**Chapter 5 Gas and Vacuum Systems**

5.1 Category 1 Piped Gas and Vacuum Systems

5.1.1\* Applicability

5.1.1.1

These requirements shall apply to health care facilities that require Category 1 systems as referenced in Chapter 4.

5.1.1.2\*

Where the terms medical gas or medical support gas occur, the provisions shall apply to all piped systems for oxygen, nitrous oxide, medical air, carbon dioxide, helium, nitrogen, instrument air, and mixtures thereof. Wherever the name of a specific gas service occurs, the provision shall apply only to that gas.

5.1.1.3

Wherever the term medical—surgical vacuum occurs, the provisions shall apply to systems for piped medical—surgical vacuum and piped waste anesthetic gas disposal (WAGD). Wherever the name of a specific vacuum service occurs, the provision shall apply only to that vacuum service.

5.1.1.4

An existing system that is not in strict compliance with the provisions of this 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.

5.1.1.5

Subsection 5.1.2 through 5.1.12.3.14.5 and 5.1.14.4.2 shall apply to new health care facilities or facilities making changes that alter the piping.

5.1.1.6

The following subsections of this chapter shall apply to the operation, management, and maintenance of Category 1 medical gas and vacuum systems in existing facilities:

5.1.2

5.1.3.1

5.1.3.2

5.1.3.3.1.7

5.1.3.3.1.8

5.1.3.3.4

5.1.3.6.2

5.1.3.8.5.2

5.1.14

5.1.15

5.1.1.7

Paragraph 5.1.14.3 and 5.1.14.4.1 shall apply to new and existing health care facilities.

5.1.2 Nature of Hazards of Gas and Vacuum Systems

Potential fire and explosion hazards associated with positive pressure gas central piping systems and medical—surgical vacuum systems shall be considered in the design, installation, testing, operation, and maintenance of these systems.

5.1.3\* Category 1 Sources

5.1.3.1 Central Supply System Identification and Labeling

5.1.3.1.1\*

Containers, cylinders, and tanks shall be designed, fabricated, tested, and marked (stamped) in accordance with regulations of DOT, Transport Canada (TC) Transportation of Dangerous Goods Regulations, or the ASME Boiler and Pressure Vessel Code, "Rules for the Construction of Unfired Pressure Vessels," Section VIII. [55:7.1.5.1]

5.1.3.1.2

Cylinder contents shall be identified by attached labels or stencils naming the contents in accordance with CGA C-7, Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers.

5.1.3.1.3

Liquid containers shall have additional product identification visible from all directions with a minimum of 51 mm (2 in.) high letters such as a 360-degree wraparound tape for medical liquid containers.

5.1.3.1.4

Cryogenic liquid containers shall be provided with gas-specific outlet connections in accordance with CGA V-5, Diameter-Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications), or CGA V-1, Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.

5.1.3.1.5

Cylinder and cryogenic liquid container outlet connections shall be affixed in such a manner as to be integral to the valve(s), unremovable with ordinary tools, or so designed as to render the attachment point unusable when removed.

5.1.3.1.6

The contents of cylinders and cryogenic liquid containers shall be verified prior to use.

5.1.3.1.7

Labels shall not be defaced, altered, or removed, and connecting fittings shall not be modified.

5.1.3.1.8

Locations containing positive pressure gases other than oxygen and medical air shall have their door(s) labeled as follows:

Positive Pressure Gases

NO Smoking or Open Flame

Room May Have Insufficient Oxygen

Open Door and Allow Room to

Ventilate Before Entering

5.1.3.1.9

Locations containing central supply systems or cylinders containing only oxygen or medical air shall have their door(s) labeled as follows:

Medical Gases

NO Smoking or Open Flame

5.1.3.2 Central Supply System Operations

5.1.3.2.1

The use of adapters or conversion fittings to adapt one gas-specific fitting to another shall be prohibited.

5.1.3.2.2

Cylinders and containers shall be handled in strict accordance with 11.6.2.

5.1.3.2.3

Only gas cylinders, reusable shipping containers, and their accessories shall be permitted to be stored in rooms containing central supply systems or gas cylinders.

5.1.3.2.4

No flammable materials, cylinders containing flammable gases, or containers containing flammable liquids shall be stored in rooms with gas cylinders.

5.1.3.2.5

If cylinders are wrapped when received, the wrappers shall be removed prior to storage.

5.1.3.2.6

Cylinders without correct markings or whose markings and gas-specific fittings do not match shall not be used.

5.1.3.2.7

Cryogenic liquid storage units intended to supply gas to the facility shall not be used to transfill other liquid storage vessels.

5.1.3.2.8

Care shall be exercised when handling cylinders that have been exposed to freezing temperatures or containers that contain cryogenic liquids to prevent injury to the skin.

5.1.3.2.9

Cylinders containing compressed gases and containers for volatile liquids shall be kept away from radiators, steam piping, and like sources of heat.

5.1.3.2.10

When cylinder valve protection caps are supplied, they shall be secured tightly in place unless the cylinder is connected for use.

5.1.3.2.11

Containers shall not be stored in a tightly closed space.

5.1.3.3\* Central Supply System Locations

5.1.3.3.1 General

Central supply systems shall be located to meet the criteria in 5.1.3.3.1.1 through 5.1.3.3.1.12.

5.1.3.3.1.1

Any of the following systems shall be permitted to be located together in the same outdoor enclosure:

Manifolds for gas cylinders without reserve supply (see 5.1.3.5.10)

Manifolds for gas cylinders with reserve supply

Manifolds for cryogenic liquid containers (see 5.1.3.5.12)

Bulk cryogenic liquid systems (see 5.1.3.5.13)

5.1.3.3.1.2

Any of the following systems shall be permitted to be located together in the same indoor enclosure:

Manifolds for gas cylinders without reserve supply (see 5.1.3.5.10)

Manifolds for gas cylinders with reserve supply

Manifolds for cryogenic liquid containers (see 5.1.3.5.12)

In-building emergency reserves (see 5.1.3.5.14)

Instrument air standby headers (see 5.1.3.9.5)

5.1.3.3.1.3

Any of the following systems shall be permitted to be located together in the same room:

Medical air compressor supply sources (see 5.1.3.6.3)

Medical—surgical vacuum sources (see 5.1.3.7)

Waste anesthetic gas disposal (WAGD) sources (see 5.1.3.8)

Instrument air compressor sources (see 5.1.3.9)

Any other compressor, vacuum pump, or electrically powered machinery

5.1.3.3.1.4

Any system listed under 5.1.3.3.1.3 shall not be located in the same room with any system listed under 5.1.3.3.1.1 or 5.1.3.3.1.2, except instrument air reserve headers complying with 5.1.3.3.1.7 and 5.1.3.9.5 shall be permitted to be in the same room as an instrument air compressor.

5.1.3.3.1.5

Locations shall be chosen to allow access by delivery vehicles and management of cylinders (e.g., proximity to loading docks, access to elevators, and passage of cylinders through public areas).

5.1.3.3.1.6

Indoor locations for oxygen, nitrous oxide, and mixtures of these gases shall not communicate with the following:

Areas involved in critical patient care

Anesthetizing locations where moderate sedation, deep sedation, or general anesthesia is administered

Locations storing flammables

Rooms containing open electrical contacts or transformers

Storage tanks for flammable or combustible liquids

Engines

Kitchens

Areas with open flames

5.1.3.3.1.7

Cylinders in use and in storage shall be prevented from reaching temperatures in excess of 54°C (130°F).

5.1.3.3.1.8

Central supply systems for nitrous oxide and carbon dioxide using cylinders or portable containers shall be prevented from reaching temperatures lower than the recommendations of the central supply system's manufacturer, but shall never be lower than —29°C (—20°F) or greater than 51.6°C (125°F).

5.1.3.3.1.9

Central supply systems for oxygen with a total capacity connected and in storage of 566,335 L (20,000 ft3) or more outside of the facility at standard temperature and pressure (STP) shall comply with NFPA 55, Compressed Gases and Cryogenic Fluids Code.

5.1.3.3.1.10

Central supply systems for nitrous oxide with a total capacity connected and in storage of 1451 kg (3200 lb) or more shall comply with CGA G-8.1, Standard for Nitrous Oxide Systems at Consumer Sites.

5.1.3.3.1.11

Central supply systems for carbon dioxide using permanently installed containers with product capacities greater than 454 kg (1000 lb) shall comply with CGA G-6.1, Standard for Insulated Carbon Dioxide Systems at Consumer Sites.

5.1.3.3.1.12

Central supply systems for carbon dioxide using permanently installed containers with product capacities of 454 kg (1000 lb) or less shall comply with CGA G-6.5, Standard for Small, Stationary, Insulated Carbon Dioxide Supply Systems.

5.1.3.3.1.13\*

Central supply systems for bulk inert gases systems with a total capacity connected and in storage of 20,000 ft3 or more of compressed gas or cryogenic fluid at standard temperature and pressure, shall comply with CGA P-18, Standard for Bulk Inert Gas Systems at Consumer Sites.

5.1.3.3.2\* Design and Construction

Locations for central supply systems and the storage of positive-pressure gases shall meet the following requirements:

They shall be constructed with access to move cylinders, equipment, and so forth, in and out of the location on hand trucks complying with 11.4.3.1.1.

They shall be secured with lockable doors or gates or otherwise secured.

If outdoors, they shall be provided with an enclosure (wall or fencing) constructed of noncombustible materials with a minimum of two entry/exits.

If indoors, they shall be constructed and use interior finishes of noncombustible or limited-combustible materials such that all walls, floors, ceilings, and doors are of a minimum 1-hour fire resistance rating.

\*They shall be compliant with NFPA 70, National Electrical Code, for ordinary locations.

They shall be heated by indirect means (e.g., steam, hot water) if heat is required.

They shall be provided with racks, chains, or other fastenings to secure all cylinders from falling, whether connected, unconnected, full, or empty.

\*They shall be supplied with electrical power compliant with the requirements for essential electrical systems as described in Chapter 6.

They shall have racks, shelves, and supports, where provided, constructed of noncombustible materials or limited-combustible materials.

They shall protect electrical devices from physical damage.

5.1.3.3.3 Ventilation

5.1.3.3.3.1 Venting of Relief Valves

Indoor supply systems shall have all relief valves vented per 5.1.3.5.6.1 (4) through (9).

5.1.3.3.3.2 Ventilation for Motor-Driven Equipment

The following source locations shall be adequately ventilated to prevent accumulation of heat:

Medical air sources (see 5.1.3.6)

Medical—surgical vacuum sources (see 5.1.3.7)

aste anesthetic gas disposal (WAGD) sources (see 5.1.3.8.1)

Instrument air sources (see 5.1.3.9)

5.1.3.3.3.3 Ventilation for Outdoor Locations

(A)

Outdoor locations surrounded by impermeable walls shall have protected ventilation openings located at the base of each wall to allow free circulation of air within the enclosure.

(B)

Walls that are shared with other enclosures or with buildings shall be permitted to not have openings.

5.1.3.3.4 Storage

5.1.3.3.4.1

Full or empty medical gas cylinders, when not connected, shall be stored in locations complying with 5.1.3.3.2 through 5.1.3.3.3 and shall be permitted to be in the same rooms or enclosures as their respective central supply systems.

5.1.3.3.4.2

Cylinders, whether full or empty, shall not be stored in enclosures containing motor-driven machinery, with the exception of cylinders intended for instrument air reserve headers complying with 5.1.3.9.5, which shall be permitted to be placed in the same location containing an instrument air compressor when it is the only motor-driven machinery located within the room. Only cylinders intended for instrument air reserve headers complying with 5.1.3.9.5 shall be permitted to be stored in enclosures containing instrument air compressors.

5.1.3.4 Control Equipment

For control equipment, as specified in 5.1.3.5.5, 5.1.3.5.6, and 5.1.3.5.7, that is physically remote from the supply system, the control equipment shall be installed within a secure enclosure to prevent unauthorized access in accordance with 5.1.3.3.2(2).

5.1.3.4.1

The enclosure shall provide enough space to perform maintenance and repair.

5.1.3.4.2

The location of the enclosure for control equipment other than for medical air shall not communicate with combustible or flammable materials.

5.1.3.5\* Central Supply Systems

Central supply systems shall be permitted to consist of the following:

Cylinder manifolds for gas cylinders per 5.1.3.5.10

Manifolds for cryogenic liquid containers per 5.1.3.5.12

Bulk cryogenic liquid systems per 5.1.3.5.13

Medical air compressor systems per 5.1.3.6

Medical—surgical vacuum producers per 5.1.3.7

WAGD producers per 5.1.3.8

Instrument air compressor systems per 5.1.3.9

Proportioning systems for medical air USP per 5.1.3.6.3.4

5.1.3.5.1 General

Central supply systems shall be obtained from a supplier or manufacturer familiar with their proper construction and use and installed in accordance with the manufacturer's instructions.

5.1.3.5.2 Permitted Locations for Medical Gases

Central supply systems and medical gas outlets for oxygen, medical air, nitrous oxide, carbon dioxide, and all other patient medical gases shall be piped only into areas where the gases will be used under the direction of licensed medical professionals for purposes congruent with the following:

Direct respiration by patients

Clinical application of the gas to a patient, such as the use of an insufflator to inject carbon dioxide into patient body cavities during laparoscopic surgery and carbon dioxide used to purge heart-lung machine blood flow ways

Medical device applications directly related to respiration

Power for medical devices used directly on patients

Calibration of medical devices intended for (1) through (4)

5.1.3.5.3 Support Gases

Central supply systems for support gases shall not be piped to, or used for, any purpose except medical support application.

5.1.3.5.4\* Materials

Materials used in central supply systems shall meet the following requirements:

In those portions of systems intended to handle oxygen at gauge pressures greater than 2413 kPa (350 psi), interconnecting hose shall contain no polymeric materials.

In those portions of systems intended to handle oxygen or nitrous oxide 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.

If potentially exposed to cryogenic temperatures, materials shall be designed for low temperature service.

If intended for outdoor installation, materials shall be installed per the manufacturer's requirements.

5.1.3.5.5 Final Line Pressure Regulators

5.1.3.5.5.1

All positive pressure supply systems shall be provided with duplex line pressure regulators piped in parallel with the following characteristics:

They shall be provided with isolation valves on the source side of each regulator.

They shall be provided with isolation or check valves on the patient side of each regulator.

A pressure indicator(s) shall be located downstream (patient or use side) of each regulator or immediately downstream of the isolating valves for the regulators.

They shall be piped to allow either regulator to be serviced without interrupting supply.

Each regulator shall be sized for 100 percent of the peak calculated demand.

They shall be constructed of materials deemed suitable by the manufacturer.

5.1.3.5.5.2

The line pressure regulators required under 5.1.3.5.5.1, when used for bulk cryogenic liquid systems, shall be of a balanced design.

5.1.3.5.6 Relief Valves

5.1.3.5.6.1

All pressure relief valves shall meet the following requirements:

They shall be of brass, bronze, or stainless steel construction.

They shall be designed for the specific gas service.

They shall have a relief pressure setting not higher than the maximum allowable working pressure (MAWP) of the component with the lowest working pressure rating in the portion of the system being protected.

They shall be vented to the outside of the building, except that relief valves for compressed air systems having less than 84,950 L (3000 ft3) at STP shall be permitted to be diffused locally by means that will not restrict the flow.

They shall have a vent discharge line that is not smaller than the size of the relief valve outlet.

Where two or more relief valves discharge into a common vent line, its internal cross-sectional area shall be not less than the aggregate cross-sectional area of all relief valve vent discharge lines served.

They shall not discharge into locations creating potential hazards.

They shall have the discharge terminal turned down and screened to prevent the entry of rain, snow, or vermin.

They shall be designed in accordance with ASME B31.3, Pressure Process Piping.

5.1.3.5.6.2

When vented to outdoors, materials and construction for relief valve discharge lines shall be the same as required for positive pressure gas distribution. (See 5.1.10.1.)

5.1.3.5.6.3

Central supply systems for positive pressure gases shall include one or more relief valves, all meeting the following requirements:

They shall be located between each final line regulator and the source valve.

They shall have a relief setting that is 50 percent above the normal system operating pressure, as indicated in Table 5.1.11.

5.1.3.5.6.4

When vented outside, relief valve vent lines shall be labeled in accordance with 5.1.11.1 in any manner that will distinguish them from the medical gas pipeline.

5.1.3.5.7 Multiple Pressures

Where a single central supply system supplies separate piped distribution networks operating at different pressures, each piped distribution network shall comply with the following:

Medical air compressor systems: 5.1.3.5.9 (pressure regulators) and 5.1.9.2.4(7) (master alarm)

All central supply systems: 5.1.3.5.5 (pressure regulators), 5.1.3.5.6 (relief valves), 5.1.4.4 (source valve), and 5.1.9.2.4(7) (master alarm)

5.1.3.5.8 Local Signals

5.1.3.5.8.1

The following systems shall have local signals located at the source equipment:

Manifolds for gas cylinders without reserve supply (see 5.1.3.5.10)

Manifolds for gas cylinders with reserve supply

Manifolds for cryogenic liquid containers (see 5.1.3.5.12)

Bulk cryogenic liquid systems (see 5.1.3.5.13)

In-building emergency reserves (see 5.1.3.5.14)

Instrument air headers (see 5.1.3.5.9)

5.1.3.5.8.2

The local signals shall meet the following requirements:

Provision of visual indication only

Labeling for the service and condition being monitored

If intended for outdoor installation, be installed per manufacturer's requirements

5.1.3.5.9\* Headers

In central supply systems using cylinders containing either gas or liquid, each header shall include the following:

\*Cylinder connections in the number required for the header's application

Cylinder lead for each cylinder constructed of materials complying with 5.1.3.5.4 and provided with end fittings permanently attached to the cylinder lead complying with CGA V-1, Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections (ANSI B57.1)

Filter of a material complying with 5.1.3.5.4 to prevent the intrusion of debris into the manifold controls

Header shutoff valve downstream of the nearest cylinder connection, but upstream of the point at which the header connects to the central supply system

Pressure indicator indicating the pressure of header contents

Check valve to prevent backflow into the header and to allow service to the header

If intended for gas cylinder service, a check valve at each connection for the cylinder lead in 5.1.3.5.9(2) to prevent loss of gas in the event of damage to the cylinder lead or operation of an individual cylinder relief valve

If intended for gas cylinder service, a pressure regulator to reduce the cylinder pressure to an intermediate pressure to allow the proper operation of the primary and secondary headers

If intended for service with cryogenic liquid containers, a pressure relief valve

Vent valves, if fitted on a header, vented outside of the building per 5.1.3.5.6.1(5) through 5.1.3.5.6.1(9) and 5.1.3.5.6.2

5.1.3.5.10\* Manifolds for Gas Cylinders Without Reserve Supply

5.1.3.5.10.1

The manifolds in this category shall be located in accordance with 5.1.3.3.1 and shall meet the following:

If located outdoors, they shall be installed in an enclosure used only for this purpose and sited to comply with minimum distance requirements in NFPA 55.

If located indoors, they shall be installed within a room used only for enclosure of such manifolds.

5.1.3.5.10.2

The manifold locations for this category shall be constructed in accordance with 5.1.3.3.2.

5.1.3.5.10.3

The manifold locations for this category shall be ventilated in accordance with 5.1.3.3.3.

5.1.3.5.10.4

The manifolds in this category shall consist of the following:

Two equal headers in accordance with 5.1.3.5.9, each with a sufficient number of gas cylinder connections for an average day's supply, but not fewer than two connections, and with the headers connected to the final line pressure regulator assembly in such a manner that either header can supply the system

Vent valves, if fitted on a header, vented outside of the building per 5.1.3.5.6.1(5) through (9) and 5.1.3.5.6.2

Intermediate relief valve(s), piped to the outside in accordance with 5.1.3.5.6.1(5) through (9), that protects the piping between the header pressure regulator and the line pressure regulator assembly, and protects the line pressure regulators from overpressure in the event of a header regulator failure

5.1.3.5.10.5

The manifolds in this category shall include an automatic means of alternating the two headers to accomplish the following in normal operation:

One header is the primary and the other is the secondary, with either being capable of either role.

When the primary header is supplying the system, the secondary header is prevented from supplying the system.

When the primary header is depleted, the secondary header automatically begins to supply the system.

5.1.3.5.10.6

The manifolds in this category shall have a local signal that visibly indicates the operating status of the equipment and shall activate an indicator at all master alarm panels when or at a predetermined set point before the secondary header begins to supply the system, indicating changeover has occurred or is about to occur.

5.1.3.5.10.7

If manifolds are located out of doors, they shall be installed per the manufacturer's requirements.

5.1.3.5.11\* Manifolds for Cryogenic Liquid Containers

5.1.3.5.11.1

Manifolds for cryogenic liquid containers shall be located in accordance with 5.1.3.3.1 and shall meet the following:

If located outdoors, they shall be installed in an enclosure used only for the enclosure of such containers. [See Figure A.5.1.3.5.12(a) for minimum citing distance requirements.]

If located indoors, they shall be installed within a room used only for the enclosure of such containers.

5.1.3.5.11.2

The manifolds in this category shall have their primary and secondary headers located in the same enclosure.

5.1.3.5.11.3

The reserve header shall be permitted to be located in the same enclosure as the primary and secondary headers or in another enclosure compliant with 5.1.3.5.11.1.

5.1.3.5.11.4

The manifolds in this category shall consist of the following:

Two equal headers per 5.1.3.5.9, each having sufficient number of liquid container connections for an average day's supply, and with the headers connected to the final line pressure regulator assembly in such a manner that either header can supply the system

Reserve header per 5.1.3.5.9 having sufficient number of gas cylinder connections for an average day's supply, but not fewer than three connections, and connected downstream of the primary/secondary headers and upstream of the final line pressure regulators

Pressure relief installed downstream of the connection of the reserve header and upstream of the final line pressure regulating assembly and set at 50 percent above the nominal inlet pressure

5.1.3.5.11.5

The manifolds in this category shall include an automatic means of controlling the three headers to accomplish the following during normal operation:

If provided with two liquid container headers, one cryogenic liquid header is the primary and the other is the secondary, with either being capable of either role.

If provided with one liquid container header and one gas cylinder header (a hybrid arrangement), the liquid container header is the primary and the gas cylinder header is the secondary.

When the primary header is supplying the system, the secondary header is prevented from supplying the system.

When the primary header is depleted, the secondary header automatically begins to supply the system.

5.1.3.5.11.6

The manifolds in this category shall be equipped with a means to conserve the gas produced by evaporation of the cryogenic liquid in the secondary header (when so provided). This mechanism shall discharge the conserved gas into the system upstream of the final line regulator assembly.

5.1.3.5.11.7

The manifolds in this category shall include a manual or automatic means to place either header into the role of primary header and the other into the role of secondary header, except where a liquid/gas hybrid manifold is employed.

5.1.3.5.11.8

The manifolds in this category shall include a means to automatically activate the reserve header if for any reason the primary and secondary headers cannot supply the system.

5.1.3.5.11.9

The manifolds in this category shall have a local signal that visibly indicates the operating status of the equipment and activates an indicator at all master alarms under the following conditions:

When or at a predetermined set point before the secondary header begins to supply the system, indicating changeover

Where a hybrid arrangement is employed, when or at a predetermined set point before the secondary (cylinder) header contents fall to one day's average supply, indicating secondary low

When or at a predetermined set point before the reserve header begins to supply the system, indicating reserve is in use

When or at a predetermined set point before the reserve header contents fall to one day's average supply, indicating reserve low

5.1.3.5.12\* Bulk Cryogenic Liquid Systems

5.1.3.5.12.1

Bulk cryogenic liquid storage systems shall be in accordance with NFPA 55, Compressed Gases and Cryogenic Fluids Code.

5.1.3.5.12.2

Bulk cryogenic liquid systems shall have the following protections:

Be installed in accordance with NFPA 55, Compressed Gases and Cryogenic Fluids Code

Meet the requirements of 5.1.3.3.2(1)

Meet the requirements of 5.1.3.3.2(8)

Meet the requirements of 5.1.3.3.2(10)

Be installed meeting the requirements in 5.1.10.1 through 5.1.10.4.7

Have a minimum work space clearance of 3 ft (1 m) around the storage container, vaporizer(s), and the cabinet opening or front side of the pressure regulating manifold for system maintenance and operation

5.1.3.5.12.3

Bulk cryogenic liquid sources shall include automatic means to provide the following functions:

When the main supply is supplying the system, the reserve supply shall be prevented from supplying the system until the main supply is reduced to a level at or below the reserve activation pressure.

When the main supply cannot supply the system, the reserve supply shall automatically begin to supply the system.

Where there is more than one main supply vessel, the system shall operate as described in 5.1.3.5.11 for primary, secondary, and reserve operation.

Where there are two or more cryogenic vessels, they shall be permitted to alternate (e.g., on a timed basis) in the roles of primary, secondary, and reserve, provided that an operating cascade (primary—secondary—reserve) as required in 5.1.3.5.11.4 is maintained at all times.

Where a cryogenic vessel is used as the reserve, the reserve vessel shall include a means to conserve the gas produced by evaporation of the cryogenic liquid in the reserve vessel and to discharge the gas into the line upstream of the final line regulator assembly as required by 5.1.3.5.11.6.

5.1.3.5.12.4\*

The bulk systems shall have a local signal that visibly indicates the operating status of the equipment and an indicator at all master alarms under the following conditions:

When or at a predetermined set point before the main supply reaches an average day's supply, indicating low contents

When or at a predetermined set point before the reserve supply begins to supply the system, indicating reserve is in use

When or at a predetermined set point before the reserve supply contents fall to one day's average supply, indicating reserve low

If the reserve is a cryogenic vessel, when or at a predetermined set point before the reserve internal pressure falls too low for the reserve to operate properly, indicating reserve failure

Where there is more than one main supply vessel, when or at a predetermined set point before the secondary vessel begins to supply the system, indicating changeover

5.1.3.5.13\* Emergency Oxygen Supply Connection (EOSC)

Emergency oxygen supply connections (EOSCs) shall be installed to allow connection of a temporary auxiliary source of supply for emergency or maintenance situations where any of the following conditions exist:

The bulk cryogenic liquid central supply system is outside of and remote from the building that the oxygen supply serves.

There is no connected oxygen reserve sufficient for an average day's supply within the building, (see 5.1.3.5.14 for requirements for such reserves).

Multiple freestanding buildings are served from a single oxygen source such that damage to the interconnecting oxygen line could result in one or more buildings losing oxygen supply, in which case each building is required to be provided with a separate emergency connection.

5.1.3.5.13.1

EOSCs shall be located as follows:

Located on the exterior of the building being served in a location accessible by emergency supply vehicles at all times in all weather conditions

Connected to the main supply line immediately downstream of the main shutoff valve

5.1.3.5.13.2

EOSCs shall consist of the following:

Physical protection to prevent unauthorized tampering

Female DN (NPS) inlet for connection of the emergency oxygen source that is sized for 100 percent of the system demand at the emergency source gas pressure

Manual shutoff valve to isolate the EOSC when not in use

Two check valves, one downstream of the EOSC and one downstream of the main line shutoff valve, with both upstream from the tee connection for the two pipelines

Relief valve sized to protect the downstream piping system and related equipment from exposure to pressures in excess of 50 percent higher than normal line pressure

Any valves necessary to allow connection of an emergency supply of oxygen and isolation of the piping to the normal source of supply

Minimum of 1 m (3 ft) of clearance around the EOSC for connection of temporary auxiliary source

5.1.3.5.14 In-Building Emergency Reserves

5.1.3.5.14.1

In-building emergency reserves shall not be used as substitutes for the bulk gas reserves that are required in 5.1.3.5.12.4.

5.1.3.5.14.2

When a reserve is provided inside the building as a substitute for the EOSC or for other purposes, it shall be located in accordance with 5.1.3.3 as follows:

In a room or enclosure constructed per 5.1.3.3.2

In a room or enclosure ventilated per 5.1.3.3.3

5.1.3.5.14.3

In-building emergency reserves shall consist of either of the following:

Gas cylinder header per 5.1.3.5.9 with sufficient cylinder connections to provide for at least an average day's supply with the appropriate number of connections being determined after consideration of the delivery schedule, the proximity of the facility to alternate supplies, and the facility's emergency plan

Manifold for gas cylinders complying with 5.1.3.5.10

5.1.3.5.14.4

In-building emergency reserves shall include a check valve in the main line placed on the distribution system side of the ordinary source's main line valve to prevent flow of gas from the emergency reserve to the ordinary source.

5.1.3.5.14.5

In-building emergency reserves shall have a local signal that visibly indicates the operating status of the equipment and an alarm at all master alarms when or just before the reserve begins to serve the system.

5.1.3.6\* Category 1 Medical Air Supply Systems

5.1.3.6.1\* Quality of Medical Air

Medical air shall be required to have the following characteristics:

It shall be supplied from cylinders, bulk containers, or medical air compressor sources, or it shall be reconstituted from oxygen USP and oil-free, dry nitrogen NF.

It shall meet the requirements of medical air USP.

It shall have no detectable liquid hydrocarbons.

It shall have less than 25 ppm gaseous hydrocarbons.

It shall have equal to or less than 1 mg/m3 (6.85 × 10-7 lb/yd3) of permanent particulates sized 1 micron or larger in the air at normal atmospheric pressure.

5.1.3.6.2\* Uses of Medical Air

Medical air sources shall be connected to the medical air distribution system only and shall be used only for air in the application of human respiration and calibration of medical devices for respiratory application.

5.1.3.6.3\* Medical Air Compressor Sources

5.1.3.6.3.1 Location

Medical air compressor systems shall be located per 5.1.3.3 as follows:

Indoors in a dedicated mechanical equipment area, adequately ventilated and with any required utilities (e.g., electricity, drains, lighting)

In a room ventilated per 5.1.3.3.3.2

For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the manufacturer

5.1.3.6.3.2 Required Components

Medical air compressor systems shall consist of the following:

Components complying with 5.1.3.6.3.4 through 5.1.3.6.3.9, arranged per 5.1.3.6.3.10

Automatic means to prevent backflow from all on-cycle compressors through all off-cycle compressors

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

Intake filter—muffler(s) of the dry type

Pressure relief valve(s) set at 50 percent above line pressure

Piping and components between the compressor and the source shutoff valve that do not contribute to contaminant levels

Except as defined in 5.1.3.6.3.2(1) through (6), materials and devices used between the medical air intake and the medical air source valve that are of any design or construction appropriate for the service as determined by the manufacturer

5.1.3.6.3.3 Air Drying Equipment

Medical air compressor systems shall preclude the condensation of water vapor in the piping distribution system by the selection of the air drying equipment.

5.1.3.6.3.4 Compressors for Medical Air

(A)\*

Compressors for medical air shall be designed to prevent the introduction of contaminants or liquid into the pipeline by any of the following methods:

Elimination of oil anywhere in the compressor (e.g., liquid ring and permanently sealed bearing compressors)

Reciprocating compressors provided with a separation of the oil-containing section from the compression chamber by at least two seals creating an area open to atmosphere that allows the following:

Direct and unobstructed visual inspection of the interconnecting shaft through vent and inspection openings no smaller than 1.5 shaft diameters in size

Confirmation by the facility operators of proper seal operation by direct visual inspection through the above-shaft opening, without disassembly of the compressor (e.g., extended head compressors with an atmospheric vent between the compression chamber and the crankcase)

Rotating element compressors provided with a compression chamber free of oil that provide the following:

Separation of each oil-containing section from the compression chamber by at least one seal having atmospheric vents on each side with the vent closest to the oil-containing section supplied with a gravity drain to atmosphere

Unobstructed visualization of the atmospheric vent(s), closest to each oil-containing section, that is accessible for inspection without disassembling the compressor

Entry of the rotating shaft into each compression chamber at a point that is above atmospheric pressure

Confirmation by the facility operators of proper seal operation by direct visual inspection of the atmospheric vents

(B)

For liquid ring compressors, service water and seal water shall be treated to control waterborne pathogens and chlorine from hyperchlorination from entering the medical air.

(C)

Liquid ring compressors shall comply with the following:

Service water and seal water of a quality recommended by the compressor manufacturer shall be used.

Reserve medical air standby headers or a backup compressor shall be installed.

When installed, the header shall comply with 5.1.3.5.9.

When installed, the number of attached cylinders shall be sufficient for 1 hour normal operation.

(D)

Compressors shall be constructed of materials deemed suitable by the manufacturer.

(E)

Antivibration mountings shall be installed for compressors as required by equipment dynamics or location and in accordance with the manufacturer's recommendations.

(F)

Flexible connectors shall connect the air compressors with their intake and outlet piping.

5.1.3.6.3.5 Aftercoolers

(A)

Aftercoolers, where required, shall be provided with individual condensate traps.

(B)

The receiver shall not be used as an aftercooler or after-cooler trap.

(C)

Aftercoolers shall be constructed of materials deemed suitable by the manufacturer.

(D)

Antivibration mountings shall be installed for aftercoolers as required by equipment dynamics or location and in accordance with the manufacturer's recommendations.

5.1.3.6.3.6 Medical Air Receivers

Receivers for medical air shall meet the following requirements:

They shall be made of corrosion-resistant materials or otherwise be made corrosion resistant.

They shall comply with Section VIII, "Unfired Pressure Vessels," of the ASME Boiler and Pressure Vessel Code.

They shall be equipped with a pressure relief valve, automatic drain, manual drain, sight glass, and pressure indicator.

They shall be of a capacity sufficient to prevent the compressors from short-cycling.

5.1.3.6.3.7 Medical Air Dryers

Medical air dryers shall meet the following requirements:

They shall be designed to provide air at a maximum dew point that is below the frost point [0°C (32°F)] at 345 kPa to 380 kPa (50 psi to 55 psi) at any level of demand.

They shall be sized for 100 percent of the system peak calculated demand at design conditions.

They shall be constructed of materials deemed suitable by the manufacturer.

They shall be provided with antivibration mountings installed as required by equipment dynamics or location and in accordance with the manufacturer's recommendations.

5.1.3.6.3.8 Medical Air Filters

Medical air filters shall meet the following requirements:

They shall be appropriate for the intake air conditions.

They shall be located upstream (source side) of the final line regulators.

They shall be sized for 100 percent of the system peak calculated demand at design conditions and be rated for a minimum of 98 percent efficiency at 1 micron or greater.

They shall be equipped with a continuous visual indicator showing the status of the filter element life.

They shall be constructed of materials deemed suitable by the manufacturer.

5.1.3.6.3.9\* Medical Air Local Alarm

A local alarm complying with 5.1.9.5 shall be provided for the medical air compressor source.

5.1.3.6.3.10 Piping Arrangement and Redundancies

(A)

Component arrangement shall be as follows:

Components shall be arranged to allow service and a continuous supply of medical air in the event of a single fault failure.

Component arrangement shall be permitted to vary as required by the technology(ies) employed, provided that an equal level of operating redundancy and medical air quality is maintained.

(B)

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 fewer than two compressors.

(C)

When aftercoolers are provided, they shall be arranged to meet either one of the following:

Arranged as a duplex or multiplex set, sized to serve the peak calculated demand with the largest single aftercooler out of service, and provided with valves adequate, to isolate any single aftercooler from the system without shutting down supply of medical air

Arranged one per compressor, sized to handle the output of that compressor, and valved as appropriate to allow repair or replacement with that compressor out of service but without shutting down supply of medical air

(D)\*

A medical air receiver(s) shall be provided with proper valves to allow the flow of compressed air to enter and exit out of separate receiver ports during normal operation and allow the receiver to be bypassed during service without shutting down the supply of medical air.

(E)

Dryers, filters, and regulators shall be at least duplexed, with each component sized to serve the peak calculated demand with the largest of each component out of service.

(F)\*

Dryers, filters, and regulators shall be provided with manual valves upstream and manual valves or check valves downstream to allow service to the components without shutting down the system in either one of the following ways:

They shall be installed for each component, upstream and downstream of each component, allowing each to be individually isolated.

They shall be installed upstream (source side) and downstream of components in series so as to create redundant parallel branches of components.

(G)

A three-way valve (three-port), indexed to flow, full port shall be permitted to be used to isolate one branch or component for the purposes of 5.1.3.6.3.10(C), 5.1.3.6.3.10(D), 5.1.3.6.3.10(E), and 5.1.3.6.3.10(F).

(H)

Under normal operation, only one aftercooler shall be open to airflow with the other aftercooler valved off.

(I)

Under normal operation, only one dryer-filter(s)-regulator sequence shall be open to airflow with the other sequence valved off.

(J)

If the relief valve required in 5.1.3.6.3.2(5) and 5.1.3.6.3.6(3) can be isolated from the system by the valve arrangement used to comply with 5.1.3.6.3.10(F), then a redundant relief valve(s) shall be installed in the parallel sequence.

(K)

A DN8 (NPS 1/4) valved sample port shall be provided downstream of the final line pressure regulators, dew point monitor, and carbon monoxide monitor and upstream of the source shutoff valve to allow for sampling of the medical air.

(L)

Medical air source systems shall be provided with a source valve per 5.1.4.4.

(M)

Where medical air piping systems at different operating pressures are required, the piping shall separate after the filters but shall be provided with separate line regulators, dew point monitors, relief valves, and source shutoff valves.

5.1.3.6.3.11 Electrical Power and Control

(A)

An additional compressor(s) shall automatically activate when the compressor(s) in operation is incapable of maintaining the required pressure.

(B)

Automatic or manual alternation of compressors shall allow division of operating time. If automatic alternation of compressors is not provided, the facility staff shall arrange a schedule for manual alternation.

(C)

Each compressor motor shall be provided with electrical components including, but not limited to, the following:

Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter

Motor starting device

Overload protection

Where compressor systems having two or more compressors employ a control transformer or other voltage control power device, installation of at least two such devices.

Control circuits arranged in such a manner that the shutdown of one compressor does not interrupt the operation of another compressor

Automatic restart function, such that the compressor(s) will restart after power interruption without manual intervention

(D)

Electrical installation and wiring shall conform to the requirements of NFPA 70, National Electrical Code.

(E)

Emergency electrical service for the compressors shall conform to the requirements of the essential electrical system as described in Chapter 6.

5.1.3.6.3.12 Compressor Intake

(A)

The medical air compressors shall draw their air from a source of clean air.

(B)

The medical air intake shall be located a minimum of 7.6 m (25 ft) from ventilating system exhausts, fuel storage vents, combustion vents, plumbing vents, vacuum and WAGD discharges, or areas that can collect vehicular exhausts or other noxious fumes.

(C)

The medical air intake shall be located a minimum of 6 m (20 ft) above ground level.

(D)

The medical air intake shall be located a minimum of 3.0 m (10 ft) from any door, window, or other opening in the building.

(E)

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:

This alternate source of supply air shall be available on a continuous 24-hour-per-day, 7-day-per-week basis.

Ventilating systems having fans with motors or drive belts located in the airstream shall not be used as a source of medical air intake.

(F)

Compressor intake piping shall be permitted to be made of materials and use a jointing technique as permitted under 5.1.10.2.

(G)

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

The common intake is sized to minimize back pressure in accordance with the manufacturer's recommendations.

Each compressor can be isolated by manual or check valve, blind flange, or tube cap to prevent open inlet piping when the compressor(s) is removed for service from the consequent backflow of room air into the other compressor(s).

(H)

The end of the intake 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 noncorroding material.

5.1.3.6.3.13 Operating Alarms and Local Signals

Medical air systems shall be monitored for conditions that can affect air quality during use or in the event of failure, based on the type of compressor(s) used in the system.

(A)

Where liquid ring air compressors, compressors having water-cooled heads, or water-cooled aftercoolers are used, air receivers shall be equipped with a high water level sensor that shuts down the compressor system and activates a local alarm indicator. [See 5.1.9.5.4(7).]

(B)

Where liquid ring compressors are used, each compressor shall have a liquid level sensor in each air-water separator that, when the liquid level is above the design level, shuts down its compressor and activates a local alarm indicator. [See 5.1.9.5.4(8).]

(C)

Where nonliquid ring compressors compliant with 5.1.3.6.3.4(A)(1) are used, the air temperature at the immediate outlet of each compressor cylinder shall be monitored by a high-temperature sensor that shuts down that compressor and activates a local alarm indicator [see 5.1.9.5.4(9)]. The temperature setting shall be as recommended by the compressor manufacturer.

(D)

Where compressors compliant with 5.1.3.6.3.4(A)(2) and (3) are used, the following requirements shall apply:

The air temperature at the immediate outlet of each compressor chamber shall be monitored by a high-temperature sensor that shuts down that compressor and activates a local alarm indicator [see 5.1.9.5.4], the temperature setting shall be as recommended by the compressor manufacturer.

Coalescing filters with element change indicator shall be provided.

Charcoal absorber shall be provided.

Gaseous hydrocarbons shall be monitored on a quarterly basis.

(E)

When the backup or lag compressor is running, a local alarm shall activate [see 5.1.9.5.4(1)]. This signal shall be manually reset.

5.1.3.6.3.14 Medical Air Quality Monitoring

Medical air quality shall be monitored downstream of the medical air regulators and upstream of the piping system as follows:

Dew point shall be monitored and shall activate a local alarm and all master alarms when the dew point at system delivery pressure exceeds +2°C (+35°F).

Carbon monoxide shall be monitored and shall activate a local alarm when the CO level exceeds 10 ppm. [See 5.1.9.5.4(2).]

Dew point and carbon monoxide monitors shall activate their individual monitor's signal at the alarm panels where their signals are required when their power is lost.

5.1.3.6.3.15 Category 1 Medical Air Proportioning System

(A) General

Medical air reconstituted from oxygen USP and nitrogen NF, produced using proportioning system(s), shall be required to meet the following:

The quality of medical air shall be in accordance with 5.1.3.6.1.

The system shall be capable of supplying this quality of medical air, per 5.1.3.5.1, over the entire range of flow.

The system shall produce medical air with an oxygen content of 19.5 percent to 23.5 percent.

The medical air shall be cleared for marketing by the FDA or approved by the FDA.

The medical air proportioning system shall operate automatically.

The mixture shall be analyzed continuously, and a recording capability shall be provided (e.g., via data port).

The analyzing system specified in 5.1.3.6.3.15(A)(3) shall be a dedicated and an independent analyzer used to control the medical air proportioning system.

If the mixture goes out of specification, an alarm shall be activated automatically, the primary medical air proportioning system shall be disconnected, and the reserve supply shall be activated.

The system shall be arranged such that manual intervention is necessary to correct the composition of the mixture before reconnecting the medical air proportioning system to the health care facility pipeline system.

If dedicated sources of oxygen USP and nitrogen NF supply the medical air proportioning system, reserve sources for the oxygen and nitrogen shall not be required.

If dedicated sources of oxygen USP and nitrogen NF supply the medical air proportioning system, they shall not be used as the reserves for oxygen and nitrogen systems supplying the pipelines of the health care facility.

\*If the sources of oxygen USP and nitrogen NF that supply the medical air proportioning system are the same sources that supply the health care facility, engineering controls shall be provided to prevent cross contamination of oxygen and nitrogen supply lines, as provided in 5.1.3.5.7.

A risk analysis and approval from the authority having jurisdiction shall be required.

(B) Location

The medical air proportioning system shall be located per 5.1.3.3 as follows:

The medical air proportioning system's supply of oxygen USP and nitrogen NF shall be located per 5.1.3.3 and NFPA 55, as applicable.

The mixing device and controls, analyzers, and receivers shall be located indoors within a room or area per 5.1.3.3.1.

The indoor location shall include atmospheric monitoring for oxygen concentration.

The indoor location shall be constructed with all required utilities (e.g., electricity, drains, lighting) per NFPA 5000.

The indoor location shall be ventilated and heated per Chapter 9 and the manufacturer's recommendations.

(C) Required Components

The medical air proportioning system shall consist of the following:

Supply of oxygen USP and supply of nitrogen NF as follows:

The supply lines shall be filtered to remove particulate entering the proportioning system.

The minimum safe supply gas temperature and recommended local signal shall be specified by the medical air proportioning system manufacturer.

Mixing device with analyzers and engineering controls per manufacturer's recommendations to include, as a minimum, the following:

At least two oxygen analyzers capable of independently monitoring oxygen concentration

Mechanism where each analyzer based upon nonconforming oxygen concentration is capable, directly or via other medical air proportioning system controls, of automatically shutting off the supply from the medical air proportioning system to the medical air piped distribution system and activating the reserve supply

Mechanism where each analyzer, based upon nonconforming oxygen concentration, is capable, directly or via other proportioning system controls, of automatically shutting off the supply of oxygen and nitrogen to the proportioning system and activating the reserve supply

Provision for manual resetting of the proportioning system after detection of nonconforming oxygen concentration and subsequent shutdown once conforming oxygen concentration is established, in order to re-establish flow to the medical air piping system

Means of verifying the performance of the analyzers by reference to an air standard, with known traceable oxygen content

Minimum of one recorder for recording the medical air proportioning system performance and air quality for a period of not less than 24 hours

Continuous analysis of the mixture and a recording capability provided (e.g., via a data port)

Mechanism for isolating the primary medical air proportioning system from the reserve supply and the medical air piping distribution system by employing sequential valves for redundancy

Capability of the reserve supply to automatically activate if the primary supply is isolated

Reserve supply of medical air USP sized, at minimum, for an average day's supply and consisting of one of the following:

Additional medical air proportioning unit with a dedicated supply of oxygen USP and nitrogen NF

Medical air compressor system per 5.1.3.5.10, with the exception of the allowance of a simplex medical air compressor system

Medical air cylinder manifold per 5.1.3.5.10

Receiver fitted with a pressure relief valve and pressure gauge as follows:

The receiver shall be constructed of corrosion-resistant materials.

The receiver, relief valves, and pressure gauges shall comply with ASME Boiler and Vessel Code and manufacturer's recommendations.

\*Warning systems per 5.1.9, including a local signal and master alarm that indicates nonconforming oxygen concentration per manufacturer's recommendations

Final line pressure regulators complying with 5.1.3.5.5

Pressure relief complying with 5.1.3.5.6

Local signals complying with 5.1.3.5.8.2

5.1.3.7\* Medical—Surgical Vacuum Supply Systems

5.1.3.7.1 Medical—Surgical Vacuum Sources

5.1.3.7.1.1

Medical—surgical vacuum sources shall be located per 5.1.3.3 as follows:

Indoors in a dedicated mechanical equipment area, adequately ventilated and with any required utilities

In a room ventilated per 5.1.3.3.3.2

For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the equipment manufacturer

5.1.3.7.1.2

Medical—surgical vacuum sources shall consist of the following:

Two or more vacuum pumps sufficient to serve the peak calculated demand with the largest single vacuum pump out of service

Automatic means to prevent backflow from any on-cycle vacuum pumps through any off-cycle vacuum pumps

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

Vacuum receiver

Piping between the vacuum pump(s), discharge(s), receiver(s), and vacuum source shutoff valve in accordance with 5.1.10.2, except brass, galvanized, or black steel pipe, which is permitted to be used as recommended by the manufacturer

Except as defined in 5.1.3.7.1.2(1) through (5), materials and devices used between the medical vacuum exhaust and the medical vacuum source that are permitted to be of any design or construction appropriate for the service as determined by the manufacturer

5.1.3.7.2 Vacuum Pumps

5.1.3.7.2.1

Vacuum pumps shall be constructed of materials deemed suitable by the manufacturer.

5.1.3.7.2.2

Antivibration mountings shall be installed for vacuum pumps as required by equipment dynamics or location and in accordance with the manufacturer's recommendations.

5.1.3.7.2.3

Flexible connectors shall connect the vacuum pumps with their intake and outlet piping.

5.1.3.7.2.4

For liquid ring vacuum pumps, seal water shall be of a quality recommended by the vacuum pump manufacturer.

5.1.3.7.3 Vacuum Receivers

Receivers for vacuum shall meet the following requirements:

They shall be made of materials deemed suitable by the manufacturer.

They shall comply with Section VIII, "Unfired Pressure Vessels," of the ASME Boiler and Pressure Vessel Code.

They shall be capable of withstanding a gauge pressure of 415 kPa (60 psi) and 760 mm (30 in.) gauge HgV.

They shall be equipped with a manual drain.

They shall be of a capacity based on the technology of the pumps.

5.1.3.7.4 Vacuum Local Alarm

A local alarm complying with 5.1.9.5 shall be provided for the vacuum source.

5.1.3.7.5 Piping Arrangement and Redundancies

5.1.3.7.5.1

Piping arrangement shall be as follows:

Piping shall be arranged to allow service and a continuous supply of medical—surgical vacuum in the event of a single fault failure.

Piping arrangement shall be permitted to vary based on the technology(ies) employed, provided that an equal level of operating redundancy is maintained.

Where only one set of vacuum pumps is available for a combined medical—surgical vacuum system and an analysis, a research, or a teaching laboratory vacuum system, such laboratories shall be connected separately from the medical—surgical system directly to the receiver tank through its own isolation valve and fluid trap located at the receiver, and between the isolation valve and fluid trap, a scrubber shall be permitted to be installed.

5.1.3.7.5.2

The medical—surgical vacuum receiver(s) shall be serviceable without shutting down the medical—surgical vacuum system by any method to ensure continuation of service to the facility's medical—surgical pipeline distribution system.

5.1.3.7.5.3

Medical—surgical vacuum source systems shall be provided with a source shutoff valve per 5.1.4.4.

5.1.3.7.6 Electrical Power and Control

5.1.3.7.6.1

Additional pumps shall automatically activate when the pump(s) in operation is incapable of adequately maintaining the required vacuum.

5.1.3.7.6.2

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.

5.1.3.7.6.3

Each pump motor shall be provided with electrical components including, but not limited to, the following:

Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter

Motor starting device

Overload protection

Where pump systems having two or more pumps employ a control transformer or other voltage control power device, at least two such devices

Control circuits arranged in such a manner that the shutdown of one pump does not interrupt the operation of another pump

Automatic restart function such that the pump(s) will restart after power interruption without manual intervention

5.1.3.7.6.4

Electrical installation and wiring shall conform to the requirements of NFPA 70, National Electrical Code.

5.1.3.7.6.5

Emergency electrical service for the pumps shall conform to the requirements of the essential electrical system as described in Chapter 6.

5.1.3.7.7 Medical—Surgical Vacuum Source Exhaust

5.1.3.7.7.1

The medical—surgical vacuum pumps shall exhaust in a manner and location that minimizes the hazards of noise and contamination to the facility and its environment.

5.1.3.7.7.2

The exhaust shall be located as follows:

Outdoors

At least 3.05 m (10 ft) from any door, window, air intake, or other openings in buildings or places of public assembly

At a level different from air intakes

Where prevailing winds, adjacent buildings, topography, or other influences will not divert the exhaust into occupied areas or prevent dispersion of the exhaust

5.1.3.7.7.3

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 noncorroding material.

5.1.3.7.7.4

The exhaust shall be free of dips and loops that might trap condensate or oil or provided with a drip leg and valved drain at the bottom of the low point.

5.1.3.7.7.5

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

The common exhaust is sized to minimize back pressure in accordance with the pump manufacturer's recommendations.

Each pump can be isolated by manual or check valve, blind flange, or tube cap to prevent open exhaust piping when the pump(s) is removed for service from consequent flow of exhaust air into the room.

5.1.3.7.8 Operating Alarms

Medical—surgical vacuum systems shall activate a local alarm when the backup or lag pump is running per 5.1.9.5. This signal shall be manually reset.

5.1.3.8\* Waste Anesthetic Gas Disposal (WAGD)

5.1.3.8.1\* Sources

WAGD sources shall be chosen in consultation with the medical staff having knowledge of the requirements to determine the type of system, number and placement of terminals, and other required safety and operating devices.

5.1.3.8.1.1

WAGD shall be permitted to be produced through the medical—surgical vacuum source, by a dedicated producer, or by venturi.

5.1.3.8.1.2

If WAGD is produced by the medical—surgical vacuum source, the following shall apply:

The medical—surgical vacuum source shall comply with 5.1.3.7.

The total concentration of oxidizers (oxygen and nitrous oxide) shall be maintained below 23.6 percent, or the vacuum pump shall comply with 5.1.3.8.2.1.

The medical—surgical vacuum source shall be sized to accommodate the additional volume.

5.1.3.8.1.3

If WAGD is produced by a dedicated WAGD producer with a total power equal to or greater than 1 horsepower in total (both producers), the following shall apply:

The WAGD source shall be located in accordance with 5.1.3.3.

The WAGD source shall be located indoors in a dedicated mechanical equipment area with any required utilities.

The WAGD source shall be ventilated per 5.1.3.3.3.2.

For air-cooled equipment, the WAGD source shall be located to maintain the ambient temperature range as recommended by the manufacturer.

The WAGD producers shall comply with 5.1.3.8.2.

5.1.3.8.1.4

If WAGD is produced by a dedicated WAGD producer with a total power less than 1 horsepower in total (both producers), the following shall apply:

The WAGD source shall be permitted to be located near the inlet(s) served.

For air-cooled equipment, the WAGD source shall be located to maintain the ambient temperature range as recommended by the manufacturer.

5.1.3.8.1.5

For liquid ring pumps in WAGD service, seal water shall be of a quality as recommended by the pump manufacturer.

5.1.3.8.1.6

The WAGD source shall consist of the following:

Two or more WAGD producers sufficient to serve the peak calculated demand with the largest single WAGD producer out of service

Automatic means to prevent backflow from any on-cycle WAGD producers through any off-cycle WAGD producers

Shutoff valve to isolate each WAGD producer from the centrally piped system and other WAGD producers for maintenance or repair without loss of medical—surgical vacuum in the system

Piping between the WAGD producers and the source shutoff valve compliant with 5.1.10.2, as recommended by the manufacturer

Antivibration mountings installed for WAGD producers as required by equipment dynamics or location and in accordance with the manufacturer's recommendations

Flexible connectors interconnecting the producers with their intake and outlet piping as required by equipment dynamics or location and in accordance with the WAGD producer manufacturer's recommendations

5.1.3.8.1.7

If WAGD is produced by a venturi, the following shall apply:

The venturi shall not be user-adjustable (i.e., require the use of special tools).

The venturi shall be driven using water, inert gas, instrument air, or other dedicated air source.

Medical air shall not be used to power the venturi.

5.1.3.8.2 WAGD Producers

5.1.3.8.2.1

Vacuum pumps dedicated for WAGD service shall be as follows:

Compliant with 5.1.3.7.2

Designed of materials and using lubricants and sealants that are inert in the presence of oxygen, nitrous oxide, and halogenated anesthetics

5.1.3.8.2.2

Vacuum producers (e.g., fans or blowers) designed for operation at vacuums below 130 mm (5 in.) HgV shall be as follows:

Permitted to be made of any materials determined by the manufacturer as suitable for the service

Provided with antivibration mountings as required by equipment dynamics or location and in accordance with the manufacturer's recommendation

Connected with their intake and outlet piping through flexible connections

Used only for WAGD service and not employed for other services

Interconnected via piping, ductwork, and so forth, made of materials determined by the manufacturer as suitable to the service

5.1.3.8.3 WAGD Connections to Vacuum Piping

If WAGD is joined to vacuum piping, it shall be connected at a minimum distance of 1.5 m (5 ft) from any vacuum inlet.

5.1.3.8.4 WAGD Alarms

5.1.3.8.4.1

When the WAGD system is served by a central source(s), a local alarm complying with 5.1.9.5 shall be provided for the WAGD source.

5.1.3.8.4.2

A WAGD source system shall activate a local alarm when the backup or lag producer is running.

5.1.3.8.5 Electrical Power and Control

5.1.3.8.5.1

Additional producers shall automatically activate when the producer(s) in operation is incapable of maintaining the required vacuum.

5.1.3.8.5.2

Automatic or manual alternation of producers shall allow division of operating time. If automatic alternation of producers is not provided, the facility staff shall arrange a schedule for manual alternation.

5.1.3.8.5.3

Each producer motor shall be provided with electrical components including, but not limited to, the following:

Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter

Motor starting device

Overload protection

Where WAGD systems having two or more producers employ a control transformer or other voltage control power device, at least two such devices

Control circuits arranged in such a manner that the shutdown of one producer does not interrupt the operation of another producer

Automatic restart function such that the pump(s) will restart after power interruption without manual intervention

5.1.3.8.5.4

Electrical installation and wiring shall conform to the requirements of NFPA 70, National Electrical Code.

5.1.3.8.5.5

Emergency electrical service for the producers shall conform to the requirements of the essential electrical system as described in Chapter 6.

5.1.3.8.6 WAGD Exhaust

The WAGD pumps shall exhaust in compliance with 5.1.3.7.7.

5.1.3.9\* Instrument Air Supply Systems

5.1.3.9.1 Quality of Instrument Air

The quality of instrument air shall be as follows:

Compliant with instrument air section in ANSI/ISA S-7.0.01, Quality Standard for Instrument Air

Filtered to 0.01 micron

Free of liquids (e.g., water, hydrocarbons, solvents)

Free of hydrocarbon vapors

Dry to a dew point of —40°C (—40°F)

5.1.3.9.2 General

5.1.3.9.2.1

Instrument air shall be permitted to be used for any medical support purpose (e.g., to remove excess moisture from instruments before further processing, or to operate medical—surgical tools, air-driven booms, pendants, or similar applications) and, if appropriate to the procedures, to be used in laboratories.

5.1.3.9.2.2

Instrument air supply systems shall be located per 5.1.3.3 as follows:

Indoors, in a dedicated mechanical equipment area that is adequately ventilated and with any required utilities

In a room ventilated per 5.1.3.3.3.2

For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the equipment manufacturer

5.1.3.9.2.3

Instrument air systems shall be prohibited from the following:

Interconnection with medical air systems

Usage for any purpose where the air will be intentionally respired by patients or staff

5.1.3.9.3 Instrument Air Source

5.1.3.9.3.1

Instrument air sources shall produce air at not less than a gauge pressure of 1380 kPa (200 psi) output pressure.

5.1.3.9.3.2

Instrument air sources shall provide air meeting the definition of instrument air in Chapter 3.

5.1.3.9.3.3

Instrument air sources shall be permitted to include at least two compressors or one compressor and a standby header complying with 5.1.3.5.8.

5.1.3.9.3.4

Instrument air sources shall comply with 5.1.3.6.3, with exceptions as specified in 5.1.3.9.

5.1.3.9.4 Instrument Air Compressors

Instrument air compressors shall be permitted to be of any type capable of not less than a gauge pressure of 1380 kPa (200 psi) output pressure and of providing air meeting the definition of instrument air in Chapter 3.

5.1.3.9.5 Instrument Air Standby Headers

Where instrument air systems are provided with a standby header, the header shall meet the following requirements:

It shall comply with 5.1.3.5.9, except that the number of attached cylinders shall be sufficient for 1 hour normal operation.

It shall use connectors as for medical air in CGA V-1, Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections (ANSI B57.1).

It shall enter the system upstream (source side) of the final line filters. (See Figure A.5.1.3.9.)

It shall automatically serve the system in the event of a failure of the compressor.

5.1.3.9.6\* Intake Air

Intake air for instrument air compressors shall be permitted to be drawn from the outside, from ducted air, or from the equipment location.

5.1.3.9.7 Instrument Air Filters

5.1.3.9.7.1

Instrument air sources shall be filtered with activated carbon filters that meet the following requirements:

They shall be located upstream (source side) of the final line filters.

They shall be sized for 100 percent of the system peak calculated demand at design conditions.

They shall be constructed of materials deemed suitable by the manufacturer.

5.1.3.9.7.2

Final line filters shall meet the following requirements:

They shall be located upstream (source side) of the final line regulators and downstream of the carbon filters

They shall be sized for 100 percent of the system peak calculated demand at design conditions.

They shall be rated for a minimum of 98 percent efficiency at 0.01 micron.

They shall be equipped with a continuous visual indicator showing the status of the filter element life.

They shall be constructed of materials deemed suitable by the manufacturer.

5.1.3.9.7.3

Filters combining the function of 5.1.3.9.7.1 and 5.1.3.9.7.2 shall be permitted to be used.

5.1.3.9.8 Instrument Air Accessories

Accessories used for instrument air sources shall comply with the following subparagraphs:

5.1.3.6.3.5 for aftercoolers

5.1.3.6.3.6 for air receivers

5.1.3.6.3.7 for air dryers

5.1.3.5.9 for air regulators

5.1.3.9.9 Instrument Air Piping Arrangement and Redundancies

Instrument air sources shall comply with 5.1.3.6.3.10, except for the following:

Systems employing a standby header shall be permitted to have simplex aftercoolers and dryers.

Systems employing a standby header shall not require a three-valve receiver bypass.

Standby headers, where provided, shall be isolated from the compressor by a check valve to prevent backflow through the compressor.

5.1.3.9.10 Instrument Air Monitoring and Alarms

5.1.3.9.10.1

Instrument air sources shall include the following alarms:

Local alarm that activates when or just before the backup compressor (if provided) activates, indicating that the lag compressor is in operation and that must be manually reset

Local alarm and alarms at all master alarm panels that activate when the dew point at system pressure exceeds —30°C (—22°F), indicating high dew point

5.1.3.9.10.2

For sources with standby headers, the following additional conditions shall activate a local alarm at the compressor site, a local signal at the header location, and alarms at all master alarm panels:

Alarm that activates when or just before the reserve begins to supply the system, indicating reserve in use

Alarm that activates when or just before the reserve falls below an average hour's supply, indicating reserve low

5.1.3.9.11 Electrical Power and Control

5.1.3.9.11.1

When multiple compressors are used, an additional compressor(s) shall automatically activate when the compressor(s) in operation is incapable of maintaining the required pressure.

5.1.3.9.11.2

When multiple compressors are used, automatic or manual alternation of compressors shall allow division of operating time. If automatic alternation of compressors is not provided, the facility staff shall arrange a schedule for manual alternation.

5.1.3.9.11.3

Each compressor motor shall be provided with electrical components including, but not limited to, the following:

Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter

Motor starting device

Overload protection

Where compressor systems having two or more compressors employ a control transformer or other voltage control power device, installation of at least two such devices

Control circuits arranged in such a manner that the shutdown of one compressor does not interrupt the operation of another compressor

Automatic restart function such that the compressor(s) will restart after power interruption without manual intervention

5.1.3.9.11.4

Electrical installation and wiring shall conform to the requirements of NFPA 70, National Electrical Code.

5.1.3.9.11.5

Emergency electrical service for the compressors shall conform to the requirements of the essential electrical system as described in Chapter 6.

5.1.4\* Valves

5.1.4.1 Gas and Vacuum Shutoff Valves

Shutoff valves shall be provided to isolate sections or portions of the piped distribution system for maintenance, repair, or planned future expansion need and to facilitate periodic testing.

5.1.4.2 Accessibility

All valves, except valves in zone valve box assemblies, shall be located in secured areas such as locked piped chases, or be locked or latched in their operating position, and be labeled as to gas supplied and the area(s) controlled.

5.1.4.2.1

Shutoff valves accessible to other than authorized personnel shall be installed in valve boxes with frangible or removable windows large enough to allow manual operation of valves.

5.1.4.2.2

Shutoff valves for use in certain areas, such as psychiatric or pediatric areas, shall be permitted to be secured with the approval of the authority having jurisdiction to prevent inappropriate access.

5.1.4.2.3

Valves for nonflammable medical gases shall not be installed in the same zone valve box assembly with flammable gases.

5.1.4.3 Valve Types

New or replacement shutoff valves shall be as follows:

They shall be of the quarter turn, full ported, ball type.

They shall be of brass or bronze construction.

They shall have extensions for brazing.

They shall have a handle indicating open or closed.

They shall consist of three pieces permitting in-line serviceability.

5.1.4.3.1

Valves for positive pressure gases shall be cleaned for oxygen service by the manufacturer.

5.1.4.3.2

Valves for vacuum or WAGD service shall be permitted to be ball or butterfly type and shall not be required to be cleaned for oxygen service.

5.1.4.4 Source Valve

A shutoff valve shall be placed at the immediate connection of each source system to the piped distribution system to allow the entire source, including all accessory devices (e.g., air dryers, final line regulators), to be isolated from the facility.

5.1.4.4.1

The source valve shall be located in the immediate vicinity of the source equipment.

5.1.4.4.2

The source valve shall be labeled in accordance with 5.1.11.2.

5.1.4.5\* Main Line 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:

The source and source valve are located inside the building served.

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.

5.1.4.5.1

The main line valve shall be located to allow access by authorized personnel only (i.e., by locating the valve above a ceiling or behind a locked access door).

5.1.4.5.2

The main line valve shall be located on the facility side of the source valve and outside of the source room, the enclosure, or where the main line first enters the building.

5.1.4.5.3

The main line valve shall be labeled in accordance with 5.1.11.2.

5.1.4.6 Riser Valve

Each riser supplied from the main line shall be provided with a shutoff valve in the riser adjacent to the main line.

5.1.4.6.1

Riser valves shall be permitted to be located above ceilings, but shall remain accessible and not be obstructed.

5.1.4.6.2

The riser valve shall be labeled in accordance with 5.1.11.2.

5.1.4.7 Service Valves

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.

5.1.4.7.1

Only one service valve shall be required for each branch off of a riser, regardless of how many zone valve boxes are installed on that lateral.

5.1.4.7.2

Service valves shall be placed in the branch piping prior to any zone valve box assembly on that branch.

5.1.4.7.3

Service valves shall be located in any one of the following areas:

Behind a locked access door

Locked open above a ceiling

Locked open in a secure area

5.1.4.7.4

Service valves shall be labeled in accordance with 5.1.11.2.

5.1.4.8 Zone Valves

All station outlets/inlets shall be supplied through a zone valve as follows:

The zone valve shall be placed such that a wall intervenes between the valve and outlets/inlets that it controls.

The zone valve shall serve only outlets/inlets located on that same story.

The zone valve shall not be located in a room with station outlets/inlets that it controls.

5.1.4.8.1

Zone valves shall be readily operable from a standing position in the corridor on the same floor they serve.

5.1.4.8.2

Zone valves shall be so arranged that shutting off the supply of medical gas or vacuum to one zone will not affect the supply of medical gas or vacuum to another zone or the rest of the system.

5.1.4.8.3

A pressure/vacuum indicator shall be provided on the station outlet/inlet side of each zone valve.

5.1.4.8.4

Zone valve boxes shall be installed where they are visible and accessible at all times.

5.1.4.8.5

Zone valve boxes shall not be installed behind normally open or normally closed doors or otherwise hidden from plain view.

5.1.4.8.6

Zone valve boxes shall not be located in closed or locked rooms, areas, or closets.

5.1.4.8.7

A zone valve shall be located immediately outside each vital life-support area, critical care area, and anesthetizing location of moderate sedation, deep sedation, or general anesthesia, in each medical gas or vacuum line, or both, and located so as to be readily accessible in an emergency.

5.1.4.8.7.1

All gas delivery columns, hose reels, ceiling tracks, control panels, pendants, booms, or other special installations shall be located downstream of the zone valve.

5.1.4.8.7.2

Zone valves shall be so arranged that shutting off the supply of gas to any one operating room or anesthetizing location will not affect the others.

5.1.4.8.8

Zone valves shall be labeled in accordance with 5.1.11.2.

5.1.4.9 In-Line Shutoff Valves

Optional in-line valves shall be permitted to be installed to isolate or shut off piping for servicing of individual rooms or areas.

5.1.4.9.1

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

They shall be located in a restricted area.

They shall be locked or latched open.

They shall be identified in accordance with 5.1.11.2.

5.1.4.10 Valves for Future Connections

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

They shall be located in a restricted area.

They shall be locked or latched closed.

They shall be identified in accordance with 5.1.11.2.

5.1.4.10.1

Future connection valves shall be labeled as to gas content.

5.1.4.10.2

Downstream piping shall be closed with a brazed cap with tubing allowance for cutting and rebrazing.

5.1.4.11 In-Line Check Valves

New or replacement check valves shall be as follows:

They shall be of brass or bronze construction.

They shall have brazed extensions.

They shall have in-line serviceability.

They shall not have threaded connections.

They shall have threaded purge points of 1/8 in. NPT.

5.1.5\* Station Outlets/Inlets

5.1.5.1

Each station outlet/inlet for medical gases or vacuums shall be gas-specific, whether the outlet/inlet is threaded or is a noninterchangeable quick coupler.

5.1.5.2

Each station outlet shall consist of a primary and a secondary valve (or assembly).

5.1.5.3

Each station inlet shall consist of a primary valve (or assembly) and shall be permitted to include a secondary valve (or assembly).

5.1.5.4

The secondary valve (or assembly) shall close automatically to stop the flow of gas (or vacuum, if provided) when the primary valve (or assembly) is removed.

5.1.5.5

Each outlet/inlet shall be legibly identified in accordance with 5.1.11.3.

5.1.5.6

Threaded outlets/inlets shall be non-interchangeable connections complying with CGA V-5, Diameter-Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications).

5.1.5.7

Each station outlet/inlet, including those mounted in columns, hose reels, ceiling tracks, or other special installations, shall be designed so that parts or components that are required to be gas-specific for compliance with 5.1.5.1 and 5.1.5.9 cannot be interchanged between the station outlet/inlet for different gases.

5.1.5.8

The use of common parts in outlets/inlets, such as springs, O-rings, fasteners, seals, and shutoff poppets, shall be permitted.

5.1.5.9

Components of a vacuum station inlet necessary for the maintenance of vacuum specificity shall be legibly marked to identify them as components or parts of a vacuum or suction system.

5.1.5.10

Components of inlets not specific to a vacuum shall not be required to be marked.

5.1.5.11

Factory-installed copper inlet tubes on station outlets extending no further than 205 mm (8 in.) from the body of the terminal shall be not less than DN8 (NPS 1/4) (3/8 in. O.D.) size, with 8 mm (0.3 in.) minimum inside diameter.

5.1.5.12

Factory-installed copper inlet tubes on station inlets extending no further than 205 mm (8 in.) from the body of the terminal shall be not less than DN10 (NPS 3/8) (1/2 in. O.D.) size, with 10 mm (0.4 in.) minimum inside diameter.

5.1.5.13

Station outlets/inlets shall be permitted to be recessed or otherwise protected from damage.

5.1.5.14

When multiple wall outlets/inlets are installed, they shall be spaced to allow the simultaneous use of adjacent outlets/inlets with any of the various types of therapy equipment.

5.1.5.15

Station outlets in systems having nonstandard operating pressures shall meet the following additional requirements:

They shall be gas-specific.

They shall be pressure-specific where a single gas is piped at more than one operating pressure [e.g., a station outlet for oxygen at 550 kPa (80 psi) shall not accept an adapter for oxygen at 345 kPa (50 psi)].

If operated at a pressure in excess of 550 kPa (80 psi), they shall be either D.I.S.S. connectors or comply with 5.1.5.15(4).

If operated at a gauge pressure between 1380 kPa and 2070 kPa (200 psi and 300 psi), the station outlet shall be designed so as to prevent the removal of the adapter until the pressure has been relieved to prevent the adapter injuring the user or others when removed from the outlet.

5.1.5.16

WAGD networks shall provide a WAGD inlet in all locations where nitrous oxide or halogenated anesthetic gas is intended to be administered.

5.1.5.16.1

Station inlets for WAGD service shall have the following additional characteristics:

They shall not be interchangeable with any other systems, including medical—surgical vacuum.

Components necessary for the maintenance of WAGD specificity shall be legibly marked to identify them as components of a WAGD inlet.

They shall be of a type appropriate for the flow and vacuum level required by the facility's gas anesthetic machines.

They shall be located to avoid physical damage to the inlet.

5.1.6\* Manufactured Assemblies

5.1.6.1

Manufactured assemblies shall be pretested by the manufacturer prior to arrival at the installation site in accordance with the following:

Initial blowdown test per 5.1.12.2.2

Initial pressure test per 5.1.12.2.3

Piping purge test per 5.1.12.2.5

Standing pressure test per 5.1.12.2.6 or 5.1.12.2.7, except as permitted under 5.1.6.2

5.1.6.2

The standing pressure test under 5.1.6.1(4) shall be permitted to be performed by any testing method that will ensure a pressure decay of less than 1 percent in 24 hours.

5.1.6.3

The manufacturer of the assembly shall provide documentation certifying the performance and successful completion of the tests required in 5.1.6.1.

5.1.6.4

Manufactured assemblies employing flexible hose shall use hose and flexible connectors with a minimum burst gauge pressure of 6895 kPa (1000 psi).

5.1.6.5

Manufactured assemblies shall have a flame spread index of not greater than 200 when tested in accordance with ASTM E 84, Standard Test Method for Surface Burning Characteristics of Building Materials, or shall comply with the requirements for heat release in accordance with NFPA 286, Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth, as described in Section 10.2 of NFPA 101, Life Safety Code.

5.1.6.6

Manufactured assemblies employing flexible hose or tubing shall be attached to the pipelines using station outlets/inlets.

5.1.6.7

Manufactured assemblies employing hose or flexible connectors, where the station outlet/inlet attached to the piping is not fully and immediately accessible (i.e., cannot be manipulated without the removal of panels, doors, and so forth), shall have station outlets/inlets with the following additional characteristics:

They shall be gas-specific connections with positive locking mechanisms that ensure the connector is firmly seated and cannot detach without intentional actuation of the release (e.g., D.I.S.S. connectors).

In pressure gases, they shall be permitted to omit the secondary valve (or assembly) required in 5.1.5.2.

In vacuum and WAGD, they shall be permitted to omit both primary and secondary valves (or assemblies) for minimum restriction to flow.

They shall be provided with a second terminal at which the user connects and disconnects that complies with 5.1.5.

5.1.6.8

Manufactured assemblies connected to the pipeline by brazing shall have station outlets/inlets that comply with 5.1.5 in all respects.

5.1.6.9

The installation of manufactured assemblies shall be tested in accordance with 5.1.12.

5.1.7\* Surface-Mounted Medical Gas Rails (MGR)

5.1.7.1

Medical gas rail (MGR) assemblies shall be permitted to be installed where multiple uses of medical gases and vacuum at a single patient location are required or anticipated.

5.1.7.2

MGR assemblies shall be entirely visible in the room, not passing into or through walls, partitions, and so forth.

5.1.7.3

MGR assemblies shall be made of materials with a melting point of at least 538°C (1000°F).

5.1.7.4

MGR assemblies shall be cleaned per 5.1.10.1.1.

5.1.7.5

Station outlets or inlets shall not be placed on the ends of MGR assemblies.

5.1.7.6

Openings for station outlets/inlets in the MGR shall be gas-specific.

5.1.7.7

Openings in the MGR not occupied by station outlets/inlets (e.g., for future use) shall be capped or plugged so that a special tool is required for removal (i.e., cannot be removed by a wrench, pliers, a screwdriver, or other common tool).

5.1.7.8

MGR assemblies shall connect to the pipeline through fittings that are brazed to the pipeline.

5.1.7.9\*

Where the pipeline and the MGR assembly are of dissimilar metals, the connections shall be plated or otherwise protected from interaction between the metals.

5.1.7.10

The installation of the MGR shall be tested in accordance with 5.1.12.

5.1.8 Pressure and Vacuum Indicators

5.1.8.1 General

5.1.8.1.1

Pressure indicators and manometers for medical gas piping systems shall be cleaned for oxygen service.

5.1.8.1.2

Gauges shall comply with ANSI/ASME B40.100, Pressure Gauges and Gauge Attachments.

5.1.8.1.3\*

The scale range of positive pressure analog indicators shall be such that the normal operating pressure is within the middle third of the total range [e.g., an indicator of 0 to 2070 kPa (0 to 300 psi) would have a lower third of 0 to 690 kPa (0 to 100 psig), a middle third of 690 kPa to 1380 kPa (100 psig to 200 psig), and a top third of 1380 kPa to 2070 kPa (200 psig to 300 psig)].

5.1.8.1.4

The accuracy of digital indicators shall be ±5 percent of the operating pressure at which they are used.

5.1.8.1.5

The scale range of vacuum indicators shall be 0 to 760 mm (0 to 30 in.) gauge HgV. Indicators with a normal range display shall indicate normal only above 300 mm (12 in.) gauge HgV.

5.1.8.1.6

Indicators adjacent to master alarm actuators and area alarms shall be labeled to identify the name of, or chemical symbol for, the particular piping system that they monitor.

5.1.8.1.7

The rated accuracy of indicators used for testing shall be 1 percent (full scale) or better at the point of reading.

5.1.8.2 Locations

5.1.8.2.1

Pressure/vacuum indicators shall be readable from a standing position.

5.1.8.2.2

Pressure/vacuum indicators shall be provided at the following locations, as a minimum:

Adjacent to the alarm-initiating device for source main line pressure and vacuum alarms in the master alarm system

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

On the station outlet/inlet side of zone valves

5.1.8.2.3

All pressure-sensing devices and main line pressure gauges downstream of the source valves shall be provided with a gas-specific demand check fitting to facilitate service testing or replacement.

5.1.8.2.3.1

Gas-specific demand check fittings shall not be required on zone valve pressure indicators.

5.1.8.2.4

Demand check fittings shall be provided for all monitors.

5.1.9\* Category 1 Warning Systems

5.1.9.1 General

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

Separate visual indicators for each condition monitored, except as permitted in 5.1.9.5.2 for local alarms that are displayed on master alarm panels

Visual indicators that remain in alarm until the situation that has caused the alarm is resolved

Cancelable audible indication of each alarm condition that produces a sound with a minimum level of 80 dBA at 0.92 m (3 ft)

Means to visually indicate a lamp or LED failure

Visual and audible indication that the communication with an alarm-initiating device is disconnected

Labeling of each indicator, indicating the condition monitored

Labeling of each alarm panel for its area of surveillance

Reinitiation of the audible signal if another alarm condition occurs while the audible alarm is silenced

Power for master, area alarms, sensors, and switches from the life safety branch of the emergency electrical system as described in Chapter 6

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

Where used for communications, wiring from switches or sensors that is supervised or protected as required by 517.30(C) (3) of NFPA 70, National Electrical Code, for life safety and critical branches circuits in which protection is any of the following types:

Conduit

Free air

Wire

Cable tray

Raceways

Communication devices that do not use electrical wiring for signal transmission will be supervised such that failure of communication shall initiate an alarm.

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

Provisions for automatic restart after a power loss of 10 seconds (e.g., during generator start-up) without giving false signals or requiring manual reset

Alarm switches/sensors installed so as to be removable

5.1.9.2\* Master Alarms

A master alarm system shall be provided to monitor the operation and condition of the source of supply, the reserve source (if any), and the pressure in the main lines of each medical gas and vacuum piping system.

5.1.9.2.1

The master alarm system shall consist of two or more alarm panels located in at least two separate locations, as follows:

One master alarm panel shall be located in the office or work space of the on-site individual responsible for the maintenance of the medical gas and vacuum piping systems.

In order to ensure continuous surveillance of the medical gas and vacuum systems while the facility is in operation, the second master alarm panel shall be located in an area of continuous observation (e.g., the telephone switchboard, security office, or other continuously staffed location).

5.1.9.2.2

A centralized computer system shall be permitted to be substituted for one of the master alarms required in 5.1.9.2.1 if the computer system complies with 5.1.9.4.

5.1.9.2.3

The master alarm panels required in 5.1.9.2.1 shall communicate directly to the alarm-initiating devices that they monitor.

5.1.9.2.3.1

Each of the two mandatory alarms shall be wired independently to the initiating device(s) for each signal.

5.1.9.2.3.2

The wiring between each mandatory alarm(s) and the initiating device(s) shall not utilize common conductors that, if interrupted, would disable more than one signal.

5.1.9.2.3.3

Each set of wires (in whatever number as required by the alarm) shall run to the initiating device(s) without interruption other than in-line splices necessary to complete the necessary length of wire.

5.1.9.2.3.4

A single initiating device shall be permitted to actuate multiple master alarms.

5.1.9.2.3.5

The mandatory master alarm panels shall not be arranged such that failure of either panel would disable any signal on the other panel.

5.1.9.2.3.6

Where initiating devices are remote from the building and the wiring is to run underground in compliance with NFPA 70, the following exceptions shall be permitted to be used:

Wiring from the initiating device and through the underground section shall be permitted to be run to a junction box located where the wiring first enters the building.

A single set of wires complying with 5.1.9.2.3.2 and 5.1.9.2.3.3 for each signal shall be permitted to connect the initiating device and the junction box.

Between the junction box and the two mandatory alarm panels, wiring shall comply with 5.1.9.2.3.1 through 5.1.9.2.3.5 in all respects.

5.1.9.2.3.7

Where a relay is required to ensure correct operation of an initiating device, the control power for the relay shall not be such that disabling any master alarm panel would disable the relay.

5.1.9.2.3.8

Master alarm signals shall not be relayed from one master alarm panel to another.

5.1.9.2.3.9

Where multi-pole alarm relays are used to isolate the alarm-initiating signals to master alarm panels, the control power source for the relays shall be independent of any of the master alarm panels.

5.1.9.2.3.10

Multiple master alarms shall be permitted to monitor a single initiating device.

5.1.9.2.4

Master alarm panels for medical gas and vacuum systems shall each include the following signals:

Alarm indication when, or just before, changeover occurs in a medical gas system that is supplied by a manifold or other alternating-type bulk system that has as a part of its normal operation a changeover from one portion of the operating supply to another

Alarm indication for a bulk cryogenic liquid system when the main supply reaches an average day's supply, indicating low contents

Alarm indication when, or just before, the changeover to the reserve supply occurs in a medical gas system that consists of one or more units that continuously supply the piping system while another unit remains as the reserve supply and operates only in the case of an emergency

Alarm indication for cylinder reserve pressure low when the content of a cylinder reserve header is reduced below one average day's supply

For bulk cryogenic liquid systems, an alarm when or at a predetermined set point before the reserve supply contents fall to one day's average supply, indicating reserve low

Where a cryogenic liquid storage unit is used as a reserve for a bulk supply system, an alarm indication when the gas pressure available in the reserve unit is below that required for the medical gas system to function

Alarm indication when the pressure in the main line of each separate medical gas system increases 20 percent or decreases 20 percent from the normal operating pressure

Alarm indication when the medical—surgical vacuum pressure in the main line of each vacuum system drops to or below 300 mm (12 in.) gauge HgV

Alarm indication(s) from the local alarm panel(s) as described in 5.1.9.5.2 to indicate when one or more of the conditions being monitored at a site is in alarm

Medical air dew point high alarm from each compressor site to indicate when the line pressure dew point is greater than +2°C (+35°F)

WAGD low alarm when the WAGD vacuum level or flow is below effective operating limits

An instrument air dew point high alarm from each compressor site to indicate when the line pressure dew point is greater than —30°C (—22°F)

Alarm indication if the primary or reserve production stops on a proportioning system

5.1.9.2.5

The alarm indications required in 5.1.9.2.4(7) and 5.1.9.2.4(8) shall originate from sensors installed in the main lines immediately downstream (on the patient or use side) of the source valves. Where it is necessary to install a main line valve in addition to a source valve (see 5.1.4.5), the sensors shall be located downstream (on the patient or use side) of the main valve.

5.1.9.3\* Area Alarms

Area alarm panels shall be provided to monitor all medical gas, medical—surgical vacuum, and piped WAGD systems supplying the following:

Anesthetizing locations where moderate sedation, deep sedation, or general anesthesia is administered

\*Critical care areas

5.1.9.3.1\*

Area alarms shall be located at a nurse's station or other similar location that will provide for surveillance.

5.1.9.3.2

Area alarm panels for medical gas systems shall indicate if the pressure in the lines in the area being monitored increases or decreases by 20 percent from the normal line pressure.

5.1.9.3.3

Area alarm panels for medical—surgical vacuum systems shall indicate if the vacuum in the area drops to or below 300 mm (12 in.) gauge HgV.

5.1.9.3.4

Alarm sensors for area alarms shall be located as follows:

\*Critical care areas shall have the alarm sensors installed on the patient or use side of each individual zone valve box assemblies.

\*Anesthetizing locations where moderate sedation, deep sedation, or general anesthesia is administered shall have the sensors installed either on the source side of any of the individual room zone valve box assemblies or on the patient or use side of each of the individual zone valve box assemblies.

5.1.9.3.5

Area alarm panels for medical gas systems shall provide visual and audible indication in the event a mismatch occurs between the transducer(s) and its associated circuit board(s).

5.1.9.4 Master Alarms by Computer Systems

Computer systems used as substitute master alarms as required by 5.1.9.2.1 (2) shall have the mechanical and electrical characteristics described in 5.1.9.4.1 and the programming characteristics described in 5.1.9.4.2.

5.1.9.4.1

Computer systems used to substitute for alarms shall have the following mechanical and electrical characteristics:

The computer system shall be in continuous uninterrupted operation and provided with power supplies as needed to ensure such reliability.

The computer system shall be continuously attended by responsible individuals or shall provide remote signaling of responsible parties (e.g., through pagers, telephone autodialers, or other such means).

Where computer systems rely on signal interface devices (e.g., electronic interfaces, other alarm panels, 4 mA to 20 mA cards), such interfaces shall be supervised such that failure of the device(s) shall initiate an alarm(s).

If the computer system does not power the signaling switches/sensors from the same power supply required in 5.1.9.4.1(1), the power supply for the signaling switches/sensors shall be powered from the life safety branch of the emergency electrical system as described in Chapter 6.

Computer systems shall be permitted to communicate directly to the sensors/switches in 5.1.9.2.3 in the same manner as an alarm panel if operation of another alarm panel(s) is not impaired.

Communication from the computer system to the signaling switches or sensors shall be supervised such that failure of communication shall initiate an alarm.

Computer systems shall be provided with an audio alert per 5.1.9.1(3), except the audio alert shall be permitted to be only as loud as needed to alert the system operator.

The facility shall ensure compliance with 5.1.9.1(12).

5.1.9.4.2

The operating program(s) for computer systems used to substitute for alarms shall include the following:

Medical gas alarms shall be allocated the priority of a life safety signal.

A medical gas alarm signal shall interrupt any other activity of a lesser priority to run the alarm algorithm(s).

The alarm algorithm shall include activation of an audible alert, activation of any remote signaling protocol, and display of the specific condition in alarm.

The alarm algorithm shall provide for compliance with 5.1.9.1(1), 5.1.9.1(2), 5.1.9.1(3), 5.1.9.1(5), 5.1.9.1(6), and 5.1.9.1(8).

5.1.9.5\* Local Alarms

Local alarms shall be installed to monitor the function of the air compressor system(s), medical—surgical vacuum pump system(s), WAGD systems, instrument air systems, and proportioning systems.

5.1.9.5.1

The signals referenced in 5.1.9.5.4 shall be permitted to be located as follows:

On or in the control panel(s) for the machinery being monitored

Within a monitoring device (e.g., dew point monitor or carbon monoxide monitor)

On a separate alarm panel(s)

5.1.9.5.2

The master alarm shall include at least one signal from the source equipment to indicate a problem with the source equipment at this location. This master alarm signal shall activate when any of the required local alarm signals for this source equipment activates.

5.1.9.5.3

If there is more than one medical air compressor system, instrument air compressor system, WAGD system, medical—surgical vacuum pump system, or proportioning system at different locations in the facility, or if the compressors and vacuum sources are in different locations in the facility, then it shall be necessary for each location to have separate alarms at the master panels.

5.1.9.5.4

The following functions shall be monitored at each local alarm site:

Backup or lag compressor in operation, to indicate when the primary or lead air compressor is incapable of satisfying the demand of the requirements of the system, except when the medical air system consists of three or more compressors, in which case the backup or lag signal is permitted to energize when the last compressor has been signaled to start

High carbon monoxide level, to indicate when the carbon monoxide level in the medical air system is 10 ppm or higher

Medical air dew point high, to indicate when the line pressure dew point is greater than +2°C (+35°F)

Backup or lag vacuum pump in operation, to indicate when the primary or lead vacuum pump is incapable of satisfying the demand of the requirements of the system, except when the vacuum pump system consists of three or more pumps, in which case the backup or lag signal is permitted to energize when the last pump has been signaled to start

When a central dedicated WAGD producer is provided per 5.1.3.8.1.3, WAGD lag in use with the signal to be manually reset

Instrument air dew point high, to indicate when the line pressure dew point is greater than —30°C (—22°F)

For compressor systems using liquid ring compressors or compressors with water-cooled components, high water in the receiver tank, to indicate when the water level in the receiver tank, has reached a level determined to be detrimental to the operation of the system

For compressor systems using liquid ring compressors, high water in the separators

For compressor systems using other than liquid ring compressors, high discharge air temperature

Proportioning systems high/low indicator when the oxygen concentration is outside 19.5 percent to 23.5 percent oxygen

Proportion systems reserve system in operation

5.1.10 Category 1 Distribution

5.1.10.1 Piping Materials for Field-Installed Positive Pressure Medical Gas Systems

5.1.10.1.1

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, except that fittings shall be permitted to be cleaned by a supplier or agency other than the manufacturer.

5.1.10.1.2

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

5.1.10.1.3

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

5.1.10.1.4\*

Tubes shall be hard-drawn seamless copper in accordance with ASTM B 819, Standard Specification for Seamless Copper Tube for Medical Gas Systems, medical gas tube, Type L, except Type K shall be used where operating pressures are above a gauge pressure of 1275 kPa (185 psi) and the pipe sizes are larger than DN80 [NPS 3 (31/8 in. O.D.)].

5.1.10.1.5

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).

5.1.10.1.6

The installer shall furnish documentation certifying that all installed piping materials comply with the requirements of 5.1.10.1.1.

5.1.10.2 Piping Materials for Field-Installed Medical—Surgical Vacuum and WAGD Systems

5.1.10.2.1 Tubes for Vacuum

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

Hard-drawn seamless copper tube in accordance with the following:

ASTM B 88, Standard Specification for Seamless Copper Water Tube, copper tube (Type K, Type L, or Type M)

ASTM B 280, Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service, copper ACR tube

ASTM B 819, Standard Specification for Seamless Copper Tube for Medical Gas Systems, copper medical gas tubing (Type K or Type L)

Stainless steel tube

5.1.10.2.2 Vacuum Tube Marking Where Required

5.1.10.2.2.1

If copper vacuum tubing is installed along with any medical gas tubing, the vacuum tubing shall, prior to installation, be prominently labeled or otherwise identified to preclude using materials or installation procedures in the medical gas system that are not suitable for oxygen service.

5.1.10.2.2.2

If medical gas tube in accordance with ASTM B 819, Standard Specification for Seamless Copper Tube for Medical Gas Systems, is used for vacuum piping, such special marking shall not be required, provided that the vacuum piping installation meets all other requirements for medical gas piping, including the prohibition of flux on copper-to-copper joints and the use of a nitrogen purge while brazing.

5.1.10.2.3 WAGD System Piping

WAGD systems shall be piped as follows:

Using materials compliant with 5.1.10.2.1 or 5.1.10.2.2

In systems operated under 130 mm (5 in.) HgV maximum vacuum only, using any noncorroding tube or ductwork

5.1.10.3 Joints

5.1.10.3.1\*

Positive pressure patient gas systems, medical support gas systems, vacuum systems, and WAGD systems shall have all turns, offsets, and other changes in direction made using fittings or techniques appropriate to any of the following acceptable joining methods:

Brazing, as described in 5.1.10.4

Welding, as described in 5.1.10.5

Memory metal fittings, as described in 5.1.10.6

Axially swaged, elastic preload fittings, as described in 5.1.10.7

Threaded, as described under 5.1.10.8

5.1.10.3.2

Vacuum systems and WAGD systems shall be permitted to have branch connections made using mechanically formed, drilled, and extruded tee-branch connections that are formed in accordance with the tool manufacturer's instructions. Such branch connections shall be joined by brazing, as described in 5.1.10.4.

5.1.10.3.3

WAGD systems designed for operation below 130 mm (5 in.) HgV shall be permitted to be joined using any method that will result in a leak-free network when tested per 5.1.12.3.2.

5.1.10.4 Brazed Joints

5.1.10.4.1 General Requirements

5.1.10.4.1.1

Fittings shall be wrought copper capillary fittings complying with ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings, or brazed fittings complying with ANSI/ASME B16.50, Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.

5.1.10.4.1.2

Cast copper alloy fittings shall not be permitted.

5.1.10.4.1.3

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.

5.1.10.4.1.4

Brazed tube joints shall be the socket type.

5.1.10.4.1.5

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

5.1.10.4.1.6

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

5.1.10.4.1.7

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

5.1.10.4.1.8

Brazing performed between bulk cryogenic liquid vessels and their vaporizers (i.e., subject to cryogenic exposure) shall be permitted to be brazed using BAg brazing alloy with flux by a brazer qualified to CGA M-1, Guide for Medical Gas Installations at Consumer Sites.

5.1.10.4.1.9

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

5.1.10.4.1.10

Braze joints shall be continuously purged with nitrogen NF.

5.1.10.4.2 Cutting Tube Ends

5.1.10.4.2.1

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

5.1.10.4.2.2

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

5.1.10.4.2.3

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

5.1.10.4.3 Cleaning Joints for Brazing

5.1.10.4.3.1

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.

5.1.10.4.3.2

The exterior surfaces of tube ends shall be cleaned prior to brazing to remove any surface oxides.

5.1.10.4.3.3

When cleaning the exterior surfaces of tube ends, no matter shall be allowed to enter the tube.

5.1.10.4.3.4

If the interior surfaces of fitting sockets become contaminated prior to brazing, they shall be recleaned for oxygen in accordance with 5.1.10.4.3.10 and be cleaned for brazing with a clean, oil-free wire brush.

5.1.10.4.3.5

Clean, nonshedding, abrasive pads shall be used to clean the exterior surfaces of the tube ends.

5.1.10.4.3.6

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

5.1.10.4.3.7

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

5.1.10.4.3.8

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

5.1.10.4.3.9

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.

5.1.10.4.3.10

The interior surfaces of tube ends, fittings, and other components that were cleaned for oxygen service by the manufacturer, but that became 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, using a solution of 450 g (1 lb) of sodium carbonate or trisodium phosphate to 11 L (3 gal) of potable water, and thoroughly rinsing them with clean, hot, potable water.

5.1.10.4.3.11

Other aqueous cleaning solutions shall be permitted to be used for on-site recleaning permitted in 5.1.10.4.3.10, provided that they are as recommended in CGA G-4.1, Cleaning Equipment for Oxygen Service, and are listed in CGA 02-DIR, Directory of Cleaning Agents for Oxygen Service.

5.1.10.4.3.12

Material that has become contaminated internally and is not clean for oxygen service shall not be installed.

5.1.10.4.3.13

Joints shall be brazed within 8 hours after the surfaces are cleaned for brazing.

5.1.10.4.4 Brazing Dissimilar Metals

5.1.10.4.4.1

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

5.1.10.4.4.2

Surfaces shall be cleaned for brazing in accordance with 5.1.10.4.3.

5.1.10.4.4.3

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

5.1.10.4.4.4

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.

5.1.10.4.4.5

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.

5.1.10.4.4.6

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.

5.1.10.4.5\* Nitrogen Purge

5.1.10.4.5.1

When brazing, 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.

5.1.10.4.5.2

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

5.1.10.4.5.3

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

5.1.10.4.5.4

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

5.1.10.4.5.5

In order to ensure 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 begins.

5.1.10.4.5.6

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.

5.1.10.4.5.7

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.

5.1.10.4.5.8

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

5.1.10.4.5.9

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.

5.1.10.4.5.10

The final brazed connection of new piping to an existing pipeline containing the system gas shall be permitted to be made without the use of a nitrogen purge.

5.1.10.4.5.11

After a final brazed connection in a positive pressure medical 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 piping shall he tested in accordance with the final tie-in test in 5.1.12.3.9.

5.1.10.4.5.12\*

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.

5.1.10.4.6 Assembling and Heating Brazed Joints

5.1.10.4.6.1

Tube ends shall be inserted into the socket, either fully or to a mechanically limited depth that is not less than the minimum cup depth (overlap) specified by ANSI/ASME B16.50, Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.

5.1.10.4.6.2

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

5.1.10.4.6.3

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.

5.1.10.4.6.4

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.

5.1.10.4.7 Inspection of Brazed Joints

5.1.10.4.7.1

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

5.1.10.4.7.2

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

5.1.10.4.7.3

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

5.1.10.4.7.4

Joints exhibiting the following conditions shall not be permitted:

Flux or flux residue (when flux or flux-coated BAg series rods are used with dissimilar metals)

Base metal melting or erosion

Unmelted filler metal

Failure of the filler metal to be clearly visible all the way around the joint at the interface between the socket and the tube

Cracks in the tube or component

Cracks in the braze filler metal

Failure of the joint to hold the test pressure under the installer-performed initial pressure test (see 5.1.12.2.3) and standing pressure test (see 5.1.12.2.6 or 5.1.12.2.7)

5.1.10.4.7.5

Brazed joints that are identified as defective under the conditions of 5.1.10.4.7.4(2) or (5) shall be replaced.

5.1.10.4.7.6

Brazed joints that are identified as defective under the conditions of 5.1.10.4.7.4(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.

5.1.10.5 Welded Joints

5.1.10.5.1 Gas Tungsten Arc Welding (GTAW) for Copper and Stainless Tube

5.1.10.5.1.1

Welded joints for medical gas and medical—surgical vacuum systems shall be permitted to be made using a gas tungsten arc welding (GTAW) autogenous orbital procedure.

5.1.10.5.1.2

The GTAW autogenous orbital procedure and the welder qualification procedure shall be qualified in accordance with Section IX, "Welding and Brazing Qualifications," of the ASME Boiler and Pressure Vessel Code.

5.1.10.5.1.3

Welder qualification procedures shall include a bend test and a tensile test in accordance with Section IX, "Welding and Brazing Qualifications," of the ASME Boiler and Pressure Vessel Code on each tube size diameter.

5.1.10.5.1.4

Each welder shall qualify to a welding procedure specification (WPS) for each tube diameter.

5.1.10.5.1.5\*

GTAW autogenous orbital welded joints shall be purged during welding with a commercially available mixture of 75 percent helium (±5 percent) and 25 percent argon (+5 percent).

5.1.10.5.1.6

The shield gas shall be as required in 5.1.10.5.1.5.

5.1.10.5.1.7

Test coupons shall be welded and inspected, as a minimum, at start of work and every 4 hours thereafter, or when the machine is idle for more than 30 minutes, and at the end of the work period.

5.1.10.5.1.8

Test coupons shall be inspected on the I.D. and O.D. by a qualified quality control inspector.

5.1.10.5.1.9

Test coupons shall also be welded at change of operator, weld head, welding power supply, or gas source.

5.1.10.5.1.10

All production welds shall be visually inspected on the O.D. by the operator, and any obvious weld failures shall be cut out and re-welded.

5.1.10.5.2 Welding for Stainless Tube

5.1.10.5.2.1

Stainless tube shall be welded using metal inert gas (MIG) welding, tungsten inert gas (TIG) welding, or other welding techniques suited to joining stainless tube.

5.1.10.5.2.2

Welders shall be qualified to Section IX, "Welding and Brazing Qualifications," of the ASME Boiler and Pressure Vessel Code.

5.1.10.6 Memory Metal Fittings

5.1.10.6.1

Memory metal fittings having a temperature rating not less than 538°C (1000°F) and a pressure rating not less than 2070 kPa (300 psi) shall be permitted to be used to join copper or stainless steel tube.

5.1.10.6.2

Memory metal fittings shall be installed by qualified technicians in accordance with the manufacturer's instructions.

5.1.10.7 Axially Swaged Fittings

5.1.10.7.1

Axially swaged, elastic strain preload fittings providing metal-to-metal seals, having a temperature rating not less than 538°C (1000°F) and a pressure rating not less than 2070 kPa (300 psi), and that, when complete, are permanent and nonseparable shall be permitted to be used to join copper or stainless steel tube.

5.1.10.7.2

Axially swaged, elastic strain preload fittings shall be installed by qualified technicians in accordance with the manufacturer's instructions.

5.1.10.8 Threaded Fittings

Threaded fittings shall meet the following criteria:

They shall be limited to connections for pressure and vacuum indicators, alarm devices, check valves, and source equipment on the source side of the source valve.

They shall be tapered pipe threads complying with ASME B1.20.1, Pipe Threads, General Purpose, Inch.

\*They shall be made up with polytetrafluroethylene tape or other thread sealant recommended for oxygen service, with sealant applied to the male threads only and care taken to ensure sealant does not enter the pipe.

5.1.10.9 Special Fittings

5.1.10.9.1

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 shall be permitted to be used.

5.1.10.9.2 Dielectric Fittings

Dielectric fittings that comply with the following shall be permitted only where required by the manufacturer of special medical equipment to electrically isolate the equipment from the system distribution piping:

They shall be of brass or copper construction with an appropriate dielectric.

They shall be permitted to be a union.

They shall be clean for oxygen where used for medical gases and medical support gases.

5.1.10.10 Prohibited Joints

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

Flared and compression-type connections, including connections to station outlets and inlets, alarm devices, and other components

Other straight-threaded connections, including unions

Pipe-crimping tools used to permanently stop the flow of medical gas and vacuum piping

Removable and nonremovable push-fit fittings that employ a quick assembly push fit connector

5.1.10.11 Installation of Piping and Equipment

5.1.10.11.1 Pipe Sizing

5.1.10.11.1.1

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

5.1.10.11.1.2

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

5.1.10.11.1.3

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

5.1.10.11.1.4

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

5.1.10.11.1.5

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.

5.1.10.11.2 Protection of Piping

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

5.1.10.11.2.1

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.

5.1.10.11.2.2

Piping underground within buildings or embedded in concrete floors or walls shall be installed in a continuous conduit.

5.1.10.11.3 Location of Piping

5.1.10.11.3.1

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.

5.1.10.11.3.2

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

Room locations for medical air compressor supply systems and medical—surgical vacuum pump supply systems

Room locations for secondary distribution circuit panels and breakers having a maximum voltage rating of 600 volts

5.1.10.11.3.3

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 is limited to 54°C (130°F) maximum.

5.1.10.11.3.4

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.

5.1.10.11.4 Pipe Support

5.1.10.11.4.1

Piping shall be supported from the building structure.

5.1.10.11.4.2

Hangers and supports shall comply with and be installed in accordance with MSS SP-58, Pipe Hangers and Supports — Materials, Design, Manufacture, Selection, Application, and Installation.

5.1.10.11.4.3

Supports for copper tube shall be sized for copper tube.

5.1.10.11.4.4

In potentially damp locations, copper tube hangers or supports that are in contact with the tube shall be plastic-coated or otherwise be electrically insulated from the tube by a material that will not absorb moisture.

5.1.10.11.4.5

Maximum support spacing shall be in accordance with Table 5.1.10.11.4.5.

Table 5.1.10.11.4.5 Maximum Pipe Support Spacing

Pipe Size Hanger Spacing

mm ft

DN8 (NPS 1/4) (3/8 in. O.D.) 1520 5

DN10 (NPS 3/8) (1/2 in. O.D.) 1830 6

DN15 (NPS 1/2) (5/8 in. O.D) 1830 6

DN20 (NPS 3/4) (7/8 in. O.D.) 2130 7

DN25 (NPS 1) (11/8 in. O.D.) 2440 8

DN32 (NPS 11/4) (13/8 in. O.D.) 2740 9

DN40 (NPS 11/2) (15/8 in. O.D.) and larger 3050 10

Vertical risers, all sizes, every floor, but not to exceed 4570 15

5.1.10.11.4.6

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

5.1.10.11.5 Underground Piping Outside of Buildings

5.1.10.11.5.1

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

5.1.10.11.5.2

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

5.1.10.11.5.3

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

Access shall be provided at the joints for visual inspection and leak testing.

The conduit, cover, or enclosure shall be self-draining and not retain groundwater in prolonged contact with the pipe.

5.1.10.11.5.4

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

5.1.10.11.5.5

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 there is no potential for damage from surface loads or surface conditions.

5.1.10.11.5.6

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

5.1.10.11.5.7

Backfill shall be clean, free from material that can damage the pipe, and compacted.

5.1.10.11.5.8

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

5.1.10.11.5.9

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

5.1.10.11.5.10

Where underground piping is installed through a wall sleeve, the outdoor end of the sleeve shall be sealed to prevent the entrance of groundwater into the building.

5.1.10.11.6 Hose and Flexible Connectors

5.1.10.11.6.1

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.

5.1.10.11.6.2

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

5.1.10.11.6.3

Metallic flexible joints shall be permitted in the pipeline where required for expansion joints, seismic protection, thermal expansion, or vibration control and shall be as follows:

For all wetted surfaces, made of bronze, copper, or stainless steel

Cleaned at the factory for oxygen service and received on the job site with certification of cleanliness

Suitable for service at 2070 kPa (300 psig) or above and able to withstand temperatures of 538°C (1000°F)

Provided with brazing extensions to allow brazing into the pipeline per 5.1.10.5

Supported with pipe hangers and supports as required for their additional weight

5.1.10.11.7 Prohibited System Interconnections

5.1.10.11.7.1

Two or more medical gas or vacuum piping systems shall not be interconnected for installation, testing, or any other reason.

5.1.10.11.7.2

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

5.1.10.11.8 Manufacturer's Instructions

5.1.10.11.8.1

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

5.1.10.11.8.2

Manufacturer's 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.

5.1.10.11.8.3

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

5.1.10.11.9 Changes in System Use

5.1.10.11.9.1

Where a positive pressure medical gas piping distribution system originally used or constructed for use at one pressure and for one gas is converted for operation at another pressure or for another gas, all provisions of 5.1.10 shall apply as if the system were new.

5.1.10.11.9.2

A vacuum system shall not be permitted to be converted for use as a gas system.

5.1.10.11.10 Qualification of Installers

5.1.10.11.10.1

The installation of medical gas and vacuum systems shall be made by qualified, competent technicians who are experienced in performing such installations, including all personnel who actually install the piping system.

5.1.10.11.10.2

Installers of medical gas and vacuum piped distribution systems, all appurtenant piping supporting pump and compressor source systems, and appurtenant piping supporting source gas manifold systems not including permanently installed bulk source systems, shall be certified in accordance with ASSE 6010, Professional Qualification Standard for Medical Gas Systems Installers.

5.1.10.11.10.3

Installers of medical gas and vacuum systems shall not use their certification to oversee installation by non-certified personnel.

5.1.10.11.10.4

Brazing shall be performed by individuals who are qualified in accordance with the provisions of 5.1.10.11.11.

5.1.10.11.10.5

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 is required under 5.1.10.11.11.

5.1.10.11.10.6

Health care organization personnel shall be permitted to install piping systems if all of the requirements of 5.1.10.11.10 are met during the installation.

5.1.10.11.11 Qualification of Brazing Procedures and Brazing

5.1.10.11.11.1

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 Qualification, both as modified by 5.1.10.11.11.2 through 5.1.10.11.11.5.

5.1.10.11.11.2

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

5.1.10.11.11.3

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

5.1.10.11.11.4

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 absence of internal oxidation in the completed coupon.

5.1.10.11.11.5

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 records meet the requirements of this code.

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.

The employer qualifies at least one brazer following each brazing procedure specification used.

5.1.10.11.11.6

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

The brazer has been qualified following the same or an equivalent procedure that the new employer uses.

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.

5.1.10.11.11.7

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.

5.1.10.11.12 Breaching or Penetrating Medical Gas Piping

5.1.10.11.12.1

Positive pressure patient medical gas piping and medical support gas piping shall not be breached or penetrated by any means or process that will result in residual copper particles or other debris remaining in the piping or affect the oxygen-clean interior of the piping.

5.1.10.11.12.2

The breaching or penetrating process shall ensure that any debris created by the process remains contained within the work area.

5.1.11\* Labeling and Identification

Color and pressure requirements shall be in accordance with Table 5.1.11.

5.1.11.1 Pipe Labeling

5.1.11.1.1

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

Name of the gas or vacuum system or the chemical symbol per Table 5.1.11

Gas or vacuum system color code per Table 5.1.11

Where positive pressure gas piping systems operate at pressures other than the standard gauge pressure in Table 5.1.11, the operating pressure in addition to the name of the gas

5.1.11.1.2

Pipe labels shall be located as follows:

At intervals of not more than 6.1 m (20 ft)

At least once in or above every room

On both sides of walls or partitions penetrated by the piping

At least once in every story height traversed by risers

5.1.11.1.3

Medical gas piping shall not be painted.

5.1.11.2 Shutoff Valves

5.1.11.2.1

Shutoff valves shall be identified with the following:

Name or chemical symbol for the specific medical gas or vacuum system

Room or areas served

Caution to not close or open the valve except in emergency

5.1.11.2.2

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 a gauge pressure of 1100 kPa to 1275 kPa (160 psi to 185 psi) for nitrogen or instrument air, the valve identification shall also include the nonstandard operating pressure.

5.1.11.2.3

Source valves shall be labeled in substance as follows:

SOURCE VALVE

FOR THE (SOURCE NAME).

5.1.11.2.4

Main line valves shall be labeled in substance as follows:

MAIN LINE VALVE FOR THE (GAS/VACUUM

NAME) SERVING (NAME OF THE BUILDING).

Table 5.1.11 Standard Designation Colors and Operating Pressures for Gas and Vacuum Systems

Gas Service Abbreviated Name Colors (Background/Text) Standard Gauge Pressure

kPa psi

Medical air Med air Yellow/black 345—380 50—55

Carbon dioxide CO2 Gray/black or gray/white 345—380 50—55

Helium He Brown/white 345—380 50—55

Nitrogen N2 Black/white 1100—1275 160—185

Nitrous oxide N2O Blue/white 345—380 50—55

Oxygen O2 Green/white or white/green 345—380 50—55

Oxygen/carbon dioxide mixtures O2/CO2 n%

(n = % of CO2) Green/white 345—380 50—55

Medical—surgical vacuum Med vac White/black 380 mm to 760 mm (15 in. to 30 in.) HgV

Waste anesthetic gas disposal WAGD Violet/white Varies with system type

Other mixtures Gas A%/Gas B% Colors as above None

Major gas for

background/minor gas for text

Nonmedical air (Category 3 gas-powered device) Yellow and white diagonal

stripe/black None

Nonmedical and Category 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 1100—1275 160—185

5.1.11.2.5

The 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).

5.1.11.2.6

The 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).

5.1.11.3 Station Outlets and Inlets

5.1.11.3.1

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

5.1.11.3.2

Where medical gas systems operate at pressures other than the standard gauge pressure of 345 kPa to 380 kPa (50 psi to 55 psi) or a 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 in addition to the name of the gas.

5.1.11.4 Alarm Panels

Labeling of alarm panels shall comply with the requirements of 5.1.9.1(6) and (7).

5.1.12\* Performance Criteria and Testing — Category 1 (Gases, Medical—Surgical Vacuum, and WAGD)

5.1.12.1 General

5.1.12.1.1

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

5.1.12.1.2

Inspection and testing shall include all components of the system, or portions thereof, including, but not limited to, gas bulk source(s); manifolds; compressed air source systems (e.g., compressors, dryers, filters, regulators); source alarms and monitoring safeguards; master alarms; pipelines; isolation valves; area alarms; zone valves; and station inlets (vacuum) and outlets (pressure gases).

5.1.12.1.3

All 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 tested.

5.1.12.1.4

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

5.1.12.1.5

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.

5.1.12.1.6

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 facility authority and any others that are required.

5.1.12.1.7

Reports shall contain detailed listings of all findings and results.

5.1.12.1.8

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

5.1.12.1.9

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

5.1.12.1.10

Before piping systems are initially put into use, the facility authority shall be responsible for ascertaining that the gas/vacuum delivered at the outlet/inlet is that shown on the outlet/inlet label and that the proper connecting fittings are installed for the specific gas/vacuum service.

5.1.12.1.11

Acceptance of the verifier's report shall be permitted to satisfy the requirements in 5.1.12.1.10.

5.1.12.1.12

The removal of components within a source system for repair and reinstallation, or the replacement of components like for like, shall be treated as new work for the purposes of testing whenever such work involves cutting or brazing new piping, or both.

5.1.12.1.12.1

Where no piping is changed, functional testing shall be performed as follows:

To verify the function of the replaced device

To ensure no other equipment in the system has been adversely impacted

5.1.12.1.12.2

Where no piping is changed, in addition to tests of general function required by 5.1.12.1.12.1, testing shall be performed as follows:

Pressure gas sources shall be tested for compliance with 5.1.12.3.14.2 as applicable to the equipment type.

Medical air and instrument air sources shall be tested to 5.1.12.3.14.3.

Vacuum and WAGD systems shall be tested to 5.1.12.3.14.5.

Alarm systems shall be tested to 5.1.12.3.5.2 and 5.1.12.3.5.3.

All affected components shall be tested as appropriate to that specific component (e.g., a replaced dew point monitor would be tested to 5.1.3.6.3.14).

5.1.12.2 Installer-Performed Tests

5.1.12.2.1 General

5.1.12.2.1.1

The tests required by 5.1.12.2 shall be performed and documented by the installer prior to the tests listed in 5.1.12.3.

5.1.12.2.1.2

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

5.1.12.2.1.3

Where manufactured assemblies are to be installed, the tests required by 5.1.12.2 shall be performed as follows:

After completion of the distribution piping, but before the standing pressure test

Prior to installation of manufactured assemblies supplied through flexible hose or flexible tubing

At all station outlets/inlets on installed manufactured assemblies supplied through copper tubing

5.1.12.2.2 Initial Piping Blow Down

Piping in medical gas and vacuum distribution systems shall be blown clear by means of oil-free, dry nitrogen NF after installation of the distribution piping but before installation of station outlet/inlet rough-in assemblies and other system components (e.g., pressure/vacuum alarm devices, pressure/vacuum indicators, pressure relief valves, manifolds, source equipment).

5.1.12.2.3 Initial Pressure Test

5.1.12.2.3.1

Each section of the piping in medical gas and vacuum systems shall be pressure tested.

5.1.12.2.3.2

Initial pressure tests shall be conducted as follows:

After blow down of the distribution piping

After installation of station outlet/inlet rough-in assemblies

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)

5.1.12.2.3.3

The source shutoff valve shall remain closed during the tests specified in 5.1.12.2.3.

5.1.12.2.3.4

The test pressure for pressure gases and vacuum systems shall be 1.5 times the system working pressure but not less than a gauge pressure of 1035 kPa (150 psi).

5.1.12.2.3.5\*

The test pressure shall be maintained until each joint has been examined for leakage by means of a leak detectant that is safe for use with oxygen and does not contain ammonia.

5.1.12.2.3.6

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

5.1.12.2.4 Initial Cross-Connection Test

It shall be determined that no cross-connections exist between the various medical gas and vacuum piping systems.

5.1.12.2.4.1

All piping systems shall be reduced to atmospheric pressure.

5.1.12.2.4.2

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

5.1.12.2.4.3

The system under test shall be charged with oil-free, dry nitrogen NF to a gauge pressure of 345 kPa (50 psi).

5.1.12.2.4.4

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.

5.1.12.2.4.5

The cross-connection test referenced in 5.1.12.2.4 shall be repeated for each installed medical gas and vacuum piping system.

5.1.12.2.4.6

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

5.1.12.2.5 Initial Piping Purge Test

The outlets in each medical gas piping system shall be purged to remove any particulate matter from the distribution piping.

5.1.12.2.5.1

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.

5.1.12.2.5.2

The purging required in 5.1.12.2.5.1 shall be started at the closest outlet/inlet to the zone valve and continue to the furthest outlet/inlet within the zone.

5.1.12.2.6 Standing Pressure Test for Positive Pressure Medical Gas Piping

After successful completion of the initial pressure tests under 5.1.12.2.3, medical gas distribution piping shall be subject to a standing pressure test.

5.1.12.2.6.1

Tests shall be conducted after the final installation of station outlet valve bodies, faceplates, and other distribution system components (e.g., pressure alarm devices, pressure indicators, line pressure relief valves, manufactured assemblies, hose).

5.1.12.2.6.2

The source valve shall be closed during this test.

5.1.12.2.6.3

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

5.1.12.2.6.4

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

5.1.12.2.6.5\*

At the conclusion of the tests, there shall be no change in the test pressure except that attributed to specific changes in ambient temperature.

5.1.12.2.6.6

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

5.1.12.2.6.7

The 24-hour standing pressure test of the positive pressure system shall be witnessed by the authority having jurisdiction or its designee. A form indicating that this test has been performed and witnessed shall be provided to the verifier at the start of the tests required in 5.1.12.3.

5.1.12.2.7 Standing Vacuum Test for Vacuum Piping

After successful completion of the initial pressure tests under 5.1.12.2.3, vacuum distribution piping shall be subjected to a standing vacuum test.

5.1.12.2.7.1

Tests shall be conducted after installation of all components of the vacuum system.

5.1.12.2.7.2

The piping systems shall be subjected to a 24-hour standing vacuum test.

5.1.12.2.7.3

Test pressure shall be between 300 mm (12 in.) HgV and full vacuum.

5.1.12.2.7.4

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

5.1.12.2.7.5\*

At the conclusion of the test, there shall be no change in the vacuum other than that attributed to changes of ambient temperature.

5.1.12.2.7.6

The 24-hour standing pressure test of the vacuum system shall be witnessed by the authority having jurisdiction or its designee. A form indicating that this test has been performed and witnessed shall be provided to the verifier at the start of the tests required in 5.1.12.3.

5.1.12.2.7.7

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

5.1.12.3 System Verification

5.1.12.3.1 General

5.1.12.3.1.1

Verification tests shall be performed only after all tests required in 5.1.12.2, Installer Performed Tests, have been completed.

5.1.12.3.1.2

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

5.1.12.3.1.3

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 6030, Professional Qualifications Standard for Medical Gas Systems Verifiers.

5.1.12.3.1.4

Testing shall be performed by a party other than the installing contractor.

5.1.12.3.1.5

When systems have not been installed by in-house personnel, testing shall be permitted by personnel of that organization who meet the requirements of 5.1.12.3.1.3.

5.1.12.3.1.6

All tests required under 5.1.12.3 shall be performed after installation of any manufactured assemblies supplied through flexible hose or tubing.

5.1.12.3.1.7

Where there are multiple possible connection points for terminals, each possible position shall be tested independently.

5.1.12.3.1.8

The gas of system designation shall be permitted to be used for all tests, regardless of the size of the system, which include the following:

Standing pressure (see 5.1.12.3.2)

Cross-connection (see 5.1.12.3.3)

Alarms (see 5.1.12.3.5)

Piping purge (see 5.1.12.3.6)

Piping particulates (see 5.1.12.3.7)

5.1.12.3.2\* Standing Pressure Test

Piping systems shall be subjected to a 10-minute standing pressure test at operating line pressure using the following procedure:

After the system is filled with nitrogen or source gas, the source valve and all zone valves shall be closed.

The piping system shall show no decrease in pressure after 10 minutes.

Any leaks found shall be located, repaired, and retested per 5.1.12.2.6.

5.1.12.3.3 Cross-Connection Test

After the closing of walls and completion of the requirements of 5.1.12.2, it shall be determined that no cross-connection of piping systems exists by either of the methods detailed in 5.1.12.3.3.1 or 5.1.12.3.3.2.

5.1.12.3.3.1 Individual Pressurization Method

(A)

All medical gas and vacuum piping systems shall be reduced to atmospheric pressure.

(B)

All sources of test gas from all of the medical gas and vacuum systems, with the exception of the one system to be checked, shall be disconnected.

(C)

The system being checked shall be pressurized to a gauge pressure of 345 kPa (50 psi).

(D)

With adapters matching outlet labels, each individual station outlet/inlet of all medical gas and vacuum systems installed shall be checked to determine that test gas is being dispensed only from the outlets/inlets of the piping system being tested.

(E)

The source of test gas shall be disconnected, and the system tested reduced to atmospheric pressure.

(F)

Proceed to test each additional piping system until all medical gas and vacuum piping systems are free of cross-connections.

5.1.12.3.3.2 Pressure Differential Method

(A)

The pressure in all medical gas systems shall be reduced to atmospheric.

(B)

The test gas pressure in all medical gas piping systems shall be increased to the values indicated in Table 5.1.12.3.3.2(B), simultaneously maintaining these nominal pressures throughout the test.

Table 5.1.12.3.3.2(B) Alternate Test Pressures

Medical Gas Pressure (Gauge)

Gas mixtures 140 kPa (20 psi)

Nitrogen/instrument air 210 kPa (30 psi)

Nitrous oxide 275 kPa (40 psi)

Oxygen 345 kPa (50 psi)

Medical air 415 kPa (60 psi)

Systems at nonstandard pressures 70 kPa (10 psi) greater or less than any other system HgV vacuum

Vacuum 510 mm (20 in.) HgV

WAGD 380 mm (15 in.) HgV (if so designed)

(C)

Systems with nonstandard operating pressures shall be tested at a gauge pressure of at least 70 kPa (10 psi) higher or lower than any other system being tested.

(D)

Any vacuum systems shall be in operation so that these vacuum systems are tested at the same time the medical gas systems are tested.

(E)

Following the adjustment of pressures in accordance with 5.1.12.3.3.2(B) and 5.1.12.3.3.2(C), each station outlet for each medical gas system shall be tested using the gas-specific connection for each system with test gauge attached to verify that the correct test pressure/vacuum is present at each outlet/inlet of each system as listed in Table 5.1.12.3.3.2(B).

(F)

Each test gauge used in performing this test shall be calibrated with the pressure indicator used for the line pressure regulator used to provide the source pressure.

(G)

Each station outlet shall be identified by label (and color marking, if used), and the pressure indicated on the test gauge shall be that listed in Table 5.1.12.3.3.2(B) for the system being tested.

5.1.12.3.4 Valve Test

Valves installed in each medical gas and vacuum piping system shall be tested to verify proper operation and rooms or areas of control.

5.1.12.3.4.1

Records shall be made listing the rooms or areas controlled by each valve for each gas.

5.1.12.3.4.2

The information shall be utilized to assist and verify the proper labeling of the valves.

5.1.12.3.5 Alarm Test

5.1.12.3.5.1 General

(A)

All warning systems for each medical gas and vacuum system(s) shall be tested to ensure that all components function properly prior to placing the system in service.

(B)

Permanent records of these tests shall be maintained.

(C)

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

(D)

Tests of warning systems for new installations (initial tests) shall be performed after the cross-connection testing (see 5.1.12.3.3), but before purging the piping (see 5.1.12.3.6) and performing the remaining verification tests. (See 5.1.12.3.7 through 5.1.12.3.14.)

(E)

Initial tests of warning systems that can be included in an addition or extension to an existing piping system shall be completed before connection of the addition to the existing system.

(F)

Test gases for the initial tests shall be oil-free, dry nitrogen NF, the gas of system designation, or operating vacuum.

(G)

Where computer systems are used as substitutes for a required alarm panel as permitted under 5.1.9.2.2, the computer system shall be included in the alarm tests as modified in 5.1.9.4.

5.1.12.3.5.2 Master Alarms

(A)

The master alarm system tests shall be performed for each of the medical gas and vacuum piping systems.

(B)

Permanent records of these tests shall be maintained with those required under 5.1.12.1.7.

(C)

The audible and noncancelable visual signals of 5.1.9.1 shall indicate if the pressure in the main line increases or decreases 20 percent from the normal operating pressure.

(D)

The operation of all master alarm signals referenced in 5.1.9.2.4 shall be verified.

5.1.12.3.5.3 Area Alarms

The warning signals for all medical gas piping systems shall be tested to verify an alarm condition if the pressure in the piping system increases or decreases 20 percent from the normal operating pressure for positive pressure gases, or when the vacuum system(s) drops below a gauge pressure of 300 mm (12 in.) HgV.

5.1.12.3.6 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 the pipeline shall be done.

5.1.12.3.6.1

The appropriate adapter shall be obtained from the facility or manufacturer, and high purge rates of at least 225 Nl/min (8 SCFM) shall be put on each outlet.

5.1.12.3.6.2

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.

5.1.12.3.6.3

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

5.1.12.3.7 Piping Particulate Test

For each positive pressure gas system, the cleanliness of the piping system shall be verified.

5.1.12.3.7.1

A minimum of 1000 L (35 ft3) of gas shall be filtered through a clean, white 0.45 micron filter at a minimum flow rate of 100 Nl/min (3.5 SCFM).

5.1.12.3.7.2

Twenty-five percent of the zones shall be tested at the outlet most remote from the source.

5.1.12.3.7.3

The filter shall accrue no more than 0.001 g (1 mg) of matter from any outlet tested.

5.1.12.3.7.4

If any outlet fails this test, the most remote outlet in every zone shall be tested.

5.1.12.3.7.5

The test shall be performed with the use of oil-free, dry nitrogen NF.

5.1.12.3.8\* Verifier Piping Purity Test

For each medical gas system, the purity of the piping system shall be verified in accordance with 5.1.12.3.8.

5.1.12.3.8.1

These tests shall be performed with oil-free, dry nitrogen NF or the system gas.

5.1.12.3.8.2

The outlet most remote from the source shall be tested for total non-methane hydrocarbons and compared to the source gas.

5.1.12.3.8.3

If the system gas is used as the source gas, it shall be tested at the source equipment.

5.1.12.3.8.4

The difference between the two tests shall in no case exceed 5 ppm of total non-methane hydrocarbons.

5.1.12.3.8.5

The difference between the two tests shall in no case exceed 5 ppm halogenated hydrocarbons.

5.1.12.3.8.6

The moisture concentration of the outlet test shall not exceed 500 ppm or an equivalent pressure dew point of —12°C (10°F) at a gauge pressure of 345 kPa (50 psi).

5.1.12.3.9 Final Tie-in Test

5.1.12.3.9.1

Prior to the connection of any work or any extension or addition to an existing piping system, the tests in 5.1.12.3.1 through 5.1.12.3.8 shall be successfully performed on the new work.

5.1.12.3.9.2

Each joint in the final connection between the new work and the existing system shall be leak-tested with the gas of system designation at the normal operating pressure by means of a leak detectant that is safe for use with oxygen and does not contain ammonia.

5.1.12.3.9.3

Vacuum joints shall be tested using an ultrasonic leak detector or other means that will allow detection of leaks in an active vacuum system.

5.1.12.3.9.4

For pressure gases, immediately after the final brazed connection is made and leak-tested, an outlet in the new piping and an outlet in the existing piping that are immediately downstream from the point or area of intrusion shall be purged in accordance with the applicable requirements of 5.1.12.3.6.

5.1.12.3.9.5

Before the new work is used for patient care, positive pressure gases shall be tested for operational pressure and gas concentration in accordance with 5.1.12.3.10 and 5.1.12.3.11.

5.1.12.3.9.6

Permanent records of these tests shall be maintained in accordance with 5.1.14.4.

5.1.12.3.10 Operational Pressure Test

Operational pressure tests shall be performed at each station outlet/inlet or terminal where the user makes connections and disconnections.

5.1.12.3.10.1

Tests shall be performed with the gas of system designation or the operating vacuum.

5.1.12.3.10.2

All gas outlets with a gauge pressure of 345 kPa (50 psi), including, but not limited to, oxygen, nitrous oxide, medical air, and carbon dioxide, shall deliver 100 SLPM (3.5 SCFM) with a pressure drop of not more than 35 kPa (5 psi) and static pressure of 345 kPa to 380 kPa (50 psi to 55 psi).

5.1.12.3.10.3

Support gas outlets shall deliver 140 SLPM (5.0 SCFM) with a pressure drop of not more than 35 kPa (5 psi) gauge and static pressure of 1100 kPa to 1275 kPa (160 psi to 185 psi) gauge.

5.1.12.3.10.4

Medical—surgical vacuum inlets shall draw 85 Nl/min (3 SCFM) without reducing the vacuum pressure below 300 mm (12 in.) gauge HgV at any adjacent station inlet.

5.1.12.3.10.5

Oxygen and medical air outlets serving critical care areas shall allow a transient flow rate of 170 SLPM (6 SCFM) for 3 seconds.

5.1.12.3.11 Medical Gas Concentration Test

After purging each system with the gas of system designation, the following shall be performed:

Each pressure gas source and outlet shall be analyzed for concentration of gas, by volume.

Analysis shall be conducted with instruments designed to measure the specific gas dispensed.

\*Allowable concentrations shall be as indicated in Table 5.1.12.3.11.

Table 5.1.12.3.11 Gas Concentrations

Medical Gas Concentration

Oxygen ≥99% oxygen

Nitrous oxide ≥99% nitrous oxide

Nitrogen ≤1% oxygen or ≥99% nitrogen

Medical air 19.5%—23.5% oxygen

Other gases As specified by ±1%, unless otherwise specified

5.1.12.3.12 Medical Air Purity Test for Compressor Sources

5.1.12.3.12.1

The medical air source shall be analyzed for concentration of contaminants by volume prior to the source valve being opened.

5.1.12.3.12.2

A sample(s) shall be taken for the air system test at the system sample port.

5.1.12.3.12.3

The test results shall not exceed the parameters in Table 5.1.12.3.12.3.

Table 5.1.12.3.12.3 Contaminant Parameters for Medical Air

Parameter Limit Value

Pressure dew point 2°C (35°F)

Carbon monoxide 10 ppm

Carbon dioxide 500 ppm

Gaseous hydrocarbons 25 ppm (as methane)

Halogenated hydrocarbons 2 ppm

5.1.12.3.13 Labeling

The presence and correctness of labeling required by this code for all components (e.g., station outlets/inlets, shutoff valves, and alarm panels) shall be verified.

5.1.12.3.14 Source Equipment Verification

5.1.12.3.14.1 General

Source equipment verification shall be performed following the installation of the interconnecting pipelines, accessories, and source equipment.

5.1.12.3.14.2 Gas Supply Sources

(A)

The system apparatus shall be tested for proper function, including the changeover from primary to secondary supply (with its changeover signal) and the operation of the reserve (with its reserve-in-use signal), before the system is put into service.

(B)

If the system has an actuating switch and signal to monitor the contents of the reserve, its function shall be tested before the system is put into service.

(C)

If the system has an actuating switch and signal to monitor the pressure of the reserve unit, its function shall be tested before the system is put into service.

(D)

Testing of the bulk supply signal and the master signal panel installations shall be arranged with the owner or the organization responsible for the operation and maintenance of the supply system for the testing of the bulk supply signals to ensure proper identification and activation of the master signal panels so that the facility can monitor the status of that supply system.

(E)

The tests required in 5.1.12.3.14.2(D) shall also be conducted when the storage units are changed or replaced.

5.1.12.3.14.3 Medical Air Compressor Systems

(A)

Tests of the medical air compressor system shall include the purity test for air quality, and the test of the alarm sensors after calibration and setup per the manufacturer's instructions, as well as lead-lag controls.

(B)

Tests shall be conducted at the sample port of the medical air system.

(C)

The operation of the system control sensors, such as dew point, air temperature, and all other air quality monitoring sensors and controls, shall be checked for proper operation and function before the system is put into service.

(D)

The quality of medical air as delivered by the compressor air supply shall be verified after installation of new components prior to use by patients.

(E)

The air quality tests in 5.1.12.3.14.3(D) shall be conducted after the medical air source system has been operating normally but with the source valve closed under a simulated load for an elapsed time of at least 12 hours.

(F)

The aggregate run time on the compressors shall not be used to determine the elapsed time.

(G)

Loading shall be simulated by continuously venting air at approximately 25 percent of the rated system capacity.

(H)

A demand of approximately 25 percent of the rated compressor capacity shall be created to cause the compressors to cycle on and off continuously and the dryers to operate for the 24-hour period.

5.1.12.3.14.4 Proportioning Systems for Medical Air USP

(A)

The system apparatus shall be tested for proper function, including the changeover from primary to secondary (if applicable) and operation of the reserve, before the system is put into service.

(B)

Tests shall include the purity of the air quality and test of the alarm sensors after calibration and setup per the manufacturer's instructions.

(C)

Tests shall be conducted at the sample port of the proportioning system.

(D)

The operation of the control sensors and all quality monitoring sensors and controls shall be checked for proper operation and function before the system is put into service.

5.1.12.3.14.5 Medical—Surgical Vacuum Systems

The proper functioning of the medical—surgical vacuum source system(s) shall be tested before it is put into service.

5.1.13 Category 1 Support Gases

5.1.13.1\* Nature of Hazards Support Gas System

5.1.13.2 Sources

Requirements for support gas sources shall be in accordance with the following:

Paragraphs 5.1.3.1 through 5.1.3.5 for nitrogen

Paragraph 5.1.3.9 for instrument air

5.1.13.3 Valves

Requirements for support gas valves shall be in accordance with 5.1.4.1 through 5.1.4.10.

5.1.13.4 Outlets

5.1.13.4.1

Requirements for nitrogen support gas outlets shall be in accordance with 5.1.5.1, 5.1.5.2, 5.1.5.4 through 5.1.5.8, 5.1.5.11, and 5.1.5.13 through 5.1.5.15.

5.1.13.4.2

Requirements for other support gas outlets shall be in accordance with 5.1.5.1, 5.1.5.2, 5.1.5.4, 5.1.5.5, 5.1.5.7, 5.1.5.8, 5.1.5.11, and 5.1.5.13 through 5.1.5.15.

5.1.13.5 Manufactured Assemblies

Requirements for support gases in manufactured assemblies shall be in accordance with 5.1.6.1 through 5.1.6.9.

5.1.13.6 Pressure Indicators

Requirements for support gas pressure indicators shall be in accordance with 5.1.8.1.1 through 5.1.8.1.4, 5.1.8.1.6, 5.1.8.1.7, and 5.1.8.2.

5.1.13.7 Warning Systems

5.1.13.7.1

General requirements for support gas warning systems shall be in accordance with 5.1.9.1.

5.1.13.7.2

Master alarm requirements for support gas shall be in accordance with 5.1.9.2.

5.1.13.7.3

Area alarm requirements for support gas shall be in accordance with 5.1.9.3.

5.1.13.7.4

Local alarm requirements for support gas shall be in accordance with 5.1.9.4.

5.1.13.8 Distribution

Requirements for support gas piping distribution shall be in accordance with 5.1.10.1, 5.1.10.3, 5.1.10.4, 5.1.10.4.1 through 5.1.10.4.6, 5.1.10.9, 5.1.10.9(1), 5.1.10.9(2), 5.1.10.9(3), and 5.1.10.11.

5.1.13.9 Labeling and Identification

Requirements for support gas labeling shall be in accordance with 5.1.11.1 through 5.1.11.4.

5.1.13.10 Performance Testing

Requirements for support gas performance testing shall be in accordance with 5.1.12, with the following exceptions:

The piping purity test (see 5.1.12.3.8) shall be permitted to be omitted.

The medical gas concentration test (see 5.1.12.3.11) shall be permitted to be omitted.

5.1.14\* Category 1 Operation and Management

5.1.14.1 Special Precautions — Patient Gas, Vacuum, WAGD, and Medical Support Gas Systems

5.1.14.1.1\*

Piping systems shall not be used for the distribution of flammable anesthetic gases.

5.1.14.1.2

Piping systems shall not be used as a grounding electrode.

5.1.14.1.3\*

Liquid or debris shall not be introduced into the medical—surgical vacuum or WAGD systems for disposal.

5.1.14.1.4\*

The medical—surgical vacuum and WAGD systems shall not be used for nonmedical applications (e.g., vacuum steam condensate return).

5.1.14.2 Maintenance of Medical Gas, Vacuum, WAGD, and Medical Support Gas Systems

5.1.14.2.1\* General

Health care facilities with installed medical gas, vacuum, WAGD, or medical support gas systems, or combinations thereof, shall develop and document periodic maintenance programs for these systems and their subcomponents as appropriate to the equipment installed.

5.1.14.2.2 Maintenance Programs

5.1.14.2.2.1 Inventories

Inventories of medical gas, vacuum, WAGD, and medical support gas systems shall include at least all source subsystems, control valves, alarms, manufactured assemblies containing patient gases, and outlets.

5.1.14.2.2.2\* Inspection Schedules

Scheduled inspections for equipment and procedures shall be established through the risk assessment of the facility and developed with consideration of the original equipment manufacturer recommendations and other recommendations as required by the authority having jurisdiction.

5.1.14.2.2.3 Inspection Procedures

The facility shall be permitted to use any inspection procedure(s) or testing methods established through its own risk assessment.

5.1.14.2.2.4 Maintenance Schedules

Scheduled maintenance for equipment and procedures shall be established through the risk assessment of the facility and developed with consideration of the original equipment manufacturer recommendations and other recommendations as required by the authority having jurisdiction.

5.1.14.2.2.5 Qualifications

Persons maintaining these systems shall be qualified to perform these operations. Appropriate qualification shall be demonstrated by any of the following:

Training and certification through the health care facility by which such persons are employed to work with specific equipment as installed in that facility

Credentialing to the requirements of ASSE 6040, Professional Qualification Standard for Medical Gas Maintenance Personnel

Credentialing to the requirements of ASSE 6030, Professional Qualification Standard for Medical Gas Systems Verifiers

5.1.14.2.3 Inspection and Testing Operations

5.1.14.2.3.1 General

The elements in 5.1.14.2.2.2 through 5.1.15 shall be inspected or tested as part of the maintenance program as follows:

\*Medical air source, as follows:

Room temperature

Shaft seal condition

Filter condition

Presence of hydrocarbons

Room ventilation

Water quality, if so equipped

Intake location

Carbon monoxide monitor calibration

Air purity

Dew point

\*Medical vacuum source — exhaust location

WAGD source — exhaust location

\*Instrument air source — filter condition

\*Manifold sources (including systems complying with 5.1.3.5.10, 5.1.3.5.11, 5.1.3.5.12, and 5.1.3.5.13), as follows:

Ventilation

Enclosure labeling

Bulk cryogenic liquid source inspected in accordance with NFPA 55, Compressed Gases and Cryogenic Fluids Code

Final line regulation for all positive pressure systems — delivery pressure

\*Valves — labeling

\*Alarms and warning systems — lamp and audio operation

Alarms and warning systems, as follows:

Master alarm signal operation

Area alarm signal operation

Local alarm signal operation

\*Station outlets/inlets, as follows:

Flow

Labeling

Latching/delatching

Leaks

5.1.14.2.3.2 Manufactured Assemblies Employing Flexible Connection(s) Between the User Terminal and the Piping System

(A)

Nonstationary booms and articulating assemblies, other than head walls utilizing flexible connectors, shall be tested for leaks, per manufacturer's recommendations, every 18 months or at a duration as determined by a risk assessment.

(B)

The system pressure to nonstationary booms and articulating arms shall be maintained at operating pressure until each joint has been examined for leakage by effective means of leak detection that is safe for use with oxygen.

(C)

Safe working condition of the flexible assemblies shall be confirmed.

(D)

D.I.S.S. connectors internal to the boom and assemblies shall be checked for leakage.

(E)

Leaks, if any, shall be repaired (if permitted), or the components replaced (if required), and the equipment retested prior to placing the equipment back into service.

(F)

Additional testing of nonstationary booms or articulating arms shall be performed at intervals defined by documented performance data.

5.1.14.3 Medical Gas and Vacuum Systems Information and Warning Signs

5.1.14.3.1

The gas content of medical gas and vacuum piping systems shall be labeled in accordance with 5.1.11.1.

5.1.14.3.2

Labels for shutoff valves shall be in accordance with 5.1.11.2 and updated when modifications are made changing the areas served.

5.1.14.4 Medical Gas and Vacuum Systems Maintenance and Record Keeping

See B.5.2.

5.1.14.4.1

Permanent records of all tests required by 5.1.12.3.1 through 5.1.12.3.14 shall be maintained in the organization's files.

5.1.14.4.2

The supplier of the bulk cryogenic liquid system shall, upon request, provide documentation of vaporizer(s) sizing criteria to the facility.

5.1.14.4.3

An annual review of bulk system capacity shall be conducted to ensure the source system has sufficient capacity.

5.1.14.4.4

Central supply systems for nonflammable medical gases shall conform to the following:

They shall be inspected annually.

They shall be maintained by a qualified representative of the equipment owner.

A record of the annual inspection shall be available for review by the authority having jurisdiction.

5.1.14.4.5

A periodic testing procedure for nonflammable medical gas and vacuum and related alarm systems shall be implemented.

5.1.14.4.6

Whenever modifications are made that breach the pipeline, any necessary installer and verification test specified in 5.1.12 shall be conducted on the downstream portions of the medical gas piping system.

5.1.14.4.7

Procedures, as specified, shall be established for the following:

Maintenance program for the medical air compressor supply system in accordance with the manufacturer's recommendations

Facility testing and calibration procedure that ensures carbon monoxide monitors are calibrated at least annually or more often if recommended by the manufacturer

Maintenance program for both the medical—surgical vacuum piping system and the secondary equipment attached to medical—surgical vacuum station inlets to ensure the continued good performance of the entire medical—surgical vacuum system

Maintenance program for the WAGD system to ensure performance

5.1.14.4.8

Audible and visual alarm indicators shall meet the following requirements:

They shall be periodically tested to determine that they are functioning properly.

Records of the test shall be maintained until the next test is performed.

5.1.14.4.9

Medical—surgical vacuum station inlet terminal performance, as required in 5.1.12.3.10.4, shall be tested as follows:

On a regular preventive maintenance schedule as determined by the facility maintenance staff

Based on flow of free air (Nl/min or SCFM) into a station inlet while simultaneously checking the vacuum level

5.1.15\* Category 1 Maintenance

Facilities shall have a routine maintenance program for their piped medical gas and vacuum systems.

5.2 Category 2 Piped Gas and Vacuum Systems

5.2.1\* Applicability

These requirements shall apply to health care facilities that qualify for Category 2 systems as referenced in Chapter 4.

5.2.1.1

Section 5.2 through 5.2.12 shall apply to new health care facilities or facilities making changes that alter the piping.

5.2.1.2

The following subsections of this chapter shall apply to the operation, management, and maintenance of Category 2 medical gas and vacuum systems in existing health care facilities:

5.1.3.3.1.7

5.1.3.3.1.8

5.1.3.3.4

5.1.3.6.2

5.1.3.8.5.2

5.1.10.11.7.1

5.2.3.1

5.2.3.2

5.2.3.5(2)

5.2.3.6(2)

5.2.3.7(2)

5.2.13

5.2.14

5.2.1.3

Subsection 5.2.11 through 5.2.12 shall apply to new and existing health care facilities.

5.2.2 Nature of Hazards of Gas and Vacuum Systems

The requirement of 5.1.2 shall apply to the nature of hazards of gas and vacuum systems.

5.2.3 Category 2 Sources

5.2.3.1 Central Supply System Identification and Labeling

Category 2 systems shall comply with 5.1.3.1.

5.2.3.2 Central Supply Operations

Category 2 systems shall comply with 5.1.3.2.

5.2.3.3 Central Supply System Locations

Category 2 systems shall comply with 5.1.3.3.

5.2.3.4 Central Supply Systems

Category 2 systems shall comply with 5.1.3.5.

5.2.3.5 Category 2 Medical Air Supply Systems

Category 2 systems shall comply with 5.1.3.6, except as follows:

Medical air compressors, dryers, aftercoolers, filters, and regulators shall be permitted to be simplex.

The facility staff shall develop their emergency plan to deal with the loss of medical air.

5.2.3.6 Category 2 Medical—Surgical Vacuum

Category 2 systems shall comply with 5.1.3.7, except as follows:

Medical—surgical vacuum systems shall be permitted to be simplex.

The facility staff shall develop their emergency plan to deal with the loss of medical—surgical vacuum.

5.2.3.7 Category 2 WAGD

Category 2 systems shall comply with 5.1.3.8, except as follows:

Medical WAGD pumps shall be permitted to be simplex.

The facility staff shall develop their emergency plan to deal with the loss of WAGD.

5.2.3.8 Instrument Air Supply Systems

Category 2 systems shall comply with 5.1.3.9.

5.2.4 Valves

Category 2 systems shall comply with 5.1.4.

5.2.5 Station Outlets and Inlets

Category 2 systems shall comply with 5.1.5.

5.2.6 Manufactured Assemblies

Category 2 systems shall comply with 5.1.6.

5.2.7 Surface-Mounted Medical Gas Rails

Category 2 systems shall comply with 5.1.7.

5.2.8 Pressure and Vacuum Indicators

Category 2 systems shall comply with 5.1.8.

5.2.9 Warning Systems (Category 2)

Warning systems associated with Category 2 systems shall provide the master, area, and local alarm functions of a Category 1 system as required in 5.1.9, except as follows:

Warning systems shall be permitted to be a single alarm panel.

The alarm panel shall be located in an area of continuous surveillance while the facility is in operation.

Pressure and vacuum switches/sensors shall be mounted at the source equipment with a pressure indicator at the master alarm panel.

5.2.10 Category 2 Distribution

Level 2 systems shall comply with 5.1.10.

5.2.11 Labeling and Identification

Category 2 systems shall comply with 5.1.11.

5.2.12 Performance Criteria and Testing—Category 2 (Gas, Medical—Surgical Vacuum, and WAGD)

Category 2 systems shall comply with 5.1.12.

5.2.13 Category 2 Operation and Management

Category 2 systems shall comply with 5.1.14.

5.2.14\* Category 2 Maintenance

Facilities shall have a routine maintenance program for their piped medical gas and vacuum systems.

5.3\* Category 3 Piped Gas and Vacuum Systems

5.3.1\* Applicability

5.3.1.1

These requirements shall apply to health care facilities that qualify to install Category 3 systems as defined in Chapter 4.

5.3.1.1.1

Subsection 5.3.2 through 5.3.11.3 and 5.3.12.3 shall apply to new health care facilities or facilities making changes that alter the piping.

5.3.1.1.2

The following subsections of this chapter shall apply to the operation, management, and maintenance of Category 3 medical gas and vacuum systems in existing health care facilities:

5.3.1.5

5.3.1.6

5.3.2

5.3.6.19.4

5.3.6.20.3

5.3.6.20.4

5.3.6.20.5

5.3.6.20.6

5.3.6.20.7

5.3.6.20.8

5.3.6.20.9

5.3.6.21.14

5.3.6.23.1.5

5.3.10

5.3.12

5.3.13

5.3.1.1.3

Paragraph 5.3.1.1, 5.3.2, 5.3.12.1, and 5.3.13.3 shall apply to new and existing health care facilities.

5.3.1.1.4

A single Category 3 medical gas source system shall not supply more than two adjoining single treatment facilities.

5.3.1.2

Category 3 medical gas systems shall only use oxygen and nitrous oxide.

5.3.1.3

Category 3 gas-powered device supply systems shall use compressed air and nitrogen.

5.3.1.4

Category 3 vacuum and scavenging systems shall be of either the wet or dry type.

5.3.1.5\*

Deep sedation and general anesthesia shall not be permitted to be administered when using a Category 3 medical gas system.

5.3.1.6

An existing Category 3 system that is not in strict compliance with the requirements of this code shall be permitted to continue in use as long as the authority having jurisdiction has determined that such use does not constitute a distinct hazard to life.

5.3.2 Nature of Hazards of Gas and Vacuum Systems

Potential fire and explosion hazards associated with Category 3 gas and vacuum systems shall be considered in the design, installation, testing, operation, and maintenance of the systems.

5.3.3 Seismic Restraint

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

5.3.4 Protection Against Cross-Connections

All connections within Category 3 medical gas (oxygen and nitrous oxide) shall be gas-specific to prevent cross-connections with other piping systems, including vacuum, water, and drive gas.

5.3.5 Systems With Nonstandard Operating Pressures

Station outlets and piped outlets for Category 3 medical gas and gas-powered dispensing devices having nonstandard operating pressures shall comply with the following additional requirements:

Be gas-specific.

Be pressure-specific where a single gas is piped at more than one operating pressure.

Be a D.I.S.S connection if operated at a gauge pressure in excess of 550 kPa (80 psi).

Be designed to prevent the removal of the adapter until the pressure has been relieved, if operated at a gauge pressure between 1380 kPa and 2070 kPa (200 psi and 300 psi).

5.3.6 Category 3 Medical Gas Supply Systems (Oxygen and Nitrous Oxide)

5.3.6.1 Installer Qualifications

5.3.6.1.1

Installers of Category 3 medical gas sources (i.e., oxygen and nitrous oxide) where the total of all gases in cylinders or containers, except nitrogen, connected and in storage at one time does not exceed 85 m3 (3000 ft3) at standard temperature and pressure (STP), or 142 m3 (5000 ft3) (STP) if oxygen is stored in a DOT Specification 4L (cryogenic liquid) container shall be certified in accordance with ASSE 6010, Professional Qualification Standard for Medical Gas Systems Installers.

5.3.6.1.2

Installers of Category 3 medical gas sources (i.e., oxygen and nitrous oxide) where the total of all gases exceeds the limits specified in 5.3.6.1.1, shall be qualified in accordance with CGA M-1, Guide for Medical Gas Installations at Consumer Sites.

5.3.6.1.3

The installers of Category 3 medical gas piped distribution systems (i.e., oxygen and nitrous oxide), regardless of source equipment size, shall be certified in accordance with ASSE 6010, Professional Qualification Standard for Medical Gas Systems Installers.

5.3.6.1.4

Installers of medical gas (i.e., oxygen and nitrous oxide) shall not use their certification to oversee installation by non-certified personnel.

5.3.6.2 Category 3 Medical Gas Distribution Piping (Oxygen and Nitrous Oxide)

5.3.6.2.1

Tubes shall be hard-drawn seamless copper in accordance with ASTM B 819, Standard Specification for Seamless Copper Tube for Medical Gas Systems, Medical Gas Tube, Not Less Than Type L

5.3.6.2.2

Tubes, valves, fittings, station outlets, and other piping components shall have been cleaned for oxygen by the manufacturer prior to installation in accordance with CGA G-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.

5.3.6.2.3

Joints for tubes, turns, offsets, and other changes in direction shall be made with brazed wrought copper capillary fittings complying with one of the following:

ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

ANSI/ASME B16.50, Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings

ASME B16.22, with socket depths equal to or greater than brazed joint pressure fittings in accordance with ANSI/ASME B16.50

5.3.6.2.4

Cast copper alloy fittings shall not be used with field-brazed joints.

5.3.6.2.5

Threaded joints in Category 3 medical gas systems (oxygen and nitrous oxide) shall comply with the following:

They shall be limited to connections to pressure indicators, alarm devices, and source equipment.

They shall have tapered threads complying with ASME B1.20.1, Pipe Threads, General Purpose, Inch.

They shall 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.

5.3.6.2.6

The following joints shall be prohibited in Category 3 medical gas piping (oxygen and nitrous oxide):

Flared and compression connections, including connections to station outlets, alarm devices, and other components

Push-lock connections

Straight-threaded connections, including unions

5.3.6.2.7

Special-purpose fittings permitted in Category 1 medical gas piping systems shall be permitted to be used in Category 3 medical gas piping systems.

5.3.6.3 Qualification of Brazing Procedures and Brazing

5.3.6.3.1

Brazing procedures and brazer performance for the installation of Category 3 medical gas piping shall meet the same qualifications as Category 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 5.3.6.3.2 through 5.3.6.3.7.

5.3.6.3.2

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

5.3.6.3.3

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

5.3.6.3.4

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

5.3.6.3.5

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 code.

The employer obtains a copy of both the brazing procedure specification and the supporting qualification record 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.

The employer qualifies at least one brazer following each brazing procedure specification used.

5.3.6.3.6

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

The brazer has been qualified following the same procedure that the new employer uses, or an equivalent procedure.

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.

5.3.6.3.7

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.

5.3.6.4 Brazed Joints

5.3.6.4.1

Brazed tube joints shall be of the socket type.

5.3.6.4.2

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.

5.3.6.4.3

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

5.3.6.4.4

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

5.3.6.4.5

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

5.3.6.4.6

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

5.3.6.5 Cutting Tube Ends

5.3.6.5.1

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

5.3.6.5.2

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

5.3.6.5.3

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

5.3.6.6 Cleaning Joints for Brazing

5.3.6.6.1

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.

5.3.6.6.2

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.

5.3.6.6.3

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

5.3.6.6.4

The use of steel wool, sand cloth, or wire brushes shall be prohibited.

5.3.6.6.5

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

5.3.6.6.6

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

5.3.6.6.7

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.

5.3.6.6.8

Material that has become contaminated internally and is not clean for oxygen service shall not be installed.

5.3.6.6.9

Joints shall be brazed within 8 hours after being cleaned for brazing.

5.3.6.7 Brazing Dissimilar Metals

5.3.6.7.1

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

5.3.6.7.2

Cast metals shall not be field-brazed.

5.3.6.7.3

Surfaces shall be cleaned for brazing in accordance with 5.3.6.6.

5.3.6.7.4

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

5.3.6.7.5

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.

5.3.6.7.6

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

5.3.6.7.7

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 to be joined.

5.3.6.8\* Nitrogen Purge

5.3.6.8.1

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

5.3.6.8.2

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

5.3.6.8.3

The nitrogen purge gas flow rate shall not be high enough to produce a positive pressure in the piping system.

5.3.6.8.4

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

5.3.6.8.5

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

5.3.6.8.6

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.

5.3.6.8.7

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

5.3.6.8.8

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

5.3.6.8.9

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.

5.3.6.9 Assembling and Heating Brazed Joints

5.3.6.9.1

Tube ends shall be inserted either fully into the depth of the fitting socket or to a mechanically limited depth that is not less than the minimum cup depth (overlap) specified in ANSI/ASME B16.50, Standard Specification for Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.

5.3.6.9.2

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

5.3.6.9.3

After flux has 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.

5.3.6.9.4

Techniques for heating joints, applying the brazing filler metal, and making the horizontal, vertical, and large-diameter joints shall be as described in sections on applying heat and brazing horizontal and vertical joints in Chapter VII, "Brazed Joints," in the CDA Copper Tube Handbook.

5.3.6.10 Inspection of Brazed Joints

5.3.6.10.1

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

5.3.6.10.2

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

5.3.6.10.3

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

5.3.6.10.4

Joints exhibiting the following conditions shall not be permitted:

Flux or flux residue (when flux or flux-coated BAg rods are used with dissimilar metals)

Base metal melting or erosion

Unmelted filler metal

Failure of the filler metal to be clearly visible all the way around the joint at the interface between the socket and the tube

Cracks in the tube or component

Cracks in the filler metal

Failure of the joint to hold the test pressure under the installer-performed initial pressure test (see 5.3.6.23.2.3) and standing pressure test (see 5.3.6.23.2.6)

5.3.6.10.5

Joints that are identified as defective under conditions specified in 5.3.6.10.4(2) or (5) shall be replaced.

5.3.6.10.6

Joints that are found to be defective under conditions specified in 5.3.6.10.4(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.

5.3.6.11 Installation of Category 3 Medical Gas Piping (Oxygen and Nitrous Oxide)

5.3.6.11.1 Pipe Sizing

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

5.3.6.11.2\* Minimum Pipe Sizes

The minimum sizes of Category 3 oxygen and nitrous oxide piping shall be as follows:

Category 3 oxygen piping systems shall be not less than DN10 (NPS 3/8 in.) (1/2 in. O.D.) size.

Category 3 nitrous oxide piping systems shall be not less than DN8 (NPS 1/4 in.) (3/8 in. O.D.) size.

5.3.6.11.3 Location of Piping

Oxygen and nitrous oxide piping shall not be located where subject to contact with oil.

5.3.6.11.4 Protection of Piping

5.3.6.11.4.1

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

5.3.6.11.4.2

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

5.3.6.12 Pipe Support

5.3.6.12.1

Piping shall be supported from the building structure.

5.3.6.12.2

Hangers and supports shall comply with and be installed in accordance with MSS SP-58, Pipe Hangers and Supports — Materials, Design, Manufacture, Selection, Application, and Installation.

5.3.6.12.3

Hangers and supports for copper tube shall be sized for copper tube.

5.3.6.12.4

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

5.3.6.12.5

The maximum support spacing for copper tube shall be in accordance with Table 5.3.6.12.5.

Table 5.3.6.12.5 Maximum Copper Tube Support Spacing

Pipe Size Hanger Spacing

mm ft

DN8 (NPS 1/4) (3/8 in. O.D.) 1520 5

DN10 (NPS 3/8) (1/2 in. O.D.) 1830 6

DN15 (NPS 1/2) (5/8 in. O.D.) 1830 6

DN20 (NPS 3/4) (7/8 in. O.D.) 2130 7

DN25 (NPS 1) (11/8 in. O.D.) 2440 8

DN32 (NPS 11/4) (13/8 in. O.D.) 2740 9

DN40 (NPS 11/2) (15/8 in. and larger O.D.) 3050 10

Vertical risers, all sizes, every floor, but not to exceed 4570 15

5.3.6.13 Underground Piping Outside of Buildings

5.3.6.13.1

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

5.3.6.13.2

The installation procedure for underground piping shall prevent physical damage to the piping while being backfilled.

5.3.6.13.3

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

Access during construction shall be provided at the joints for visual inspection and leak testing.

The conduit, cover, or enclosure shall be self-draining and not retain groundwater in prolonged contact with copper tubing.

5.3.6.13.4

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

5.3.6.13.5

The minimum backfill cover above the top of the piping or its enclosure shall be 900 mm (36 in.), except that the minimum cover shall be permitted to be reduced to 450 mm (18 in.) where there is no potential for damage from surface loads or surface conditions.

5.3.6.13.6

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

5.3.6.13.7

Backfill shall be clean, free from material that can damage the pipe, and compacted.

5.3.6.13.8

A continuous warning tape or marker shall be placed immediately above the piping or its enclosure to clearly identify the pipeline by specific name.

5.3.6.13.9

A continuous warning means shall also be placed above the pipeline at approximately one-half the depth of burial.

5.3.6.13.10

Where buried piping is extended into a building through a wall sleeve, the outdoor end of the sleeve shall be sealed watertight to prevent the entrance of groundwater into the building.

5.3.6.14 Underground Piping Within Buildings

5.3.6.14.1

The installation procedure for underground piping shall prevent physical damage to the piping while being backfilled.

5.3.6.14.2

If the underground piping is protected by a conduit, cover, or other enclosure, access shall be provided at the joints during construction for visual inspection and leak testing.

5.3.6.14.3

The piping shall be backfilled with clean sand or gravel.

5.3.6.15 Piping Within Floor Slabs Prohibited

Category 3 medical gas piping (oxygen and nitrous oxide) shall not be installed within floor slabs.

5.3.6.16 Hose and Flexible Connectors

5.3.6.16.1

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.

5.3.6.16.2

Hose and flexible connectors, metallic or nonmetallic, shall have a minimum burst gauge pressure of 6895 kPa (1000 psi).

5.3.6.16.3

Medical gas hose and flexible connectors shall be oxygen compatible.

5.3.6.16.4

Hose and flexible connectors shall be clearly identified as to the gas content.

5.3.6.16.5

Hose and flexible connectors for Category 3 medical gases (oxygen and nitrous oxide) shall be gas-specific and not be permitted to conduct any other gas, gas mixture, or liquid.

5.3.6.17\* Category 3 Medical Gas Station Outlets (Oxygen and Nitrous Oxide)

5.3.6.17.1\*

Each station outlet for Category 3 medical gases shall be gas-specific, whether the outlet connection is threaded or is a noninterchangeable quick coupler.

5.3.6.17.2

Each station outlet shall consist of a primary and secondary valve (or assembly).

5.3.6.17.3

Each secondary valve (or assembly) shall close automatically to stop the flow of gas when the primary valve (or assembly) is removed.

5.3.6.18 Piped Outlets for Connection to Category 3 Medical Gas Dispensing Devices

5.3.6.18.1

Piped outlets for connection to Category 3 medical gas dispensing devices shall be gas-specific.

5.3.6.18.2

Piped outlets shall include a check valve and be capped until connected to the gas dispensing device.

5.3.6.18.3

Where piped outlets are connected to gas dispensing devices by flexible tubing, the tubing shall have a minimum burst gauge pressure of 6895 kPa (1000 psi) and be rated for oxygen use.

5.3.6.18.4

All connections between piped outlets and gas dispensing devices shall be gas-specific to prevent cross-connections.

5.3.6.19 Emergency Shutoff Valves

5.3.6.19.1\*

Where a central Category 3 medical gas (oxygen and nitrous oxide) supply is remote from a single treatment facility, the main supply line shall be provided with an emergency shutoff valve so located in the single treatment facility as to be accessible from all use-point locations in an emergency.

5.3.6.19.2

Where a central Category 3 medical gas (oxygen and nitrous oxide) supply system supplies two treatment facilities, each facility shall be provided with an emergency shutoff valve so located in the treatment facility as to be accessible from all use-point locations in an emergency.

5.3.6.19.3

Emergency shutoff valves shall be labeled to indicate the gas controlled and shall shut off only the gas to the treatment facility that they serve.

5.3.6.19.4

A remotely activated shutoff valve at a supply manifold shall not be used for emergency shutoff. For clinical purposes, such a remote valve actuator shall not fail-closed in the event of a loss of electric power. Where remote actuators are the type that fail-open, it shall be mandatory that cylinder shutoff valves be closed whenever the system is not in use.

5.3.6.20 Locations of Medical Gas Source Equipment (Oxygen and Nitrous Oxide)

5.3.6.20.1

Gas storage locations in facilities with Category 3 medical gas systems with a total of all gases in cylinders or containers, except nitrogen, connected and in storage at one time that does not exceed 85 m3 (3000 ft3) at standard temperature and pressure (STP), or 142 m3 (5000 ft3) (STP) if oxygen is stored in a DOT Specification 4L (cryogenic liquid) container shall comply with 5.3.6.20.3 through 5.3.6.20.12.

5.3.6.20.2

Gas storage locations in facilities with Category 3 medical gas systems with a total of all gases in cylinders or containers exceeding quantities listed in 5.3.6.20.1 shall comply with 5.1.3.3.

5.3.6.20.3

Enclosures shall serve no purpose other than to contain the medical gas source equipment (oxygen and nitrous oxide), except that nitrogen source equipment in 5.3.7.7 and compressed air cylinders in 5.3.7.6 shall be permitted in the enclosure.

5.3.6.20.4

Storage of full or empty gas cylinders, or both, shall be permitted in the same enclosure.

5.3.6.20.5

Air compressors, vacuum pumps, and other equipment shall not be located in enclosures for medical gas cylinders (oxygen and nitrous oxide source equipment).

5.3.6.20.6

If enclosures are outdoors or remote from the treatment facilities that they serve, they shall be kept locked.

5.3.6.20.7

Cylinders in use and in storage shall be prevented from reaching temperatures in excess of 54°C (130°F). Nitrous oxide cylinders shall be prevented from reaching temperatures lower than —7°C (20°F).

5.3.6.20.8

Only gas cylinders, reusable shipping containers, and their accessories shall be permitted to be stored in rooms containing central supply systems or gas cylinders.

5.3.6.20.9

No flammable materials, cylinders containing flammable gases, or containers containing flammable liquids shall be stored in rooms with gas cylinders.

5.3.6.20.10

Indoor enclosures shall not communicate directly with medical gas (oxygen and nitrous oxide) use points or storage locations for oxidizers.

5.3.6.20.11

Outdoor enclosures that are adjacent to a building wall shall be located such that the distance to any window or door of the adjacent building is greater than 3.05 m (10 ft).

5.3.6.20.12

Enclosures for Category 3 medical gas source equipment shall be provided with doors or gates.

5.3.6.21 Category 3 Medical Gas Source Equipment (Oxygen and Nitrous Oxide)

5.3.6.21.1

Mechanical means shall be provided to ensure that the medical gas source equipment is connected to the correct medical gas distribution piping system.

5.3.6.21.2

Cylinder valve outlets for oxygen and nitrous oxide shall comply with CGA V-1, Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.

5.3.6.21.3

Threaded connections to manifolds shall comply with CGA V-5, Diameter-Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications).

5.3.6.21.4

A check valve shall be provided downstream of each pressure regulator.

5.3.6.21.5

A pressure relief valve set at 50 percent above the normal line pressure shall be located downstream of the check valve in 5.3.6.21.4.

5.3.6.21.6

Pressure relief valves shall be brass, bronze, or stainless steel and designed for oxygen service.

5.3.6.21.7

Hose and flexible connectors shall have a gauge pressure rating not less than 6895 kPa (1000 psi).

5.3.6.21.8

Materials used in central supply systems shall meet the following requirements:

In those portions of systems intended to handle oxygen at gauge pressures equal to or greater than 2413 kPa (350 psi), interconnecting hose shall contain no polymeric materials.

In those portions of systems intended to handle oxygen or nitrous oxide material, construction shall be compatible with oxygen under the temperatures and pressures to which the components can be exposed.

If potentially exposed to cryogenic temperatures, materials shall be designed for low temperature service.

If intended for outdoor installation, materials shall be installed per the manufacturer's requirements.

5.3.6.21.9

Flexible connectors of other than all-metal construction that connect manifolds to the gas distribution piping shall not exceed 1.52 m (5 ft) in length and shall not penetrate walls, floors, ceilings, or partitions.

5.3.6.21.10

Medical gas source equipment that serves one or two treatment facilities shall include two banks of one or more cylinders of oxygen and (if used) two banks of one or more cylinders of nitrous oxygen, each bank containing at least an average day's supply.

5.3.6.21.11

The two banks of each medical gas source shall be manifolded so that either bank can supply its distribution piping system.

5.3.6.21.12

Where the source equipment is remote from a single treatment facility and an "in use" bank is unable to supply the system, the manifold shall automatically switch to the secondary bank.

5.3.6.21.13

Where the source equipment serves multiple treatment facilities and an "in use" bank is unable to supply the system, the manifold shall automatically switch to the secondary bank.

5.3.6.21.14

Where the source equipment is not remote and is accessible from a single treatment facility served and an "in use" bank is unable to supply the system, the manifold shall be manually (or automatically) switched to the secondary bank.

5.3.6.22 Category 3 Warning Systems

5.3.6.22.1

Warning systems for medical gas systems (oxygen and nitrous oxide) in Category 3 facilities shall provide the following alarms:

Oxygen main line pressure low

Oxygen main line pressure high

Oxygen changeover to secondary bank or about to changeover (if automatic)

Nitrous oxide main line pressure low

Nitrous oxide main line pressure high

Nitrous oxide changeover to secondary bank or about to changeover (if automatic)

5.3.6.22.2

Warning systems shall have at least one single alarm panel in each treatment facility served by the medical gas source equipment.

5.3.6.22.3

Alarm panels shall be located in an area of continuous surveillance while the facility is in operation.

5.3.6.22.4

Pressure switches/sensors that monitor main line pressure shall be mounted at the source equipment with pressure alarm indicators (lamp or LED) at the alarm panel.

5.3.6.22.5

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.

5.3.6.22.6

Visual indications shall remain until the situation that caused the alarm is resolved.

5.3.6.22.7

Pressure switches/sensors shall be installed downstream of any emergency shutoff valves and any other shutoff valves in the system and shall cause an alarm for the medical gas if the pressure decreases or increases 20 percent from the normal operating pressure.

5.3.6.22.8

A cancelable audible indication of each alarm condition that produces a sound at the alarm panel shall reinitiate the audible signal if another alarm condition occurs while the audible signal is silenced.

5.3.6.23 Performance Criteria and Testing — Category 3 Medical Gases (Oxygen and Nitrous Oxide)

5.3.6.23.1 General

5.3.6.23.1.1

Inspection and testing shall be performed on all new piped medical gas systems (oxygen and nitrous oxide), additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that all applicable provisions of this code have been adhered to and system integrity has been achieved or maintained.

5.3.6.23.1.2

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.

5.3.6.23.1.3

Reports shall contain detailed listings of all findings and results.

5.3.6.23.1.4

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

5.3.6.23.1.5

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

5.3.6.23.1.6

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

5.3.6.23.2 Initial Tests for Category 3 Medical Gases (Oxygen and Nitrous Oxide)

5.3.6.23.2.1 General

(A)

The initial tests required by 5.3.6.23.2 shall be performed prior to the verification tests listed in 5.3.6.23.3 by one or more of the following, who shall be qualified under ASSE 6010, Professional Qualification Standard for Medical Gas Systems Installers:

Installer

Representative of the system supplier

Representative of the system manufacturer

Medical gas systems verifier qualified under 5.3.6.23.3.1 (A)

(B)

The test gas for medical gas systems shall be oil-free, dry nitrogen NF.

(C)

Where manufactured assemblies are to be installed, the tests required under 5.3.6.23.2 shall be performed as follows:

After completion of the distribution piping

Prior to installation or connection of manufactured assemblies having internal flexible hose or flexible tubing

At all station outlets on manufactured assemblies supplied through copper tubing

(D)

Where plastic vacuum and scavenging piping systems are installed, they shall be visually inspected for cross-connections to positive pressure systems prior to applying positive test pressures to the copper piping systems.

5.3.6.23.2.2 Initial Piping Blow Down

Piping in Category 3 medical gas distribution systems shall be blown clear by by a means of oil-free, dry nitrogen NF after installation of the distribution piping but before installation of station outlets and other system components (i.e., pressure alarm devices, pressure indicators, pressure relief valves, manifolds, source equipment).

5.3.6.23.2.3 Initial Pressure Test

(A)

Each section of the piping in Category 3 medical gas piping systems shall be pressure tested by a party qualified under 5.3.6.23.2.1(A), using oil-free, dry nitrogen NF.

(B)

Initial pressure tests shall be conducted as follows:

After blow down of the distribution piping

After installation of station outlets/inlets rough-in assemblies, with test caps permitted to be used

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

(C)

The source shutoff valves for the piping systems shall remain closed during the tests.

(D)

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

(E)\*

The test pressure shall be maintained until each joint has been examined for leakage by means of a leak detectant that is safe for use with oxygen and does not contain ammonia.

(F)

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

5.3.6.23.2.4 Initial Cross-Connection Test

A party qualified under 5.3.6.23.2.1(A) shall determine that no cross-connections exist between the various medical gas piping systems (oxygen and nitrous oxide).

(A)

The Category 3 medical gas piping systems shall be at atmospheric pressure.

(B)

Faceplates for gas outlets shall be installed.

(C)

The test gas for medical gas piping systems shall be oil-free, dry nitrogen NF.

(D)

The source of test gas shall be connected only to the medical gas piping system being tested.

(E)

The medical gas system being tested shall be pressurized to a gauge pressure of 345 kPa (50 psi).

(F)

Each individual system gas outlet in each installed medical gas piping system (oxygen and nitrous oxide) shall be checked to determine that the test gas is being dispensed only from the outlets in the medical gas piping system being tested.

(G)

The cross-connection test shall be repeated for each installed medical gas piping system.

(H)

The proper labeling and identification of system outlets shall be confirmed during the tests.

5.3.6.23.2.5 Initial Piping Purge Test

The outlets in each Category 3 medical gas piping system shall be purged by a party qualified under 5.3.6.23.2.1(A) to remove any particulate matter from the distribution piping.

(A)

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

(B)

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.

(C)

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

5.3.6.23.2.6 Initial Standing Pressure Test

After successful completion of the initial pressure tests under 5.3.6.23.2.3, Category 3 medical gas distribution piping shall be subjected to a standing pressure test by a party qualified under 5.3.6.23.2.1(A).

(A)

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

(B)

The source valve shall be closed during the test.

(C)

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

(D)

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

(E)

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).

(F)

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

5.3.6.23.3 System Verification for Category 3 Medical Gases (Oxygen and Nitrous Oxide)

5.3.6.23.3.1 General

(A)

Verification tests shall be conducted on Category 3 medical gases (oxygen and nitrous oxide) 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 Qualification Standard for Medical Gas Systems Verifiers.

(B)

Verification testing shall be performed by a party other than the installing contractor, the system supplier, or the system manufacturer.

(C)

Verification tests shall be performed only after all tests required in 5.3.6.23.2 have been successfully completed on the medical gas piping systems.

(D)

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

(E)

All verification tests required under 5.3.6.23.3 shall be performed after installation of any manufactured assemblies having internal hose or tubing.

(F)

Where manufactured assemblies with internal tubing or hose include multiple possible connection points for terminals, each possible connection point shall be tested independently.

(G)

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:

Standing pressure (see 5.3.6.23.3.3)

Cross-connection by individual pressurization (see 5.3.6.23.3.4)

Cross-connection by pressure differential (see 5.3.6.23.3.5)

Warning system (see 5.3.6.23.3.6)

Piping purge (see 5.3.6.23.3.7)

Piping particulate (see 5.3.6.23.3.8)

Piping purity (see 5.3.6.23.3.9)

Operational pressure (see 5.3.6.23.3.10)

(H)

All verification test results shall be reported as required in 5.3.6.23.3.1.

5.3.6.23.3.2 Source Equipment Verification

(A) General

Source equipment verification for Category 3 medical gases (oxygen and nitrous oxide) shall be performed following the installation of the interconnecting pipelines, accessories, and source equipment.

(B) Use of Source Equipment for Pipeline Verification Tests

Where the source equipment and system gas is permitted to be used for verification testing of the distribution piping, the source equipment shall be verified prior to verification of the distribution piping.

(C) Automatic Changeover

Where medical gas sources include automatic changeover to a secondary bank, the system apparatus shall be tested for proper function, including the changeover from primary to secondary supply (with its changeover alarm signal), before the source equipment is put into service.

5.3.6.23.3.3 Verifier Standing Pressure Test

Category 3 medical gas piping systems (oxygen and nitrous oxide) shall be subjected to a 10-minute standing pressure test at operating line pressure using the following procedures:

The system source shutoff valve shall be closed, unless it is being used as the test gas.

After the system is filled with oil-free, dry nitrogen NF or the system gas, the test source valve shall be closed.

The piping system downstream of the valve shall show no decrease in pressure after 10 minutes.

Any leaks shall be located by the installer, repaired by the installer (if permitted), replaced by the installer (if required), and retested by the verifier.

5.3.6.23.3.4 Verifier Cross-Connection Test by Individual Pressurization

After closing of walls and completion of the requirements of 5.3.6.23.2, it shall be determined that no cross-connections exist between the Category 3 medical gas systems (oxygen and nitrous oxide) by either use of the following individual pressurization methods or by the pressure differential method in 5.3.6.23.3.5:

Reduce the pressure in all Category 3 medical gas systems to atmospheric.

Pressurize one of the Category 3 medical gas piping systems to a gauge pressure of 345 kPa (50 psi) using oil-free, dry nitrogen NF or the system gas.

Test each medical gas outlet using appropriate adapters to verify that the test gas pressure is present only at the outlets in the Category 3 medical gas piping system being tested.

After it has been verified that a Category 3 medical gas piping system is free of cross-connections, disconnect the source of test gas and reduce the piping to atmospheric pressure.

Proceed to test each Category 3 medical gas piping system until each is verified to be free of cross-connections.

5.3.6.23.3.5 Verifier Cross-Connection Test by Pressure Differential

After closing of walls and completion of the requirements of 5.3.6.23.2, it shall be determined that no cross-connections exist between the Category 3 medical gas systems (oxygen and nitrous oxide) by either use of the pressure differential method in 5.3.6.23.3.5(A) through 5.3.6.23.3.5(F) or by the individual pressurization method in 5.3.6.23.3.4.

(A)

The pressure in all Category 3 medical gas systems shall be reduced to atmospheric.

(B)

The test gas shall be oil-free, dry nitrogen NF or the system gas.

(C)

The test gas pressures shall be gauge pressures of 345 kPa (50 psi) for oxygen and 275 kPa (40 psi) for nitrous oxide, with simultaneous maintenance of these nominal pressures throughout the test.

(D)

Following the adjustment of system pressures in accordance with 5.3.6.23.3.5(C), each station outlet for each medical gas system shall be tested using the gas-specific connection for each system with a test gauge attached to verify that the correct test pressure is present at each outlet of each system.

(E)

Each test gauge used in performing the test shall be calibrated with the pressure indicators for the line pressure regulators that provide the test pressures.

(F)

Each station outlet shall be identified by label (and color marking, if used), and the pressure indicated on the test gauge shall be that listed in 5.3.6.23.3.5(C) for the system being tested.

5.3.6.23.3.6 Verifier Warning System Tests

(A)

All warning systems that are installed for Category 3 medical gases (oxygen and nitrous oxide) shall be verified to ensure that all components function correctly prior to placing the system into service.

(B)

Permanent records of the tests shall be maintained.

(C)

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.

(D)

Tests of warning systems for new installations shall be performed after the verifier's cross-connection testing (see 5.3.6.23.3.4 or 5.3.6.23.3.5), but before purging the piping (see 5.3.6.23.3.7) and performing the remaining verification tests. (See 5.3.6.23.3.8 through 5.3.6.23.3.10.)

(E)

Test gases shall be either oil-free, dry nitrogen NF or the system gas.

(F)

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

(G)

The operation of the Category 3 medical gas line pressure alarms required by 5.3.6.22.1 shall be verified.

(H)

The operation of the Category 3 changeover alarms, if provided under 5.3.6.22.1, shall be verified.

(I)

If automatic changeover is provided under 5.3.6.21.12 or 5.3.6.21.13, audible and noncancelable visual signals shall indicate whenever automatic changeover occurs or is about to occur.

(J)

Where Category 3 medical gas systems (oxygen and nitrous oxide) include other alarm features that are not mandatory in 5.3.6.21, they shall be functionally tested in accordance with their intended purpose and the equipment manufacturer's recommendations.

5.3.6.23.3.7 Verifier Piping Purge Test

(A)

In order to remove any traces of particulate matter deposited in the pipelines as a result of construction, a heavy, intermittent purging of each Category 3 medical gas (oxygen and nitrous oxide) pipeline shall be performed.

(B)

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

(C)

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.

(D)

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

5.3.6.23.3.8 Verifier Piping Particulate Test

The cleanliness of the piping in each Category 3 medical gas system (oxygen and nitrous oxide) shall be verified as follows:

The test shall be performed using oil-free, dry nitrogen NF or the system gas.

A minimum of 1000 L (35 ft3) of gas shall be filtered through a clean, white 0.45 micron filter at a minimum flow rate of 100 SLPM (3.5 SCFM).

Each zone shall be tested at the outlet most remote from the source.

The filter shall accrue no more than 0.001 g (1 mg) of matter from any outlet tested.

5.3.6.23.3.9\* Verifier Piping Purity Test

For each Category 3 medical gas system (oxygen and nitrous oxide), the purity of the piping system shall be verified as follows:

The tests shall be performed with oil-free, dry nitrogen NF or the system gas.

The outlet most remote from the source shall be tested for total non-methane hydrocarbons and compared to the source gas.

If the system gas is used as the source gas, it shall be tested at the source equipment.

The difference between the two tests shall in no case exceed 5 ppm of total non-methane hydrocarbons.

The difference between the two tests shall in no case exceed 5 ppm halogenated hydrocarbons.

The moisture concentration of the outlet test shall not exceed 500 ppm or an equivalent pressure dew point of —12°C (10°F) at a gauge pressure of 345 kPa (50 psi).

5.3.6.23.3.10 Verifier Operational Pressure Test

(A)

Operational pressure tests shall be performed at each station outlet in Category 3 medical gas piping systems (oxygen and nitrous oxide) where the user makes connections and disconnections.

(B)

Tests shall be performed using either oil-free, dry nitrogen NF or the system gas.

(C)

Medical gas outlets (oxygen and nitrous oxide) shall deliver 50 SLPM (1.8 SCFM) with a pressure drop of not more than 35 kPa (5 psi) from a gauge pressure of 345 kPa to 380 kPa (50 psi to 55 psi).

5.3.6.23.3.11\* Verifier Gas Concentration Test

After purging each Category 3 medical gas piping system with the gas of system designation, the following shall be performed:

Each medical gas outlet (oxygen and nitrous oxide) shall be analyzed for concentration of gas by volume.

Analysis shall be conducted with instruments designed to measure the specific gas dispensed.

Allowable concentrations shall be as follows:

Oxygen ≥99 percent oxygen

Nitrous oxide ≥99 percent nitrous oxide

5.3.6.23.3.12 Verifier Final Tie-in Test

(A)

Prior to the connection of any new piping in extensions or additions to an existing piping system, the final tests in 5.3.6.23.3 shall be successfully performed on the new work.

(B)

Each joint in the final connection between the new work and the existing system shall be leak-tested with the gas of system designation at the normal operating pressure by means of a leak detectant that is safe for use with oxygen and does not contain ammonia.

(C)

Vacuum joints shall be tested using an ultrasonic leak detector or other means that allow detection of leaks in an active vacuum system.

(D)

Immediately after a 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 5.3.6.23.3.7.

5.3.6.23.3.13 Verification of Labeling

The labeling and identification of source equipment, shutoff valves, alarm panels, and station outlets for Category 3 medical gas systems (oxygen and nitrous oxide) shall be verified.

5.3.7\* Category 3 Gas-Powered Device Supply Systems (Compressed Air and Nitrogen)

5.3.7.1 General Requirements

5.3.7.1.1

Category 3 gas-powered device supply systems shall be used to drive dynamic devices, to dry surfaces for patient treatment, to drive vacuum turbines, and to remove excess moisture from instruments before further processing and for other general compressed gas uses in Category 3 facilities.

5.3.7.1.2

Category 3 gas-powered device supply systems shall be permitted to be used to supply power to gas-driven devices for scavenging, but only where the exhaust of the scavenging device is a closed vent to the outside of the building.

5.3.7.1.3\*

Category 3 gas-powered device supply systems shall be furnished by the equipment manufacturer(s) or supplier(s), who shall be familiar with the proper application of the equipment and shall supervise its installation.

5.3.7.1.4

Installers of Category 3 gas-powered device supply systems shall be experienced in the installation and testing of such systems and the requirements of this code.

5.3.7.2 Piping for Gas-Powered Devices

5.3.7.2.1 Tubes

5.3.7.2.1.1

Tubes shall be in accordance with one of the following:

ASTM B 819, Standard Specification for Seamless Copper Tube for Medical Gas Systems, medical gas tube, not less than Type L

ASTM B 88, Standard Specification for Seamless Copper Water Tube, water tube, not less than Type L

ASTM B 280, Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service, ACR tube (O.D. size)

5.3.7.2.1.2

Tubing shall be hard temper or annealed (soft temper).

5.3.7.2.2 Fittings

Fittings for Category 3 gas-powered device supply piping shall be one of the following:

Brazed or soldered fittings complying with ASME B16.22, Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

Brazed fittings complying with ASME B16.50, Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings

Brazed fittings complying with ASME B16.22, with socket depths equal to or greater than braze-joint pressure fittings in compliance with ANSI/ASME B16.50.

Flared fittings complying with ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes

Compression fittings (3/4 in. maximum size)

Special-purpose fittings permitted for Category 1 medical gas piping

5.3.7.2.3 Joints

5.3.7.2.3.1

Joints for Category 3 gas-powered device supply piping shall be of the brazed, soldered, threaded, flared, or compression type.

5.3.7.2.3.2

Where joints are brazed, they shall comply with the requirements for Category 3 medical gas piping in 5.3.6.1 through 5.3.6.10.

5.3.7.2.3.3

Soldered joints in Category 3 gas-powered supply 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 that complies with ASTM B 32, Standard Specification for Solder Metal.

5.3.7.3 Installation of Gas-Powered Device Piping

5.3.7.3.1 Pipe Sizing

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

5.3.7.3.2 Protection of Piping

Piping shall be protected in accordance with 5.3.6.11.4.

5.3.7.3.3 Pipe Support

Pipe support shall be in accordance with 5.3.6.12.

5.3.7.3.4 Underground Piping Outside of Buildings

Buried piping outside of buildings shall be in accordance with 5.3.6.13.

5.3.7.3.5 Underground Piping Within Buildings

Underground piping within buildings shall be in accordance with 5.3.6.14.

5.3.7.3.6 Piping Within Floor Slabs

5.3.7.3.6.1

Category 3 gas-powered device piping (compressed air and nitrogen) that is installed within floor slabs shall be enclosed in a conduit, in flexible plastic tubing, or by other means to prevent contact between the copper tubing and concrete.

5.3.7.3.6.2

During construction, access shall be provided at any joints for visual inspection and leak testing.

5.3.7.4 Valves in Gas-Powered Device Piping

Shutoff valves shall be permitted to be installed in Category 3 gas-powered device piping.

5.3.7.5 Location of Gas-Powered Device Source Equipment

5.3.7.5.1

Source equipment for Category 3 gas-powered devices shall be one or more of the following:

One or more air compressors

One or more air compressors with compressed air cylinders

Nitrogen cylinders

5.3.7.5.2

Air compressors for Category 3 gas-powered devices shall be installed in a designated mechanical equipment area, heated and ventilated in accordance with 5.1.3.3.2 and 5.1.3.3.3, and have required utilities (e.g., electrical power, drains, lighting).

5.3.7.5.3

Where nitrogen or compressed air in cylinders is used, the cylinders shall be permitted to be located in a compressor equipment room.

5.3.7.5.4

Nitrogen and compressed air cylinders shall be permitted to be located in enclosures for Category 3 medical gases (oxygen and nitrous oxide).

5.3.7.6 Air Compressor Source Equipment

5.3.7.6.1 General

Category 3 compressed air compressor supply systems shall include the following:

Disconnect switch(es)

Motor-starting device(s)

Motor overload protection device(s)

One or more compressors

For single, duplex, or multiple compressor systems, means for activation/de-activation of each individual compressor

When multiple compressors are used, manual or automatic means to alternate individual compressors

When multiple compressors are used, manual or automatic means to activate the additional unit(s) should the in-service unit(s) be incapable of maintaining adequate pressure

Intake filter—muffler(s) of the dry type

Receiver(s) with a manual or automatic drain

Shutoff valves

Compressor discharge check valve(s) (for multiple compressors)

Air dryer(s) that maintains a minimum of 40 percent relative humidity at operating pressure and temperature

In-line final particulate/coalescing filters rated at 0.01 micron, with filter status indicator to ensure the delivery of compressed air with a maximum allowable 0.05 ppm liquid oil

Pressure regulator(s)

Pressure relief valve

Pressure indicator

Moisture indicator

5.3.7.6.2 Receiver(s)

5.3.7.6.2.1

The receiver(s) shall have the capacity to prevent short cycling of the compressor(s).

5.3.7.6.2.2

The receiver(s) shall comply with Section VIII, "Unfired Pressure Vessels," of the ASME Boiler and Pressure Vessel Code.

5.3.7.6.3\* Moisture Indicator

5.3.7.6.3.1

The moisture indicator shall be located in the active airstream prior to, or after, the receiver and upstream of any system pressure regulators.

5.3.7.6.3.2

The moisture indicator shall indicate (e.g., by color change, digital readout, or other method understood by the user) when the relative humidity of the compressed air exceeds 40 percent at line pressure and temperature.

5.3.7.6.4 Pressure Relief Valve Discharge

Pressure relief valves for compressed air systems having less than 84,950 L (3000 ft3) at STP shall be permitted to discharge locally indoors in a safe manner that will not restrict the flow.

5.3.7.6.5\* Source of Compressor Intake Air

5.3.7.6.5.1

Air sources for a compressor(s) located inside the building shall meet the following requirements:

They shall be located within a space where no chemical-based materials are stored or used.

They shall be located in a space that is not used for patient medical treatment.

They shall not be taken from a room or space in which there is an open or semi-open discharge from a Category 3 vacuum or scavenging system.

5.3.7.6.5.2

Air sources for a compressor(s) located outside the building shall be drawn from locations where no contamination from vacuum or scavenging system discharges or particulate matter is anticipated.

5.3.7.7 Compressed Air Cylinder Source Equipment

5.3.7.7.1

Compressed air cylinders shall be permitted to be installed in enclosures for Category 3 medical gases (oxygen and nitrous oxide) as described in 5.3.6.20.2 or in a mechanical room.

5.3.7.7.2

Compressed air cylinder source equipment shall include the following:

One or more cylinders of compressed air, each providing at least an average day's supply

Manifold if primary and secondary cylinders are provided

Line pressure regulating valve

Check valve downstream from the pressure regulating valve

Pressure relief valve set at 50 percent above the normal line pressure and located downstream from the check valve specified in 5.3.7.7.2(4)

5.3.7.7.3

Mechanical means shall be provided to ensure that the compressed air cylinder gas source equipment is connected to the correct gas distribution piping system.

5.3.7.7.4

Threaded connections to manifolds shall comply with CGA V-5, Diameter-Index Safety System (Noninterchangeable Low Pressure Connections far Medical Gas Applications).

5.3.7.7.5

Flexible connectors shall have a gauge pressure rating not less than 6895 kPa (1000 psi).

5.3.7.7.6

Flexible connectors of other than all-metal construction that connect manifolds to the gas distribution piping shall not exceed 1.52 m (5 ft) in length and shall not penetrate walls, floors, ceilings, or partitions.

5.3.7.7.7

Pressure relief valves for compressed air cylinder systems having less than 84,950 L (3000 ft3) at STP shall be permitted to discharge locally indoors in a safe manner that will not restrict the flow.

5.3.7.8\* Nitrogen Source Equipment

5.3.7.8.1

Nitrogen source equipment shall be permitted to be installed in enclosures for Category 3 medical gases (oxygen and nitrous oxide) as described in 5.3.6.20.2 or in a mechanical room.

5.3.7.8.2

Nitrogen source equipment shall include the following:

One or more cylinders of nitrogen NF, each providing at least an average day's supply

Manifold, if primary and secondary cylinders are provided

Line pressure regulating valve

Check valve downstream from the pressure regulating valve

A pressure relief valve set at 50 percent above the normal line pressure and located downstream from the check valve specified in 5.3.7.8.2(4)

Pressure relief valve discharge piped to outdoors at a point that will not create a probable hazard and that is turned down to prevent the entry of rain or snow

5.3.7.8.3

Mechanical means shall be provided to ensure that the nitrogen gas source equipment is connected to the correct gas distribution piping system.

5.3.7.8.4

Cylinder valve outlets for nitrogen shall comply with CGA V-1, Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.

5.3.7.8.5

Threaded connections to manifolds shall comply with CGA V-5, Diameter-Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications).

5.3.7.8.6

Flexible connectors shall have a gauge pressure rating not less than 6895 kPa (1000 psi).

5.3.7.8.7

Flexible connectors of other than all-metal construction that connect manifolds to the gas distribution piping shall not exceed 1.52 m (5 ft) in length and shall not penetrate walls, floors, ceilings, or partitions.

5.3.8 Category 3 Vacuum and Scavenging Systems

5.3.8.1 General Requirements

5.3.8.1.1

Category 3 vacuum and scavenging systems shall be furnished by an equipment manufacturer(s) or a supplier(s) who is familiar with the proper application of the equipment and shall be installed under their supervision.

5.3.8.1.2

Installers of Category 3 vacuum and scavenging systems shall be experienced in the installation and testing of such systems and the requirements of this code.

5.3.8.1.3

Any water supply and drain piping associated with vacuum or scavenging source equipment shall comply with the locally adopted plumbing code.

5.3.8.2 Piping for Vacuum and Scavenging Systems

5.3.8.2.1

Piping for Category 3 vacuum and scavenging systems shall be copper, PVC plastic, or CPVC plastic.

5.3.8.2.2

Copper piping shall comply with the requirements for Category 3 gas-powered supply piping as follows:

Copper tubing shall be in accordance with 5.3.7.2.1.

Copper fittings shall be in accordance with 5.3.7.2.2.

Joints in copper tubing shall be in accordance with 5.3.7.2.3.

5.3.8.2.3

PVC plastic piping shall be in accordance with the following:

PVC plastic pipe shall be Schedule 40 or Schedule 80, complying with ASTM D 1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

PVC plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, complying with ASTM D 2466, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40, or ASTM D 2467, Standard Specification Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

Joints in PVC plastic piping shall be solvent-cemented in accordance with ASTM D 2672, Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.

5.3.8.2.4

CPVC plastic piping shall be iron pipe size (IPS) or copper tube size (CTS) in accordance with the following:

CPVC IPS plastic pipe shall be Schedule 40 or Schedule 80, complying with ASTM F 441, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.

CPVC IPS plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, complying with ASTM F 438, Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chlorinated) (CPVC) Plastic Pipe Fittings, Schedule 40, or ASTM F 439, Standard Specification for Chlorinated Poly (Vinyl Chlorinated) (CPVC) Plastic Pipe Fittings, Schedule 80.

CPVC CTS plastic pipe and fittings 1/2 in. through 2 in. size shall be SDR 11, complying with ASTM D 2846, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems.

Solvent cement for joints in CPVC plastic piping shall comply with ASTM F 493, Solvent Cements for CPVC Pipe and Fittings.

5.3.8.3 Installation of Vacuum and Scavenging Piping

5.3.8.3.1 Pipe Sizing

Piping systems shall be designed and sized to draw the required flow rates at the utilization vacuums.

5.3.8.3.2 Protection of Piping

Piping shall be protected in accordance with 5.3.6.11.4.

5.3.8.3.3 Copper Pipe Support

Pipe support for copper piping shall be in accordance with 5.3.6.12.

5.3.8.3.4 Plastic Pipe Support

The maximum support spacing for plastic pipe shall be in accordance with Table 5.3.8.3.4.

Table 5.3.8.3.4 Maximum Plastic Pipe Support Spacing

Pipe Size Hanger Spacing

mm ft

DN15 (NPS 1/2) (5/8 in. O.D.) 1220 4.00

DN20 (NPS 3/4) (7/8 in. O.D.) 1220 4.00

DN25 (NPS 1) (11/8 in. O.D.) 1320 4.33

DN32 (NPS 11/4) (13/8 in. O.D.) 1320 4.33

DN40 (NPS 11/2) (15/8in. O.D.) 1420 4.66

DN50 (NPS 2) (23/8 in. O.D.) 1420 4.66

DN65 (NPS 21/2) (27/8 in. O.D.) and larger 1520 5.00

Vertical risers, all sizes, every floor, but not to exceed 3040 10.00

5.3.8.3.5 Underground Piping Outside of Buildings

Buried piping outside of buildings shall be in accordance with 5.3.6.13.

5.3.8.3.6 Underground Piping Within Buildings

Underground piping within buildings shall be in accordance with 5.3.6.14.

5.3.8.3.7 Piping Within Floor Slabs

5.3.8.3.7.1

Copper Category 3 vacuum and scavenging piping that is installed within floor slabs shall be enclosed in a conduit, flexible plastic tubing, or other means to prevent contact between the copper tubing and concrete.

5.3.8.3.7.2

Plastic Category 3 vacuum and scavenging piping shall be permitted to contact concrete.

5.3.8.3.7.3

During construction, access shall be provided at all joints for visual inspection and leak testing.

5.3.8.3.7.4

Care shall be taken to protect plastic piping from damage from vibrators while wet concrete is being consolidated.

5.3.8.3.8 Valves in Vacuum and Scavenging Systems

Shutoff valves shall be permitted to be installed in Category 3 vacuum and scavenging piping.

5.3.8.3.9\* Category 3 Vacuum and Scavenging Source Equipment

5.3.8.3.9.1

Category 3 vacuum sources shall include the following:

Vacuum pump or pumps suited for wet or dry service as intended in the system design

If intended for wet service, properly vented liquid/air separator

5.3.8.3.9.2

Category 3 vacuum and scavenging source equipment shall be obtained from, and be installed under the supervision of, the manufacturer(s) or supplier(s) who is familiar with its installation, operation, and use.

5.3.8.3.10 Drainage From Vacuum Equipment

None of the requirements of 5.3.8.3.10.1 through 5.3.8.3.10.6 for drainage in Category 3 vacuum systems shall supersede provisions of the local plumbing code.

5.3.8.3.10.1

Liquids drained from a Category 3 vacuum source shall discharge indirectly to a sanitary drainage system through an approved air gap to a trapped and vented drain.

5.3.8.3.10.2

The clear air gap between a vacuum drain outlet, or indirect drain pipe, and the flood category rim of an indirect waste receptor, or other point of disposal, shall be not less than twice the diameter of the effective opening of the drain served, but not less than 25.4 mm (1 in.), unless the local plumbing code requires a larger air gap.

5.3.8.3.10.3

Where the drainage is from a waste holding tank on the suction side of the vacuum source, the following requirements shall be met:

A check valve shall be installed in the drain line from the holding tank between the tank and any vent lines.

The trap in the building drainage system shall be the deep-seal type that is conventionally vented within the plumbing system.

An additional vent shall be installed between the holding tank drain check valve and the drain trap, on the inlet side of the trap, to close and seal the check valve while the holding tank is operating under vacuum and collecting waste.

The additional vent described in 5.3.8.3.10.3(3) shall be permitted to be connected to the plumbing system vents, unless a drain pump system with a positive pressure discharge is installed, in which case 5.3.8.3.10.4 shall apply.

Both of the vents in 5.3.8.3.10.3(3) and (4) shall extend vertically to not less than 152 mm (6 in.) above the top of the holding tank before turning horizontal.

Outdoor vents shall be protected against the entry of insects, vermin, debris, and precipitation.

The trap and drain branch shall be not less than two pipe sizes larger than the waste pipe from the separator, but not less than DN50 (NPS 2).

The trap seal shall be not less than 100 mm (4 in.) deep.

The vent for the vacuum check valve shall be not less than the size of the check valve.

The vent for the trap shall be not less than one-half the size of the trap and drain branch.

5.3.8.3.10.4\*

Where the drainage is from a waste holding tank on the suction side of the vacuum source and a positive discharge pump drain system is in place, the following requirements shall be met:

The pump shall drain indirectly to the plumbing system through an air gap equal to the diameter of the discharge pipe but not less than 25.4 mm (1 in.) above the rim.

A check valve shall be installed in the drain line from the holding tank to the drain.

The trap in the building drainage system shall be the deep-seal type that is conventionally vented within the plumbing system.

The trap and drain branch shall be not less than two pipe sizes larger than the waste pipe from the separator, but not less than DN40 (NPS 11/2).

The trap seal shall be at least two times the exhaust back pressure in the separator but not less than 100 mm (4 in.) deep.

5.3.8.3.10.5

Where the drainage is at a positive pressure from an air/waste separator on the discharge side of the vacuum source, the following requirements shall be met:

Where there is a positive pressure discharge from a vacuum pump, it shall be required to drain through an air/waste separator.

Discharge shall be either of the following:

Direct into a trap in the building drainage system that is the deep-seal type and is conventionally vented within the plumbing system

Indirect to the plumbing system through an air gap equal to the diameter of the discharge pipe, but not less than 25.4 mm (1 in.) above the rim

The trap vent shall extend vertically to not less than 152 mm (6 in.) above the top of the separator before turning horizontal.

Outdoor vents shall be protected against the entry of insects, vermin, debris, and precipitation.

The trap and drain branch shall be two pipe sizes larger than the waste pipe from the separator, but not less than DN40 (NPS 11/2).

The air/waste separator vent shall be the full size of the separator vent connection.

The separator vent shall be separate from the building vent piping.

5.3.8.3.10.6

The indirect drainage from vacuum equipment shall discharge to the sanitary drainage system through an approved air gap without causing overflow or splatter on building surfaces.

5.3.8.3.11 Vacuum Exhaust

The exhaust from Category 3 vacuum and scavenging sources shall comply with the following:

The exhaust shall be piped to the outside through a separate vent system.

The exhaust point shall be chosen to minimize the hazards of noise.

The exhaust point shall be remote from any door, window, or other opening into the building.

The exhaust point shall be located at a different elevation than air intakes.

The exhaust point shall not be located where affected by prevailing winds, adjacent buildings, topography, or other obstacles to the rapid dispersion of the exhaust gases.

The exhaust point shall be protected against the entry of insects, vermin, debris, and precipitation.

The exhaust piping shall be sized to prevent back pressure greater than the pump manufacturer's recommendations.

\*Where multiple pumps exhaust through a common pipe, each pump shall be fitted with a check valve or a manual isolation valve or shall be arranged to allow capping the individual pump exhausts when a pump is removed for service.

Where multiple pumps exhaust through a common pipe, piping shall be arranged following the pump manufacturer's recommendations.

5.3.9 Performance Criteria and Testing — Category 3 Gas-Powered Device Supply Systems, Vacuum Systems, and Scavenging Systems

5.3.9.1 General

5.3.9.1.1

Inspection and testing shall be performed on all new piped Category 3 gas-powered device supply systems (compressed air and nitrogen), Category 3 vacuum systems, Category 3 scavenging systems, and their additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that all applicable provisions of this document have been adhered to and system integrity has been achieved or maintained.

5.3.9.1.2

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.

5.3.9.1.3

Reports shall contain detailed listings of all findings and results.

5.3.9.1.4

The responsible facility authority shall review the inspection and test records prior to the use of any systems to ensure that all findings and results of the inspections and tests have been successfully completed.

5.3.9.1.5

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

5.3.9.1.6

Before piping systems are initially put into use, the Category 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 or vacuum.

5.3.9.2 Initial Testing of Category 3 Gas-Powered Device Supply Systems, Category 3 Vacuum Systems, and Category 3 Scavenging Systems

5.3.9.2.1 General

5.3.9.2.1.1

The initial tests required by 5.3.9.2 shall be performed prior to the final tests required by 5.3.9.3.

5.3.9.2.1.2

Initial tests shall be conducted by one or more of the following, who shall be experienced in the installation, operation, and testing of Category 3 gas-powered device supply systems, vacuum systems, and scavenging systems:

Installer

Representative of the system supplier

Representative of the system manufacturer

Medical gas system's verifier qualified under 5.3.6.23.3.1 (A)

5.3.9.2.1.3

The test gas for Category 3 gas-powered device supply systems shall be oil-free, dry nitrogen NF or the system gas.

5.3.9.2.1.4

Where manufactured assemblies are to be installed, the initial tests required under 5.3.9.2 shall be performed as follows:

After completion of the distribution piping

Prior to installation or connection of manufactured assemblies having internal tubing or hose.

At all outlets and inlets on manufactured assemblies having internal copper tubing

5.3.9.2.2 Blow Down

Piping in Category 3 gas-powered device supply systems shall be blown clear using oil-free, dry nitrogen NF as follows:

After installation of the distribution piping

After installation of outlet shutoff valves

Before connection to the use points

Before installation of system components (e.g., pressure indicators, pressure relief valves, manifolds, source equipment)

5.3.9.2.3 Initial Pressure Test for Copper Piping Systems

5.3.9.2.3.1

Each section of the piping in Category 3 gas-powered device supply systems, copper vacuum systems, and copper scavenging systems shall be pressure tested using oil-free, dry nitrogen NF or the system gas.

5.3.9.2.3.2

Initial pressure tests shall be conducted as follows:

After blow down of the distribution piping

After installation of outlet and inlet shutoff valves station outlets and inlets

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

5.3.9.2.3.3

The source shutoff valves for the piping systems shall remain closed during the tests, unless being used for the pressure test gas.

5.3.9.2.3.4

The test pressure shall be 1.5 times the system working pressure but not less than a gauge pressure of 1035 kPa (150 psi).

5.3.9.2.3.5

The test pressure shall be maintained until each joint has been examined for leakage by means of a leak detectant that is safe for use with oxygen and does not contain ammonia.

5.3.9.2.3.6

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

5.3.9.2.4 Initial Leak Test for Category 3 Plastic Vacuum and Scavenging Piping Systems

5.3.9.2.4.1

Each section of the piping in Category 3 vacuum and scavenging systems with plastic piping shall be leak tested using a test vacuum or the vacuum source equipment.

5.3.9.2.4.2

If installed, the vacuum source shutoff valves for the piping systems shall remain closed during the tests, unless being used for the leak test vacuum source.

5.3.9.2.4.3

The leak test vacuum shall be a minimum of 300 mm (12 in.) HgV.

5.3.9.2.4.4

The test vacuum shall be maintained until each joint has been examined for leakage by means of a leak detectant that is safe for use with oxygen and does not contain ammonia.

5.3.9.2.4.5

Leaks, if any, shall be located, repaired or replaced (if required) by the installer, and retested.

5.3.9.2.5 Initial Cross-Connection Test for Copper Piping Systems

5.3.9.2.5.1

Tests shall be conducted to determine that no cross-connections exist between the Category 3 gas-powered device supply piping systems (compressed air and nitrogen), Category 3 copper vacuum piping systems, and Category 3 copper scavenging piping systems.

5.3.9.2.5.2

The piping systems shall be at atmospheric pressure.

5.3.9.2.5.3

The test gas shall be oil-free, dry nitrogen NF or compressed air.

5.3.9.2.5.4

The source of test gas shall be connected only to the piping system being tested.

5.3.9.2.5.5

The piping system being tested shall be pressurized to a gauge pressure of 345 kPa (50 psi).

5.3.9.2.5.6

The individual system gas outlet and vacuum inlet in each installed gas-powered device and copper vacuum or copper scavenging piping system shall be checked to determine that the test gas pressure is present only at the piping system being tested.

5.3.9.2.5.7

The cross-connection test shall be repeated for each installed Category 3 piping system for gas-powered devices and for vacuum and scavenging with copper piping.

5.3.9.2.5.8

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

5.3.9.2.6 Initial Cross-Connection Test for Category 3 Plastic Vacuum and Scavenging Piping Systems

5.3.9.2.6.1

Tests shall be conducted to determine that no cross-connections exist between any Category 3 plastic vacuum piping systems or Category 3 plastic scavenging piping systems and any Category 3 gas-powered device supply systems.

5.3.9.2.6.2

The vacuum source shutoff valves for the vacuum piping systems shall remain closed during the tests, unless they are being used for the cross-connection test vacuum source.

5.3.9.2.6.3

The cross-connection test vacuum shall be a minimum of 300 mm (12 in.) HgV.

5.3.9.2.6.4

The source of test vacuum shall be connected only to the vacuum piping system being tested.

5.3.9.2.6.5

The individual gas-powered device system gas outlets and vacuum/scavenging system inlets shall be checked to determine that the test vacuum is only present at the vacuum/scavenging piping system being tested.

5.3.9.2.6.6

The cross-connection tests shall be repeated for each installed vacuum and scavenging system with plastic piping.

5.3.9.2.6.7

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

5.3.9.2.7 Initial Piping Purge Test for Gas-Powered Device Systems

5.3.9.2.7.1

The outlets in each Category 3 gas-powered device supply piping system shall be purged to remove any particulate matter from the distribution piping.

5.3.9.2.7.2

The test gas shall be oil-free, dry nitrogen NF or the system gas.

5.3.9.2.7.3

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.

5.3.9.2.7.4

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

5.3.9.2.8 Initial Standing Pressure Test for Gas-Powered Device Systems Piping

After successful completion of the initial pressure tests under 5.3.9.2.3, Category 3 gas-powered device distribution piping shall be subjected to a standing pressure test.

5.3.9.2.8.1

Tests shall be conducted after the installation of outlet valves and other distribution system components (e.g., pressure indicators and line pressure relief valves).

5.3.9.2.8.2

The source valve shall be closed unless the source gas is being used for the test.

5.3.9.2.8.3

The piping systems shall be subjected to a 24-hour standing pressure test using oil-free, dry nitrogen NF or the system gas.

5.3.9.2.8.4

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

5.3.9.2.8.5

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).

5.3.9.2.8.6

Leaks, if any, shall be located, repaired (unless prohibited) or replaced (if required) by the installer, and retested.

5.3.9.3 Final Testing of Category 3 Gas-Powered Device Supply Systems, Vacuum Systems, and Scavenging Systems

5.3.9.3.1 General

5.3.9.3.1.1

Final testing of gas-powered device systems, vacuum systems, and scavenging systems shall be performed only after all initial tests required by 5.3.9.2 have been performed.

5.3.9.3.1.2

The final tests required by 5.3.9.3.2 through 5.3.9.3.6 shall be performed by one or more of the following, who shall be experienced with the installation, operation, and testing of Category 3 gas-powered device supply systems, vacuum systems, and scavenging systems:

Installer

Representative of the system supplier

Representative of the system manufacturer

Medical gas systems verifier qualified under 5.3.6.23.3.1(A)

5.3.9.3.1.3

The test gas shall be oil-free, dry nitrogen NF or the system gas or vacuum.

5.3.9.3.2 Final Standing Pressure Test (Category 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:

After the system is filled with oil-free, dry nitrogen NF or the system gas, the source valve shall be closed.

The piping system downstream of the valve shall show no decrease in pressure after 10 minutes.

Any leaks found shall be located, repaired (unless prohibited) or replaced (if required) by the installer, and retested.

5.3.9.3.3 Final Standing Vacuum Test (Category 3 Vacuum and Scavenging Systems)

Each Category 3 vacuum and scavenging piping system shall be subjected to a 10-minute standing vacuum test at operating line vacuum using the following procedures:

After the system has stabilized at the operating line vacuum, the source valve and any zone valves shall be closed.

The piping system upstream of the valves shall show no decrease in vacuum after 10 minutes.

Leaks, if any, shall be located, repaired (unless prohibited) or replaced (if required) by the installer, and retested.

5.3.9.3.4 Final Cross-Connection Test (Category 3 Gas-Powered Devices and Vacuum and Scavenging Systems)

After closing of walls and completion of the requirements of 5.3.9.2, it shall be determined that no cross-connections exist between the piping systems for Category 3 gas-powered devices and vacuum and scavenging systems using the following method:

Test each piping system independently, starting with the vacuum and scavenging systems first, and check that the test vacuum is present only at inlets of the system being tested.

Reduce all piping systems to atmospheric pressure.

Operate the Category 3 vacuum or scavenging system being tested at the normal system vacuum, using the source equipment.

Test each Category 3 gas-powered device gas outlet and vacuum or scavenging inlet using 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 or scavenging systems.

Shut down the vacuum source equipment and slowly break the vacuum in the vacuum piping system, increasing its pressure to atmospheric.

Test each Category 3 vacuum and scavenging system until all are determined to be free of cross-connections.

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).

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.

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.

Proceed to test each gas-powered device piping system until all are determined to be free of cross-connections.

5.3.9.3.5 Final Piping Purge Test (Category 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.

5.3.9.3.5.1

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

5.3.9.3.5.2

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.

5.3.9.3.5.3

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

5.3.9.3.6 Final Tie-in Test (Category 3 Gas-Powered Devices and Vacuum and Scavenging Systems)

5.3.9.3.6.1

Prior to the connection of any new piping in extensions or additions to an existing piping system, the final tests in 5.3.9.3 shall be successfully performed on the new work.

5.3.9.3.6.2

Each joint in the final connection between the new work and the existing system shall be leak-tested, with the gas of system designation or vacuum at the normal operating pressure or vacuum, by means of a leak detectant that is safe for use with oxygen and does not contain ammonia.

5.3.9.3.6.3

For gas-powered device piping, immediately after a 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 5.3.9.3.5.

5.3.9.3.7 Source Equipment Testing (Category 3 Gas-Powered Devices and Vacuum and Scavenging Systems)

5.3.9.3.7.1 General

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

5.3.9.3.7.2 Use of Source Equipment for Distribution Piping Tests

Where the source equipment and system gas or vacuum is used for testing of the distribution piping, the source equipment shall be checked out and placed in operation prior to testing the distribution piping.

5.3.9.3.7.3 Compliance With Manufacturer's Instructions

The source equipment for a Category 3 gas-powered device system(s), vacuum system(s), and scavenging system(s) shall be checked out and placed in operation according to the manufacturer's instructions.

5.3.10 Compressed Gas Cylinders and Containers

5.3.10.1

Only cylinders and containers constructed, tested, and maintained in accordance with U.S. Department of Transportation specifications and regulations shall be permitted to be used.

5.3.10.2

Cylinder contents shall be identified by attached labels or stencils naming the contents in accordance with CGA C-7, Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers.

5.3.10.3

The contents of cylinders and containers shall be verified prior to use.

5.3.10.4

Labels shall not be defaced, altered, or removed, and connecting fittings shall not be modified.

5.3.11 Labeling and Identification

5.3.11.1 Pipe Labeling

5.3.11.1.1

Piping, both exposed and concealed, 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 its chemical symbol.

5.3.11.1.3

Where positive pressure gas piping systems operate at nonstandard pressures, the pipe labels shall also 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:

At intervals of not more than 6.1 m (20 ft)

At least once in or above every room

On both sides of walls or partitions penetrated by the piping

At least once in every story height on risers

5.3.11.2 Identification of Shutoff Valves

Shutoff valves shall be identified with the following information:

Name or chemical symbol for the specific system

Name of the room(s) or area(s) served

Caution to not close (or open) the valve except in an emergency

5.3.11.3 Identification of Outlets and Inlets

Outlets and inlets shall be identified as to the name or chemical symbol for the specific gas, vacuum, or scavenging provided.

5.3.12\* System Use and Instructions

5.3.12.1 Prohibited System Interconnections

5.3.12.1.1

Two or more systems for Category 3 medical gas, gas-powered device gas, or vacuum and scavenging shall not be interconnected for testing or any other reason.

5.3.12.1.2

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

5.3.12.2 Changes in System Use

5.3.12.2.1

Where a Category 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 and requirements of Section 5.3 shall apply.

5.3.12.2.2

Piping for Category 3 gas-powered devices or Category 3 vacuum shall not be permitted to be converted for use as a Category 3 medical gas piping system for oxygen or nitrous oxide.

5.3.12.3 System and Equipment Manufacturer's Instructions

5.3.12.3.1

The installation of individual components shall be made in accordance with the system or equipment manufacturer's instructions.

5.3.12.3.2

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

5.3.12.3.3

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

5.3.13 Operation and Management of Category 3 Systems

5.3.13.1

Precautions for handling cylinders shall be in accordance with Chapter 11.

5.3.13.2 Special Precautions for the Use of Category 3 Gas and Vacuum Piping Systems

5.3.13.2.1

Category 3 gas piping systems shall not be used for the distribution of flammable anesthetic gases.

5.3.13.2.2

Piping systems for Category 3 gases shall not be used as grounding electrodes.

5.3.13.2.3

Category 3 vacuum piping shall not be used for vacuum steam condensate return or other nonmedical vacuum applications.

5.3.13.2.4

Every Category 3 facility shall establish a procedure for manually turning off the gas supply at the cylinder valves at the end of each work day.

5.3.13.2.5

Emergency shutoff valves or remote actuators shall not be used to turn off the gas supply at the end of the work day.

5.3.13.3 Category 3 Gas and Vacuum Systems Identification and Warning Signs

The labeling and identification of Category 3 gas and vacuum systems shall comply with the requirements of 5.3.11.

5.3.13.4 Category 3 Gas and Vacuum Systems Maintenance and Record Keeping

5.3.13.4.1

Permanent records of all tests required by Section 5.3 shall be maintained on-site in the organization's files.

5.3.13.4.2

A periodic testing procedure for Category 3 gas and vacuum systems and related alarm systems shall be implemented.

5.3.13.4.3

Whenever modifications are made that breach the pipeline, any necessary installer and verification test specified in 5.3.9 shall be conducted on the downstream portions of the medical gas piping system.

5.3.13.4.4

A maintenance program shall be established for the following:

Relief valves in accordance with applicable codes or manufacturer's recommendation

Drive gas supply system in accordance with manufacturer's recommendations

Vacuum source equipment and accessories in accordance with manufacturer's recommendations

Vacuum piping system and the secondary equipment attached to vacuum station inlets to ensure the continued good performance of the entire vacuum system

Scavenging systems to ensure performance

5.3.13.4.5

An audible and visual alarm indicator(s) shall meet the following requirements:

It shall be periodically tested to determine that it is functioning properly.

The records of the test shall be maintained until the next test is performed.