/station	1/station	—	—	—	—
Anesthesia workroom	1/station	—	1/station	—	—	—	—

¹ Includes pediatric nursery.

² Includes obstetric recovery.

³ Emergency trauma rooms used for surgical procedures shall be classified as general operating rooms.

⁴ Vacuum inlets required are in addition to any inlets used as part of a scavenging system for removal of anesthetizing gases.

TABLE 13-4
System Sizing – Flow Requirements for Station Inlet/Outlet¹

Number of Inlet/Outlet Terminal Units per Facility	Diversity Percentage of Average Flow per Inlet/Outlet Terminal Units	Minimum Permissible System Flow ² SCFM (liters/minute)	
		All Pressurized Medical Gas Systems	Vacuum Systems
1–10	100%	Actual Demand	See
11–25	75%	7.0 (200)	Table
26–50	50%	13.1 (375)	13-5
51–100	50%	17.5 (500)	

¹ Flow rates of station inlets/outlets per Table 13-2.

² The minimum system flow is the average inlet/outlet flow times the number of station inlets/outlets times the diversity percentage.

TABLE 13-5
Outlet Rating for Vacuum Piping Systems

Location of Medical-Surgical Vacuum Outlets	Free-Air Allowance, Expressed as CFM (LPM) at 1 Atmosphere		Zone Allowances Corridors-Risers Main Supply Line-Valves	
	Per Room	Per Outlet	Simultaneous Usage, Factor Percent	Air to Be Transported CFM (LPM)*
Operating Rooms				
Major "A"(Radical, Open Heart)	3.5 (99.1)	–	100	3.5 (99.1)
(Organ Transplant)	3.5 (99.1)	–	100	3.5 (99.1)
(Radical Thoracic)	3.5 (99.1)	–	100	3.5 (99.1)
Major "B"(All Other Major ORs)	2.0 (56.6)	–	100	2.0 (56.6)
Minor	1.0 (28.3)	–	100	1.0 (28.3)
Delivery Rooms	1.0 (28.3)	–	100	1.0 (28.3)
Recovery Rooms (Post- Anesthesia) and Intensive Care Units (a minimum of 2 outlets per bed in each such department)				
1st outlet at each bed	–	3.0 (85.0)	50	1.5 (42.5)
2nd outlet at each bed	–	1.0 (28.3)	50	0.5 (14.2)
3rd outlet at each bed	–	1.0 (28.3)	10	0.1 (2.8)
All others at each bed	–	1.0 (28.3)	10	0.1 (2.8)
Emergency Rooms	–	1.0 (28.3)	100	1.0 (28.3)
Patient Rooms				
Surgical –		1.0 (28.3)	50	0.5 (14.2)
Medical –		1.0 (28.3)	10	0.1 (2.8)
Nurseries	–	1.0 (28.3)	10	0.1 (2.8)
Treatment and Examining Rooms	–	0.5 (14.2)	10	0.05 (1.4)
Autopsy Area	–	2.0 (56.6)	20	0.4 (11.3)
Inhalation Therapy, Central Supply and Instructional Areas	–	1.0 (28.3)	10	0.1 (2.8)

*Free air at 1 atmosphere

TABLE 13-6
Size of Gas/Vacuum Piping
Maximum Delivery Capacity³ in SCFM (LPM)

Medical System	Gas Pipe Size Inch ²	Length of Piping in Feet (m) ¹									
		100	(30)	250	(76)	500	(152)	750	(228)	1,000	(304)
Oxygen	1/2	15.0	(425)	10.6	(300)	7.4	(209)	5.9	(167)	5.1	(144)
	3/4	40.0	(1,133)	28.3	(801)	19.6	(555)	15.7	(445)	13.3	(377)
	1	50.0	(1,416)	50.0	(1,416)	40.2	(1,138)	32.2	(912)	27.7	(784)
Nitrous Oxide	1/2	15.0	(425)	9.5	(269)	6.5	(184)	5.3	(150)	4.5	(127)
	3/4	30.0	(849)	24.7	(699)	17.1	(484)	13.7	(388)	11.7	(331)
	1	40.0	(1,113)	40.0	(1,133)	34.7	(983)	28.2	(7,98)	24.3	(688)
Medical Air	1/2	18.1	(512)	11.1	(314)	7.8	(221)	6.3	(177)	5.3	(151)
	3/4	40.0	(1,133)	29.9	(847)	21.0	(595)	16.5	(467)	14.1	(399)
	1	50.0	(1,416)	50.0	(1,416)	42.1	(1,192)	35.8	(1,013)	29.2	(826)
Vacuum	1	22.8	(645)	13.7	(388)	9.5	(269)	7.6	(215)	6.5	(184)
	1-1/4	40.1	(1,135)	24.5	(694)	16.7	(473)	13.3	(377)	11.2	(317)
	1-1/2	63.7	(1,804)	38.9	(1,101)	26.8	(759)	21.1	(600)	17.9	(507)
	2	132.7	(3,758)	81.4	(2,305)	56.0	(1,586)	45.0	(1,274)	38.3	(1,084)
Nitrogen	1/2	25.0	(708)	25.0	(708)	25.0	(708)	23.8	(674)	20.6	(583)
	3/4	60.0	(1,699)	60.0	(1,699)	60.0	(1,699)	60.0	(1,699)	54.2	(1,535)
	1	110.0	(3,115)	110.0	(3,115)	110.0	(3,115)	110.0	(3,115)	110.0	(3,115)

¹ Length of piping includes a 30% allowance for fittings.

² One-half inch (12.7 mm) diameter pipe is the minimum size allowed in medical gas systems.

³ Based on the following maximum pressure drops:

Oxygen, nitrous oxide, and medical air – 5 psig (10 in. Hg)

Vacuum – 1.96 psig (4 in. Hg)

Nitrogen – 20 psig (41 in. Hg)

TABLE 13-7
Maximum Pipe Support Spacing
[NFPA 99:5.1.10.10.4.5]

Pipe Size	Hanger Spacing	
	ft.	mm
DN8 (NPS 1/4)	5	1,520
DN10 (NPS 3/8)	6	1,830
DN15 (NPS 1/2)	6	1,830
DN20 (NPS 3/4)	7	2,130
DN25 (NPS 1)	8	2,440
DN32 (NPS 1-1/4)	9	2,740
DN40 (NPS 1-1/2)		
and larger	10	3,050
Vertical risers, all sizes		
Every floor but not to exceed:	15	4,570