Committee Input No. 1117-NFPA 99-2021 [Sections 5.1.1.1, 5.1.1.2]

Sections 5.1.1.1, 5.1.1.2

5.1.1.1

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

~~**5.1.1.2** –~~

~~Category 1 piped gas or piped vacuum system requirements shall be applied where any of the following criteria is met:~~

(1) ~~General anesthesia, as defined in 3.3.68.1 , or deep sedation, as defined in 3.3.68.2 , is performed.~~

(2) ~~The loss of the piped gas or piped vacuum systems is likely to cause major injury or death of patients, staff, or visitors.~~

Submitter Information Verification

Committee: HEA-PIP

Submittal Date: Mon Aug 16 09:07:19 EDT 2021

Committee Statement

Committee Statement: This CI is intended to permit further review for action at the second draft stage. It is noted that the determination of risk categories is based on the risk assessment required by Ch. 4. A task group has been appointed to further study the correlation of the risk categories with the requirements of Chs. 5 and 15.

Response Message: CI-1117-NFPA 99-2021

Committee Input No. 1071-NFPA 99-2021 [Section No. 5.1.9]

~~**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:~~

(1) ~~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~~

(2) ~~Visual indicators that remain in alarm until the situation that has caused the alarm is resolved~~

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

(4) ~~Means to indicate a lamp or LED failure and audible failure~~

(5) ~~Visual and audible indication that the communication with an alarm-initiating device is disconnected~~

(6) ~~Labeling of each indicator, indicating the condition monitored~~

(7) ~~Labeling of each alarm panel for its area of surveillance~~

(8) ~~Reinitiating of the audible signal if another alarm condition occurs while the audible alarm is silenced~~

(9) ~~Power for master alarms, area alarms, sensors, and switches from the life safety branch of the essential electrical system as described in Chapter 6~~

(10) ~~Power for local alarms, dew point sensors, and carbon monoxide sensors permitted to be from the same essential electrical branch as is used to power the air compressor system~~

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

(12) ~~Conduit~~

(13) ~~Free air~~

(14) ~~Wire~~

(15) ~~Cable tray~~

(16) ~~Raceways~~

(17) ~~Communication devices that do not use electrical wiring for signal transmission and are supervised such that failure of communication initiates an alarm~~

(18) ~~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~~

(19) ~~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~~

(20) ~~Alarm switches/sensors installed so as to be removable and accessible for service and testing~~

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:

(1) 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.

(2) 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 5.1.9.3 .

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 –

If communication is achieved by wires, the following shall apply:

(A) –

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

(B) –

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.

(C) –

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.

(D) –

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:

(1) 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.

(2) A single set of wires complying with 5.1.9.2.3.1(B) and 5.1.9.2.3.1(C) for each signal shall be permitted to connect the initiating device and the junction box.

(3) Between the junction box and the two mandatory alarm panels, wiring shall comply with 5.1.9.2.3.1(A) through 5.1.9.2.3.1(C) , 5.1.9.2.3.4 , and 5.1.9.2.3.5 in all respects.

5.1.9.2.3.2 –

If communication is achieved by means other than wires, the following shall apply:

~~**(A)** –~~

~~Each of the mandatory alarms shall communicate independently to the initiating device(s) for each signal.~~

~~**(B)** –~~

~~The means of communication between each mandatory alarm(s) and the initiating device(s) shall not utilize a common communication device that, if interrupted, would disable the signal from another initiating device(s).~~

~~**5.1.9.2.3.3** –~~

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

~~**5.1.9.2.3.4** –~~

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

~~**5.1.9.2.3.5** –~~

~~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.~~

~~**5.1.9.2.3.6** –~~

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

~~**5.1.9.2.3.7** –~~

~~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.~~

~~**5.1.9.2.3.8** –~~

~~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:

(1) 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

(2) Alarm indication for a cryogenic fluid central supply system when the main supply reaches one average day's supply, indicating low contents

(3) 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

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

(5) For cryogenic fluid central supply systems, an alarm when or at a predetermined set point before the reserve supply contents fall to one average day's supply, indicating low reserve

(6) Where a cryogenic liquid storage unit is used as a reserve for a cryogenic fluid central 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

(7) 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

(8) 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

(9) 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

(10) 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)

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

(12) 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)

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

(14) When oxygen is supplied from an oxygen central supply system using concentrators *(see 5.1.3.9)* , the following signals shall be provided:

(15) For each concentrator unit used in the oxygen central supply system, an alarm indication that oxygen concentration from that oxygen concentrator unit is below 91 percent

(16) For each oxygen concentrator unit used in the oxygen central supply system, an alarm indication that the isolating valve for that oxygen concentrator unit is closed and the unit is isolated

(17) For each cylinder header used as a source, an alarm indication that the header is in use

(18) For each cylinder header used as a source, an alarm indication that the cylinder contents are below one average day's supply

(19) If the source in use changes because of a failure to appropriately supply the system, an alarm indication that an unexpected oxygen supply change has occurred

(20) An alarm indication that the pressure in the common line on the source side of the line pressure controls is low

(21) An alarm indication that the oxygen concentration from the supply system is below 91 percent

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 5.1.4.3)* , the sensors shall be located downstream (on the patient or use side) of the main valve.

5.1.9.3 – 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 5.1.9.3.1 and the programming characteristics described in 5.1.9.3.2 .

5.1.9.3.1 –

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

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

(2) 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).

(3) 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).

(4) If the computer system does not power the signaling switches/sensors from the same power supply required in 5.1.9.3.1(1) , the power supply for the signaling switches/sensors shall be powered from the life safety branch of the essential electrical system as described in Chapter 6 .

(5) 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.

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

(7) 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.

(8) The facility shall ensure compliance with 5.1.9.1(13) .

5.1.9.3.2 –

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

(1) The medical gas alarm shall be allocated the priority of a life safety signal.

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

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

(4) The alarm algorithm shall provide for compliance with 5.1.9.1(1) through 5.1.9.1(5) , and 5.1.9.1(8) .

5.1.9.4 * – Area Alarms.

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

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

(2)* Category 1 space

5.1.9.4.1 * –

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

5.1.9.4.2 –

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.

5.1.9.4.3 –

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.

5.1.9.4.4 * –

Alarm sensors for area alarms shall be located as follows:

(1)* Category 1 spaces, other than anesthetizing locations addressed in 5.1.9.4.4 (2), shall have the alarm sensors installed on the patient or use side of each of the individual zone valve box assemblies.

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

5.1.9.4.5 –

One area alarm panel shall be acceptable to monitor multiple rooms located within an immediate vicinity meeting the requirements of 5.1.9.4.4(2) .

5.1.9.4.6 –

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).

5.1.9.5 * – 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:

(1) On or in the control panel(s) for the central supply system or supply source being monitored

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

(3) 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 central supply system, for a specific gas or vacuum pipeline or more than one central supply system and pipeline for the same gas in the building, then it shall be necessary for each location to have separate local alarms per 5.1.9.5.4 and signals at the master panels per 5.1.9.2.4 .

~~**5.1.9.5.4** –~~

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

(1) ~~Low medical air reserve capacity, to indicate when the medical air source is operating under a demand that could not be managed if one compressor ceased to operate~~

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

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

(4) ~~Low medical vacuum reserve capacity, to indicate when the medical vacuum source is operating under a demand that could not be managed if one pump ceased to operate~~

(5) ~~Low WAGD reserve capacity, to indicate when the WAGD source is operating under a demand that could not be managed if one producer ceased to operate~~

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

(7) ~~Low instrument air reserve capacity, if instrument air is provided by a source with more than one compressor, to indicate when the instrument air source is operating under a demand that could not be managed if one compressor ceased to operate~~

(8) ~~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~~

(9) ~~For compressor systems using liquid ring compressors, high water in the separator~~

(10) ~~For compressor systems using other than liquid ring compressors, high discharge air temperature~~

(11) ~~Proportioning systems high/low indicator when the oxygen concentration is outside the 19.5 percent to 23.5 percent oxygen range~~

(12) ~~Proportion systems reserve system in operation~~

(13) ~~When oxygen is supplied from an oxygen central supply system using concentrators *(see 5.1.3.9)* , the following signals shall be provided at the system's local alarm site(s):~~

(14) ~~For each cylinder header used as a source, an alarm indication that the header is in use~~

(15) ~~For each cylinder header used as a source, an alarm indication that the cylinder contents are below one average day's supply~~

(16) ~~If the source in use changes because of a failure to appropriately supply the system, an alarm indication indicating an unexpected oxygen supply change has occurred~~

(17) ~~An alarm indication that the pressure in the common line on the source side of the line pressure controls is low~~

(18) ~~An alarm indication that the oxygen concentration from the supply system is below 91 percent~~

[See attached "CI-1071" file]

Supplemental Information

File Name	Description	Approved

CI-1071.docx

Submitter Information Verification

Committee: HEA-PIP

Submittal Date: Thu Aug 05 18:03:36 EDT 2021

Committee Statement

Committee Statement: Further review of the alarm requirements of 5.1.9 is needed. This committee input is intended to solicit public comments and to permit revisions to be made at the second draft stage if warranted.

Response Message: CI-1071-NFPA 99-2021

Public Input No. 3-NFPA 99-2020 [Section No. 5.1.9]

From: Harrington, Greg <gharrington@NFPA.org>
Sent: Wednesday, August 4, 2021 3:32 PM
To: Carroll, Elena <ecarroll@nfpa.org>
Subject: FW: PI#3

Elena, could you please forward to HEA-PIP? Thx.

From: m.allen@toposit.net <m.allen@toposit.net>

Delete 5.1.9.1 (5); (11); (12), 5.1.9.2.3 in favor of new clause:

5.1.9.2 Alarm Communication. Communication which is essential to the mandatory surveillance described in 5.1.9.2.4 (signals in the master alarm), 5.1.9.2.1 (master alarm to master alarm), 5.1.9.5.1 (local alarm to master alarm(s)), 5.1.9.5.4 (signals in the local alarm(s)), 5.1.9.4.2 (pressure signals in area alarms) or 5.1.9.4.3 (vacuum signals in area alarm(s)), including communication between alarm signals and their associated switches and sensors or between alarm panels shall comply with the the appropriate clauses below:

5.1.9.2.1* if by dedicated signal wiring;

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

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

(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.

(4) wiring shall be supervised or protected as required by 517.30(C)(3) of NFPA 70 for life safety and critical branches circuits in which protection is any of the following types:
a.
Conduit
b.
Free air
c.
Wire
d.
Cable tray
e.
Raceways
(5) interruption of the circuit (e.g. by wire breakage or disconnection) shall initiate the associated visual signal(s) and audio alert(s).

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

(a)
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.
(b)

A single set of wires complying with 5.1.9.2.3.1(B) and 5.1.9.2.3.1(C) for each signal shall be permitted to connect the initiating device and the junction box.

(c)

Between the junction box and the two mandatory alarm panels, wiring shall comply with 5.1.9.2.3.1(A) through 5.1.9.2.3.1(C), 5.1.9.2.3.4, and 5.1.9.2.3.5 in all respects.

5.1.9.2.2 if by physical communication (e.g. wired ethernet, fiberoptic or other transmission over a physical medium):

(1) At least one of the mandatory master alarms shall be wired directly to the alarm-initiating device(s) that they monitor.

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

(3) interruption of the communication whether due to failure of the physical medium by breakage or disconnection, failure of any intermediary device necessary to continued communication (e.g. hubs, routers, switches, etc.) shall initiate either:

(A) all the affected visual signal(s) and audio alert(s) or;

(B) a specific signal failure signal and audio alert(s) indicating that communication has been interrupted and the alarms are no longer functional .

(4) all devices required for the communication of signals shall be powered from the life safety branch of the essential electrical system as described in Chapter 6.

5.1.9.2.3 if by intangible communication (e.g. wireless, lifi, etc.):

(1) At least one of the mandatory master alarms shall be wired directly to the alarm-initiating device(s) that they monitor.

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

(3) interruption of the communication whether due to interference in the intangible medium or failure of any intermediary device necessary to continued communication (e.g. transmitters, receptors, etc.) shall initiate all the affected visual signal(s) or a specific signal failure signal indicating that communication has been interrupted and the alarms are no longer functional. All audio alert(s) shall also activate.

(4) at least two independent pathways for communication shall be provided (i.e. a mesh network or similar);

(5) all devices required for the communication of signals shall be powered from the life safety branch of the essential electrical system as described in Chapter 6.

5.1.9.2.4 Alarm communication may utilize multiple methods within a single panel or within a complete alarm system. Where multiple methods are used, each signal shall be considered separately for compliance with 5.1.9.2.

5.1.9.2.5 The Responsible Facility Authority shall include in their emergency plan a protocol for providing at least equivalent surveillance of the medical gas sources in the event any alarm or alarm signal becomes inoperative through interruption of communications. Such equivalent surveillance shall remain in place until full normal operation of all alarms is restored.

Renumber sections that follow (current 5.1.9.2 to end)

Substantiation:

The original submission appears as an attempt to clarify some of the requirements that earlier work on this subject included in the standard. This is an advisable change, as users are struggling to understand the

requirements in light of the available technologies. Part of that struggle is due to the earlier changes having been created in the context of what the code already included (i.e. wiring) rather than a more complete rewrite around the technologies actually available. It would appear that a more complete correction would be useful.

The three classes of known methods are grouped here (wire, communication using a physical medium and wireless formats) Each is separately described and specific requirements for each are clarified based on their unique risks.

Because it is understood that these are still emerging technologies without wide use or long histories of successful use, the proposal continues to consider wired alarms as the "gold standard".

It is not practical to implement these technologies within the context of the rule that prohibited a single device that could take out more than one signal (see 99 18 5.1.9.2.3.2 (b)) Therefore, this requirement should be deleted. However, a side effect of this change is that the "master-slave" alarm configuration which has been long prohibited must be permitted (see 99 18 5.1.9.2.3.6).

To deal with these two points, two new mandates are proposed:
1. one of the two master alarms must be wired. In this way at least one of the alarms will operate without fail.
2. the facility must have a plan to deal with loss of communication such that should communication be lost, they are ready to compensate.

The net effect of the proposal is intended to read as follows:

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

1. Separate visual indicators for each condition monitored, except as permitted in 5.1.9.5.2 for local alarms that are displayed on master alarm panels;
2. Visual indicators that remain in alarm until the situation that has caused the alarm is resolved;
3. Cancelable audible indication of each alarm condition that produces a sound with a minimum level of 80 dBA at 0.92 m (3 ft);
4. Means to indicate a lamp or LED failure and audible failure;
5. Labeling of each indicator, indicating the condition monitored;
6. Labeling of each alarm panel for its area of surveillance;
7. Reinitiating of the audible signal if another alarm condition occurs while the audible alarm is silenced;
8. Power for master alarms, area alarms, sensors, and switches from the life safety branch of the essential electrical system as described in Chapter 6;
9. 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;
10. 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;
11. 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;
12. Alarm switches/sensors installed so as to be removable and accessible for service and testing.

5.1.9.2 Alarm Communication. Communication which is essential to the mandatory surveillance described in 5.1.9.3.3 (signals in the master alarm), 5.1.9.3.1 (master alarm to master alarm), 5.1.9.5.1 (local alarm to master alarm(s)), 5.1.9.5.4 (signals in the local alarm), and 5.1.9.4 (signals in an area alarm), including that between alarm signals and their associated switches and sensors or between alarm panels shall comply with the the appropriate clauses below:

5.1.9.2.1* if by dedicated signal wiring;

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

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

(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.

(4) wiring shall be supervised or protected as required by 517.30(C)(3) of NFPA 70 for life safety and critical branches circuits in which protection is any of the following types:

a.
Conduit

b.
Free air

c.
Wire

d.
Cable tray

e.
Raceways

(5) interruption of the circuit (e.g. by wire breakage or disconnection) shall initiate the associated visual signal(s) and audio alert(s).

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

(a)
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.

(b)
A single set of wires complying with 5.1.9.2.3.1(B) and 5.1.9.2.3.1(C) for each signal shall be permitted to connect the initiating device and the junction box.

(c)
Between the junction box and the two mandatory alarm panels, wiring shall comply with 5.1.9.2.3.1(A) through 5.1.9.2.3.1(C), 5.1.9.2.3.4, and 5.1.9.2.3.5 in all respects.

5.1.9.2.2 if by physical communication (e.g. wired ethernet, fiberoptic or other transmission over a physical medium):

(1) At least one of the mandatory master alarms shall be wired directly to the alarm-initiating device(s) that they monitor.

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

(3) interruption of the communication whether due to failure of the physical medium by breakage or disconnection, failure of any intermediary device necessary to continued communication (e.g. hubs, routers, switches, etc.) shall initiate either all the affected visual signal(s) or a specific signal failure signal indicating that communication has been interrupted and the alarms are no longer functional. All audio alert(s) shall also activate.

(4) all devices required for the communication of signals shall be powered from the life safety branch of the essential electrical system as described in Chapter 6.

5.1.9.2.3 if by intangible communication (e.g. wireless, lifi, etc.):

(1) At least one of the mandatory master alarms shall be wired directly to the alarm-initiating device(s) that they monitor.

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

(3) interruption of the communication whether due to interference in the intangible medium or failure of any intermediary device necessary to continued communication (e.g. transmitters, receptors, etc.) shall initiate all the affected visual signal(s) or a specific signal failure signal indicating that communication has been interrupted and the alarms are no longer functional. All audio alert(s) shall also activate.

(4) at least two independent pathways for communication shall be provided (i.e. a mesh network or similar);

(5) all devices required for the communication of signals shall be powered from the life safety branch of the essential electrical system as described in Chapter 6.

5.1.9.2.4 Alarm communication may utilize multiple methods within a single panel or within a complete alarm system. Where multiple methods are used, each signal shall be considered separately for compliance with 5.1.9.2.

5.1.9.2.5 The Responsible Facility Authority shall include in their emergency plan a protocol for providing at least equivalent surveillance of the medical gas sources in the event any alarm or alarm signal becomes inoperative through interruption of communications. Such equivalent surveillance shall remain in place until full normal operation of all alarms is restored.

5.1.9.3* 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.

5.1.9.3.1

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

1.
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.

2.
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).

5.1.9.3.2

A centralized computer system shall be permitted to be substituted for one of the master alarms required in 5.1.9.3 if the computer system complies with 5.1.9.4.

5.1.9.3.3

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

1.
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

2.
Alarm indication for a cryogenic fluid central supply system when the main supply reaches one average day’s supply, indicating low contents

3.

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

4.

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

5.

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

6.

Where a cryogenic liquid storage unit is used as a reserve for a cryogenic fluid central 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

7.

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

8.

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

9.

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

10.

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)

11.

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

12.

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)

13.

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

14.

When oxygen is supplied from an oxygen central supply system using concentrators *(see 5.1.3.9)*, the following signals shall be provided:

1.

For each concentrator unit used in the oxygen central supply system, an alarm indication that oxygen concentration from that oxygen concentrator unit is below 91 percent

2.

For each oxygen concentrator unit used in the oxygen central supply system, an alarm indication that the isolating valve for that oxygen concentrator unit is closed and the unit is isolated

3.

For each cylinder header used as a source, an alarm indication that the header is in use

4.

For each cylinder header used as a source, an alarm indication that the cylinder contents are below one average day's supply

5.

If the source in use changes because of a failure to appropriately supply the system, an alarm indication that an unexpected oxygen supply change has occurred

6.

An alarm indication that the pressure in the common line on the source side of the line pressure controls is low

7.

An alarm indication that the oxygen concentration from the supply system is below 91 percent

5.1.9.3.4

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 5.1.4.3)*, the sensors shall be located downstream (on the patient or use side) of the main valve.

5.1.9.4 Master Alarms by Computer Systems.

Computer systems used as substitute master alarms as required by 5.1.9.3 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:

1. The computer system shall be in continuous uninterrupted operation and provided with power supplies as needed to ensure such reliability.
2. 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).
3. 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).
4. If the computer system does not power the signaling switches/sensors from the same power supply required in 5.1.9.3.1(1), the power supply for the signaling switches/sensors shall be powered from the life safety branch of the essential electrical system as described in Chapter 6.
5. Computer systems shall be permitted to communicate directly to the sensors/switches required in 5.1.9.3.3 in the same manner as an alarm panel if operation of another alarm panel(s) is not impaired.
6. Communication from the computer system to the signaling switches or sensors shall be supervised such that failure of communication shall initiate an alarm.
7. 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.
8. The facility shall ensure compliance with 5.1.9.1(11).

5.1.9.4.2

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

1. The medical gas alarm shall be allocated the priority of a life safety signal.
2. A medical gas alarm signal shall interrupt any other activity of a lesser priority to run the alarm algorithm(s).
3. The alarm algorithm shall include activation of an audible alert, activation of any remote signaling protocol, and display of the specific condition in alarm.
4. The alarm algorithm shall provide for compliance with 5.1.9.1(1) through 5.1.9.1(7).

5.1.9.4* Area Alarms.

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

1.
Anesthetizing locations where moderate sedation, deep sedation, or general anesthesia is administered
2.
*Category 1 space

5.1.9.4.1*
Area alarms shall be located at a nurse's station or other similar location that will provide for surveillance.

5.1.9.4.2
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.

5.1.9.4.3
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.

5.1.9.4.4
Alarm sensors for area alarms shall be located as follows:
1.
*Category 1 spaces shall have the alarm sensors installed on the patient or use side of each individual zone valve box assemblies.
2.
*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.

5.1.9.4.5
One area alarm panel shall be acceptable to monitor multiple rooms located within an immediate vicinity meeting the requirements of 5.1.9.4.4(2).

5.1.9.4.6
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).

5.1.9.5* 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:
1.
On or in the control panel(s) for the central supply system or supply source being monitored
2.
Within a monitoring device (e.g., dew point monitor or carbon monoxide monitor)
3.
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 central supply system, for a specific gas or vacuum pipeline or more than one central supply system and pipeline for the same gas in the building, then it shall be necessary for each location to have separate local alarms per 5.1.9.5.4 and signals at the master panels per 5.1.9.3.4.

5.1.9.5.4

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

1. Low medical air reserve capacity, to indicate when the medical air source is operating under a demand that could not be managed if one compressor ceased to operate
2. High carbon monoxide level, to indicate when the carbon monoxide level in the medical air system is 10 ppm or higher
3. Medical air dew point high, to indicate when the line pressure dew point is greater than +2°C (+35°F)
4. Low medical vacuum reserve capacity, to indicate when the medical vacuum source is operating under a demand that could not be managed if one pump ceased to operate
5. Low WAGD reserve capacity, to indicate when the WAGD source is operating under a demand that could not be managed if one producer ceased to operate
6. Instrument air dew point high, to indicate when the line pressure dew point is greater than −30°C (−22°F)
7. Low instrument air reserve capacity, if instrument air is provided by a source with more than one compressor, to indicate when the instrument air source is operating under a demand that could not be managed if one compressor ceased to operate
8. 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
9. For compressor systems using liquid ring compressors, high water in the separator
10. For compressor systems using other than liquid ring compressors, high discharge air temperature
11. Proportioning systems high/low indicator when the oxygen concentration is outside the 19.5 percent to 23.5 percent oxygen range
12. Proportion systems reserve system in operation
13. When oxygen is supplied from an oxygen central supply system using concentrators *(see 5.1.3.9)*, the following signals shall be provided at the system's local alarm site(s):

1. For each cylinder header used as a source, an alarm indication that the header is in use
2. For each cylinder header used as a source, an alarm indication that the cylinder contents are below one average day's supply
3. If the source in use changes because of a failure to appropriately supply the system, an alarm indication indicating an unexpected oxygen supply change has occurred
4. An alarm indication that the pressure in the common line on the source side of the line pressure controls is low
5.

An alarm indication that the oxygen concentration from the supply system is below 91 percent

Committee Input No. 1103-NFPA 99-2021 [Section No. 5.1.12.2.3]

5.1.12.2.3 Initial Pressure Test.

5.1.12.2.3.1

Each new section of the

~~piping in~~

medical gas and vacuum pipeline distribution systems shall be pressure tested.

5.1.12.2.3.2

Initial pressure tests shall be conducted as follows:

(1) After blowdown of the distribution piping

(2) After installation of station outlet/inlet rough-in assemblies

(3) 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 if applicable .

5.1.12.2.3.4

The test pressure for pressure gases and vacuum systems shall be 1.5 times the system operating 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 and until the systems have been proven leak free by an accepted industry standard .

5.1.12.2.3.6

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

Submitter Information Verification

Committee: HEA-PIP

Submittal Date: Fri Aug 06 18:33:20 EDT 2021

Committee Statement

Committee Statement: The committee input is in response to PI-342 and is intended to solicit public comments and to permit further review at the second draft stage.

Response Message: CI-1103-NFPA 99-2021

Committee Input No. 1085-NFPA 99-2021 [Section No. 5.1.12.4.8.2]

5.1.12.4.8.2

The outlet most remote from the source shall be tested for total nonmethane hydrocarbons and halogenated hydrocarbons and compared to the source gas and shall be tested for any potential contaminants in the pipeline that could pose a risk to patients due to the manufacturing, cleaning, or installation procedures .

Submitter Information Verification

Committee: HEA-PIP

Submittal Date: Fri Aug 06 15:18:08 EDT 2021

Committee Statement

Committee Statement: The committee is soliciting public comments on appropriate testing for pipeline purity.

Response Message: CI-1085-NFPA 99-2021

Committee Input No. 1118-NFPA 99-2021 [Section No. 5.2.1.2]

~~**5.2.1.2** –~~

~~Category 2 piped gas or piped vacuum system requirements shall be permitted when all of the following criteria are met:~~

(1) ~~Only moderate sedation (as defined in 3.3.68.3), minimal sedation (as defined in 3.3.68.4), or no sedation is performed. Deep sedation and general anesthesia shall not be permitted.~~

(2) ~~The loss of the piped gas or piped vacuum systems is likely to cause minor injury to patients, staff, or visitors.~~

(3) ~~The facility piped gas or piped vacuum systems are intended for Category 2 patient care space per 3.3.140.2 .~~

Submitter Information Verification

Committee: HEA-PIP

Submittal Date: Mon Aug 16 09:11:38 EDT 2021

Committee Statement

Committee Statement: This CI is intended to permit further review for action at the second draft stage. It is noted that the determination of risk categories is based on the risk assessment required by Ch. 4. A task group has been appointed to further study the correlation of the risk categories with the requirements of Chs. 5 and 15.

Response Message: CI-1118-NFPA 99-2021

Committee Input No. 1119-NFPA 99-2021 [Section No. 5.3.1.2]

~~**5.3.1.2** –~~

~~Category 3 piped gas and vacuum systems shall be permitted when all of the following criteria are met:~~

(1) ~~Only minimal sedation, as defined in 3.3.68.4 , or no sedation is performed. Deep sedation, moderate sedation, and general anesthesia are not performed.~~

(2) ~~The loss of the piped gas and vacuum systems is not likely to cause injury to patients, staff, or visitors but can cause discomfort.~~

(3) ~~The facility piped gas and vacuum systems are intended for Category 3 patient care rooms in accordance with 3.3.140.3 .~~

Submitter Information Verification

Committee: HEA-PIP

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Committee Statement

Committee Statement: This CI is intended to permit further review for action at the second draft stage. It is noted that the determination of risk categories is based on the risk assessment required by Ch. 4. A task group has been appointed to further study the correlation of the risk categories with the requirements of Chs. 5 and 15.

Response Message: CI-1119-NFPA 99-2021

Committee Input No. 1075-NFPA 99-2021 [Chapter 15]

~~**Chapter 15** – Dental Gas and Vacuum Systems~~

~~**15.1** – Applicability.~~

~~This chapter shall apply to dental health care facilities that qualify to install dental gas and vacuum piping systems.~~

~~**15.1.1** –~~

~~Category 1 dental piped gas and piped vacuum system requirements shall be applied in facilities where general anesthesia and deep sedation is performed, as defined in 3.3.68.1 and 3.3.68.2 .~~

~~**15.1.2** –~~

~~Category 2 dental piped gas and piped vacuum system requirements shall be applied in facilities where only moderate and minimal sedation is performed, as defined in 3.3.68.3 and 3.3.68.4 .~~

~~**15.1.3** –~~

~~Category 3 dental piped gas and piped vacuum system requirements shall be applied in facilities where minimal or no sedation is performed, as defined in 3.3.68.4 .~~

~~**15.1.4** –~~

~~A single facility shall be permitted to include dental gas and vacuum systems for more than one category of dental piped gas and vacuum systems.~~

~~**15.1.5** –~~

~~An existing system that is not in strict compliance with the provisions of this code shall be permitted to continue in use unless the authority having jurisdiction has determined that such use constitutes a distinct hazard to life.~~

~~**15.1.6** –~~

~~The requirements for Category 1 dental gas and vacuum systems for the operation, management, and maintenance of gas and vacuum piping systems shall apply to both new and existing facilities within the scope of this chapter and in accordance with 5.1.1.5 .~~

~~**15.1.7** –~~

~~The following sections of this chapter shall apply to the operation, management, and maintenance of Category 2 dental gas and vacuum systems in both new and existing facilities:~~

(1) ~~15.1.5~~

(2) ~~15.2~~

(3) ~~15.4.2.4.3~~

(4) ~~15.4.2.4.5~~

(5) ~~15.4.2.4.13~~

(6) ~~15.4.2.5.14~~

(7) ~~15.4.2.6.4~~

(8) ~~15.4.9~~

15.1.8 –

The following sections of this chapter shall apply to the operation, management, and maintenance of Category 3 dental gas and vacuum systems in both new and existing facilities:

(1) 15.1.5

(2) 15.2

(3) 15.5.8

15.1.9 –

Where the term *Responsible Facility Authority* is used, that entity shall follow the requirements of 5.1.14.1 .

15.2 – Nature of Hazards of Gas and Vacuum Systems.

Potential fire and explosion hazards associated with positive-pressure dental gas systems and vacuum systems shall be considered in the design, installation, testing, operation, and maintenance of these systems.

15.3 – Category 1 Dental Gas and Vacuum Systems.

15.3.1 – General.

Facilities that perform deep sedation and general anesthesia associated with dental treatment shall meet the requirements for Category 1 dental gas and vacuum systems.

15.3.2 – Category 1 Medical Gas Systems (Dental).

15.3.2.1 – Medical Gas and Vacuum Sources.

15.3.2.1.1 – Central Supply System Identification and Labeling.

Category 1 systems shall comply with 5.1.3.1 .

15.3.2.1.2 – Central Supply Operations.

Category 1 systems shall comply with 5.1.3.2 .

15.3.2.1.3 – Central Supply System Locations.

Category 1 systems shall comply with 5.1.3.3 .

15.3.2.1.4 – Central Supply Systems.

Category 1 systems shall comply with 5.1.3.5 .

15.3.2.1.5 – Medical Air Supply Systems.

Category 1 systems shall comply with 5.1.3.6 , except as follows:

(1) Medical air compressors, dryers, aftercoolers, filters, and regulators shall be permitted to be simplex.

(2) The facility staff shall develop their emergency plan to deal with the loss of medical air.

15.3.2.1.6 –

Oxygen supply systems using concentrators shall be permitted to consist of two sources, one of which shall be a cylinder header with sufficient cylinder connections for an average day's supply.

15.3.2.1.7 – Medical–Surgical Vacuum Systems.

Category 1 systems shall comply with 5.1.3.7 , except as follows:

(1) Medical–surgical vacuum systems shall be permitted to be simplex.

(2) The facility staff shall develop their emergency plan to deal with the loss of medical–surgical vacuum.

15.3.2.1.8 – WAGD Systems.

Category 1 systems shall comply with 5.1.3.8 , except as follows:

(1) Medical WAGD pumps shall be permitted to be simplex.

(2) The facility staff shall develop their emergency plan to deal with the loss of WAGD.

15.3.2.2 – Valves.

Category 1 systems shall comply with 5.1.4 .

15.3.2.3 – Station Outlets and Inlets.

Category 1 systems shall comply with 5.1.5 .

15.3.2.4 – Manufactured Assemblies.

Category 1 systems shall comply with 5.1.6 .

15.3.2.5 – Surface-Mounted Medical Gas Rails.

Category 1 systems shall comply with 5.1.7 .

15.3.2.6 – Pressure and Vacuum Indicators.

Category 1 systems shall comply with 5.1.8 .

15.3.2.7 – Warning Systems.

Warning systems associated with Category 1 systems shall provide the master, area, and local alarm functions of a Category 1 system as required in 5.1.9 , except as follows:

(1) Warning systems shall be permitted to be a single alarm panel.

(2) The alarm panel shall be located in an area of continuous surveillance while the facility is in operation.

(3) Pressure and vacuum switches/sensors shall be mounted at the source equipment with a pressure indicator at the master alarm panel.

15.3.2.8 – Medical Gas Distribution.

Category 1 systems shall comply with 5.1.10 .

15.3.2.9 – Labeling and Identification.

Category 1 systems shall comply with 5.1.11 .

15.3.2.10 – Performance Criteria and Testing (Medical Gas, Medical–Surgical Vacuum, and WAGD).

Category 1 systems shall comply with 5.1.12 .

15.3.2.11 – Support Gases.

Category 1 systems shall comply with 5.1.13 except as follows:

(1) Nitrogen source equipment shall be permitted to be installed in enclosures for Category 3 medical gases or in a mechanical room.

(2) Nitrogen source equipment shall include the following:

(3) One or more cylinders of nitrogen NF, sufficient for at least one average day's supply

(4) A manifold, if primary and secondary cylinders are provided

(5) A line pressure regulating valve

(6) A check valve downstream from the pressure regulating valve

(7) A pressure relief valve set at 50 percent above the normal line pressure and located downstream from the check valve

(8) A pressure relief valve discharge piped to the outdoors at a point that will not create a probable hazard and that is turned down to prevent the entry of rain or snow

15.3.2.12 – Medical Gas and Vacuum Operation and Management.

Category 1 systems shall comply with 5.1.14 .

15.3.3 – Category 1 Dental Air and Vacuum Piping Systems.

15.3.3.1 – General.

15.3.3.1.1 –

Dental air and vacuum piping systems shall include dental support gases and dental vacuum systems.

15.3.3.1.2 –

Dental vacuum systems shall include dental vacuum and nitrous oxide scavenging.

15.3.3.2 – Equipment Locations for Dental Air and Vacuum Systems.

15.3.3.2.1 – General.

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

(1) Medical air compressor supply sources

(2) Dental air compressor sources and reserve headers

(3) Dental-surgical vacuum sources

(4) Dental vacuum sources

(5) WAGD sources

(6) Any other compressor, vacuum pump, or electrically powered machinery

15.3.3.2.2 – Cylinders and Containers.

Cylinders and containers for gases shall be handled in accordance with Chapter 11 .

15.3.3.2.3 – Ventilation.

The following source locations for motor-driven equipment shall be adequately ventilated to prevent accumulation of heat:

(1) Medical air sources

(2) Instrument air sources

(3) Dental compressed air sources

(4) Dental-surgical vacuum sources

(5) Dental vacuum sources

(6) WAGD sources

15.3.3.3 – Dental Gas and Vacuum Source Equipment.

15.3.3.3.1 – General.

15.3.3.3.1.1 –

The capacity of source equipment shall be based on the design requirements for the facility, including the number of gas outlets, vacuum inlets, and other connections, and their individual capacities.

15.3.3.3.1.2 –

The system design requirements shall be included in the data used for testing and verifying the operation of the gas and vacuum piping systems.

15.3.3.4 * – Dental Air.

15.3.3.4.1 – General.

15.3.3.4.1.1 –

Dental air shall be used as a support gas for driving dental tools and shall be permitted to be used to supply air-driven equipment. Dental compressed air shall not be used for respiration.

15.3.3.4.1.2 –

Dental air outlets shall not be interchangeable with any other gas outlets, including oxygen, nitrous oxide, medical air, instrument air, and nitrogen.

15.3.3.4.2 – Dental Air Compressor Units.

15.3.3.4.2.1 –

Dental air compressor units shall include dental air compressors, vibration isolation, air receivers, coalescent air filters, adsorption dryers, exhaust silencer/filters, moisture indicators, and service access manifolds, electrical disconnects, motor wiring, and controls.

15.3.3.4.2.2 –

Air compressors shall be scroll dental, reciprocating dental, or the oil-free dental types.

15.3.3.5 * – Dental Vacuum.

15.3.3.5.1 – General.

15.3.3.5.1.1 –

Dental vacuum shall be used for oral evacuation and nitrous oxide scavenging.

15.3.3.5.1.2 –

Dental vacuum inlets shall not be interchangeable with any other vacuum inlets, including dental-surgical vacuum.

15.3.3.5.2 – Dental Vacuum Units.

15.3.3.5.2.1 –

Dental vacuum units shall include dental vacuum pumps, vibration isolation, separation tanks, vacuum inlet, vacuum exhaust, condensate drain, motor wiring, and controls.

15.3.3.5.2.2 –

Dental vacuum pumps shall be dental dry vacuum or dental liquid (wet) ring pumps. Pumps shall be oil-free or oil-lubricated, and suitable for nitrous oxide scavenging.

15.3.3.6 – Nitrous Oxide Scavenging.

15.3.3.6.1 – General.

15.3.3.6.1.1 –

The use of scavenging shall be limited to portions of dental facilities where moderate or minimal sedation is administered. WAGD shall be provided where the dental treatment involves general anesthesia or deep sedation.

15.3.3.6.1.2 –

Active nitrous oxide scavenging shall include the use of a nasal mask on the patient. The nasal mask shall be connected to a scavenging inlet in the dental vacuum system through a flow-limiting adapter.

15.3.3.6.1.3 –

Nitrous oxide scavenging inlets shall not be interchangeable with any other vacuum inlets, including medical-surgical vacuum, dental vacuum, and WAGD.

15.3.3.6.2 – Connection to Dental Vacuum.

Scavenging connections to the dental vacuum system shall be a direct high-volume evacuation (HVE) connection to a high-volume vacuum port with a capacity of 45 L/min (1.6 cfm).

15.3.3.7 – Piping for Dental Air and Vacuum Systems.

15.3.3.7.1 – General.

15.3.3.7.1.1 –

Piping for dental compressed air systems shall comply with 15.3.3.7.2 .

15.3.3.7.1.2 –

Piping for dental vacuum systems and scavenging systems shall comply with 15.3.3.7.3 .

15.3.3.7.2 – Piping for Dental Air Systems.

15.3.3.7.2.1 – General.

Pipe, fittings, and joints in piping for dental compressed air systems shall be in accordance with 15.3.3.7.2.2 through 15.3.3.7.2.5 .

15.3.3.7.2.2 – Pipe.

Pipe under 15.3.3.7.2 shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service* , ACR tube (O.D. size)

15.3.3.7.2.3 –

Copper tube shall be hard temper or annealed (soft temper).

15.3.3.7.2.4 – Fittings.

Fittings for piping under 15.3.3.7.2 shall be permitted to be any of the following acceptable joining methods:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings in compliance with ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (**3** ⁄ **4** in. maximum size)

15.3.3.7.2.5 – Joints.

Joints for piping under 15.3.3.7.2 shall comply with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6 .

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal* .

15.3.3.7.3 – Piping for Dental Vacuum Systems and Scavenging Systems.

15.3.3.7.3.1 – General.

Piping for dental vacuum systems and scavenging systems shall be copper, PVC plastic, or CPVC plastic.

15.3.3.7.3.2 – Copper Piping.

Copper piping under 15.3.3.7.3 shall be in accordance with 15.3.3.7.3.2(A) through 15.3.3.7.3.2(D) .

(A) – Copper Tube.

Copper tubing shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service* , ACR tube (O.D. size)

(B) –

Copper tube shall be hard temper or annealed (soft temper).

(C) – Copper Fittings.

Copper fittings shall comply with the following:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings conforming to ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (**3** ⁄ **4** in. maximum size)

(D) – Joints for Copper Piping.

Joints in copper tubing shall be in accordance with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6 .

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal* .

15.3.3.7.3.3 – PVC Plastic Piping.

PVC plastic piping under 15.3.3.7.3 shall be in accordance with the following:

(1) PVC plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM D1785, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120* .

(2) PVC plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM D2466, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40* , or ASTM D2467, *Standard Specification Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80* .

(3) Joints in PVC plastic piping shall be solvent-cemented in accordance with ASTM D2672, *Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement* .

15.3.3.7.3.4 – CPVC Plastic Piping.

CPVC plastic piping under 15.3.3.7.3 shall be in accordance with the following:

(1) CPVC IPS plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM F441/F441M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80* .

(2) CPVC IPS plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40* , or ASTM F439, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80* .

(3) CPVC CTS plastic pipe and fittings **1** /**2** in. through 2 in. size shall be SDR 11, conforming to ASTM D2846/D2846M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems* .

(4) Solvent cement for joints in CPVC plastic piping shall comply with ASTM F493, *Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride)(CPVC) Plastic Pipe and Fittings* .

15.4 – Category 2 Dental Gas and Vacuum Systems.

15.4.1 – General.

15.4.1.1 –

Category 2 dental gas and vacuum system shall be limited to facilities that, at most, provide moderate and minimal sedation.

15.4.1.2 –

The medical gases shall be limited to oxygen and nitrous oxide.

15.4.1.3 –

The dental support gases shall be provided from a dental air source system.

15.4.1.4 –

The vacuum systems shall be dental vacuum and nitrous oxide scavenging.

15.4.1.5 –

All connections within Category 2 medical gas (oxygen and nitrous oxide) shall be gas-specific to prevent cross-connections with other piping systems, including vacuum, water, and dental air.

15.4.1.6 –

Station outlets and piped outlets for Category 2 medical gas and dental air having nonstandard operating pressures shall comply with the following additional requirements:

(1) Be gas-specific.

(2) Be pressure-specific where a single gas is piped at more than one operating pressure.

(3) Be a D.I.S.S connection if operated at a gauge pressure in excess of 550 kPa (80 psi).

(4) 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).

15.4.1.7 –

Requirements for Category 2 dental gas and vacuum systems relating to the operation, management, and maintenance of oxygen and nitrous oxide piping systems shall apply both new and existing facilities as specified in 15.1.7 .

15.4.2 – Medical Gas Systems (Oxygen and Nitrous Oxide).

15.4.2.1 – Installer Qualifications (Oxygen and Nitrous Oxide).

15.4.2.1.1 –

Installers of medical gas systems shall be certified in accordance with ASSE 6010, *Professional Qualification Standard for Medical Gas Systems Installers* , regardless of the capacity of the source equipment.

15.4.2.1.2 –

Installers of medical gas systems shall not use their certification to oversee installation by noncertified personnel.

15.4.2.1.3 –

Brazing of medical gas piping systems shall be performed by individuals who are qualified in accordance with 15.4.6.1 .

15.4.2.1.4 –

Prior to any installation work involving brazing, the installer of the medical gas piping systems shall provide documentation required by 15.4.6.1 for the qualifications of the brazing procedures and individual brazers.

15.4.2.2 – Central Supply System Identification and Labeling (Oxygen and Nitrous Oxide).

15.4.2.2.1 –

Cylinders, containers, 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]

15.4.2.2.2 –

Cylinder contents shall be identified by attached labels or stencils naming the contents in accordance with the mandatory requirements of CGA C-7, *Guide to Classification and Labeling of Compressed Gases* .

15.4.2.2.3 –

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.

15.4.2.2.4 –

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

15.4.2.2.5 –

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.

15.4.2.2.6 –

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

15.4.2.2.7 –

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

15.4.2.2.8 –

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

15.4.2.2.9 –

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

15.4.2.3 – Central Supply System Operations (Oxygen and Nitrous Oxide).

15.4.2.3.1 –

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

15.4.2.3.2 –

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

15.4.2.3.3 –

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

15.4.2.3.4 –

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

15.4.2.3.5 –

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

15.4.2.3.6 –

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

15.4.2.3.7 –

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

15.4.2.3.8 –

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.

15.4.2.3.9 –

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

15.4.2.3.10 –

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

15.4.2.3.11 –

Containers shall not be stored in a tightly closed space.

15.4.2.3.12 –

Cylinders in use and in storage shall be prevented from reaching temperatures in excess of 52°C (125°F).

15.4.2.3.13 –

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 −7°C (20°F) or greater than 52°C (125°F).

15.4.2.4 – Locations of Medical Gas Source Equipment (Oxygen and Nitrous Oxide).

15.4.2.4.1 –

Gas storage locations in facilities with Category 2 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 m^3 (3000 ft^3) at standard temperature and pressure (STP), or 142 m^3 (5000 ft^3) (STP) if oxygen is stored in a DOT specification 4 L (cryogenic liquid) container shall comply with 15.4.2.4.3 through 15.4.2.4.13 .

15.4.2.4.2 * –

Gas storage locations in facilities with Category 2 medical gas systems with a total of all gases in cylinders or containers exceeding quantities listed in 15.4.2.4.1 shall comply with 5.1.3.3 .

15.4.2.4.3 –

Enclosures shall serve no purpose other than to contain the medical gas source equipment (oxygen and nitrous oxide), except that nitrogen source equipment and compressed air cylinders shall be permitted in the enclosure.

15.4.2.4.4 –

Storage of full or empty gas cylinders, or both, shall be permitted in the same enclosure.

15.4.2.4.5 –

Air compressors, vacuum pumps, and other equipment shall not be located in enclosures for medical gas cylinders (oxygen and nitrous oxide source equipment).

15.4.2.4.6 * –

If enclosures are outdoors or remote from the treatment facilities that they serve, they shall be kept locked.

15.4.2.4.7 –

Cylinders in use and in storage shall be prevented from reaching temperatures in excess of 52°C (125°F). Nitrous oxide cylinders shall be prevented from reaching temperatures lower than −7°C (20°F).

15.4.2.4.8 –

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

15.4.2.4.9 –

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

15.4.2.4.10 –

Indoor enclosures shall not communicate directly with medical gas (oxygen and nitrous oxide) use points or storage locations for oxidizers.

15.4.2.4.11 –

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).

15.4.2.4.12 –

Enclosures for medical gas (oxygen and nitrous oxide) source equipment shall be provided with doors or gates.

15.4.2.4.13 –

Cylinders in service or in storage shall be individually secured and located to prevent falling or being knocked over.

15.4.2.5 – Medical Gas Source Equipment (Oxygen and Nitrous Oxide).

15.4.2.5.1 –

Mechanical means shall be provided to ensure that the medical gas source equipment is connected to the correct medical gas distribution piping system.

15.4.2.5.2 –

Cylinder valve outlets for oxygen and nitrous oxide shall comply with CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* .

15.4.2.5.3 –

Threaded connections to manifolds shall comply with CGA V-5, *Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)* .

15.4.2.5.4 –

A check valve shall be provided downstream of each pressure regulator.

15.4.2.5.5 –

A pressure relief valve set at 50 percent above the normal line pressure shall be located downstream of the check valve in 15.4.2.5.4 .

15.4.2.5.6 –

Pressure relief valves shall be brass, bronze, or stainless steel and designed for oxygen service.

15.4.2.5.7 –

Hose and flexible connectors shall have a gauge pressure rating not less than 6895 kPa (1000 psi).

15.4.2.5.8 –

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

(1) 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.

(2) 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.

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

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

15.4.2.5.9 –

Nonmetallic hoses and flexible connectors shall not exceed 1.52 m (5 ft) in length and shall not be concealed or penetrate walls, floors, ceilings, or partitions.

15.4.2.5.9.1 –

Source equipment shall not be connected to the piping system through flexible connectors.

15.4.2.5.10 –

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 one average day's supply.

15.4.2.5.11 –

The two banks of each medical gas source shall be manifolded so that either bank can supply its distribution piping system.

15.4.2.5.12 –

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.

15.4.2.5.13 –

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.

15.4.2.5.14 –

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.

15.4.2.6 – Emergency Shutoff Valves (Oxygen and Nitrous Oxide).

15.4.2.6.1 * –

All Category 2 medical gas systems shall have an emergency shutoff valve accessible from all use-point locations in an emergency.

15.4.2.6.2 –

Where a central medical gas supply system supplies two treatment facilities, each facility shall be provided with an emergency shutoff valve located in that treatment facility so as to be accessible from all use-point locations in an emergency.

15.4.2.6.3 –

Emergency shutoff valves shall be labeled to indicate the gas controlled by the shutoff valve and shall shut off only the gas to the treatment facility that they serve.

15.4.2.6.4 –

A remotely activated shutoff valve at a gas supply manifold shall not be used for emergency shutoff.

15.4.2.6.4.1 –

For clinical purposes, such a remote valve actuator shall not fail-close in the event of loss of electric power.

15.4.2.6.4.2 –

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.

15.4.2.7 – Station Outlets and Risers (Oxygen and Nitrous Oxide).

15.4.2.7.1 –

Each gas outlet shall be gas-specific.

15.4.2.7.2 –

Gas outlets shall consist of a primary and a secondary valve or assembly.

15.4.2.7.3 –

Each gas outlet shall be legibly identified.

15.4.2.7.4 –

Threaded outlets shall be noninterchangeable connections complying with the mandatory requirements of CGA V-5, *Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)* .

15.4.2.7.5 –

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.

15.4.2.8 – Manufactured Assemblies (Oxygen and Nitrous Oxide).

Category 2 systems shall comply with 5.1.6 .

15.4.2.9 – Pressure and Vacuum Indicators (Oxygen and Nitrous Oxide).

Category 2 systems shall comply with 5.1.8 .

15.4.2.10 – Warning Systems (Oxygen and Nitrous Oxide).

Category 2 warning systems shall comply with 5.2.9 , except as follows:

(1) Warning systems shall be permitted to be a single alarm panel.

(2) The alarm panel shall be located in an area of continuous surveillance while the facility is in operation.

(3) Pressure and vacuum switches/sensors shall be mounted at the source equipment with a pressure indicator at the master alarm panel.

(4) Warning systems for medical gas systems shall provide the following alarms:

(5) Oxygen main line pressure low

(6) Oxygen main line pressure high

(7) Oxygen changeover to secondary bank or about to changeover (if automatic)

(8) Nitrous oxide main line pressure low

(9) Nitrous oxide main line pressure high

(10) Nitrous oxide changeover to secondary bank or about to changeover (if automatic)

(11) 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.

(12) Visual indications shall remain until the situation that caused the alarm is resolved.

(13) 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.

(14) 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.

15.4.2.11 – Labeling and Identification.

Category 2 systems shall comply with 5.1.11 .

~~**15.4.3** – Category 2 Dental Air and Vacuum Piping Systems.~~

~~**15.4.3.1** – General.~~

~~**15.4.3.1.1** –~~

~~Dental air and vacuum piping systems shall include dental support gases and dental vacuum systems.~~

~~**15.4.3.1.2** –~~

~~Dental vacuum systems shall include dental vacuum and nitrous oxide scavenging.~~

~~**15.4.3.2** – Equipment Locations for Dental Air and Vacuum Systems.~~

~~**15.4.3.2.1** – General.~~

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

(1) ~~Dental air compressor sources and reserve headers~~
(2) ~~Dental-surgical vacuum sources~~
(3) ~~Dental vacuum sources~~
(4) ~~Any other compressor, vacuum pump, or electrically powered machinery~~

~~**15.4.3.2.2** – Cylinders and Containers.~~

~~Cylinders and containers for gases shall be handled in accordance with Chapter 11 .~~

~~**15.4.3.2.3** – Ventilation for Motor-Driven Equipment.~~

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

(1) ~~Medical air sources~~
(2) ~~Instrument air sources~~
(3) ~~Dental compressed air sources~~
(4) ~~Dental-surgical vacuum sources~~
(5) ~~Dental vacuum sources~~
(6) ~~WAGD sources~~

~~**15.4.3.3** – Dental Gas and Vacuum Source Equipment.~~

~~**15.4.3.3.1** – General.~~

~~**15.4.3.3.1.1** –~~

~~The capacity of source equipment shall be based on the design requirements for the facility, including the number of gas outlets, vacuum inlets, and other connections, and their individual capacities.~~

~~**15.4.3.3.1.2** –~~

~~The system design requirements shall be included in the data used for testing and verifying the operation of the gas and vacuum piping systems.~~

~~**15.4.3.3.2** – Dental Air.~~

~~**15.4.3.3.2.1** – General.~~

~~**(A)** –~~

~~Dental air shall be used as a support gas for driving dental tools and shall be permitted to be used to supply air-driven equipment. Dental compressed air shall not be used for respiration.~~

~~**(B)** –~~

~~Dental air outlets shall not be interchangeable with any other gas outlets, including oxygen, nitrous oxide, medical air, instrument air, and nitrogen.~~

~~**15.4.3.3.2.2** – Dental Air Compressor Units.~~

~~**(A)** –~~

~~Dental air compressor units shall include dental air compressors, vibration isolation, air receivers, coalescent air filters, adsorption dryers, exhaust silencer/filters, moisture indicators, service access manifolds, electrical disconnects, motor wiring, and controls.~~

~~**(B)** –~~

~~Air compressors shall be scroll dental, reciprocating dental, or the oil-free dental types.~~

~~**15.4.3.3.3** – Dental Vacuum.~~

~~**15.4.3.3.3.1** – General.~~

~~**(A)** –~~

~~Dental vacuum shall be used for oral evacuation and nitrous oxide scavenging.~~

~~**(B)** –~~

~~Dental vacuum inlets shall not be interchangeable with any other vacuum inlets, including dental-surgical vacuum.~~

~~**15.4.3.3.3.2** – Dental Vacuum Units.~~

~~**(A)** –~~

~~Dental vacuum units shall include dental vacuum pumps, vibration isolation, separation tanks, vacuum inlet, vacuum exhaust, condensate drain, motor wiring, and controls.~~

~~**(B)** –~~

~~Dental vacuum pumps shall be dental dry vacuum or dental liquid (wet) ring pumps. Pumps shall be oil-free or oil-lubricated and suitable for nitrous oxide scavenging.~~

~~**15.4.3.3.4** – Nitrous Oxide Scavenging.~~

~~**15.4.3.3.4.1** – General.~~

~~**(A)** –~~

~~The use of scavenging shall be limited to portions of dental facilities where moderate or minimal sedation is administered. WAGD shall be provided where the dental treatment involves general anesthesia or deep sedation.~~

~~**(B)** –~~

~~Active nitrous oxide scavenging shall include the use of a nasal mask on the patient. The nasal mask shall be connected to a scavenging inlet in the dental vacuum system through a flow-limiting adapter.~~

~~**(C)** –~~

~~Nitrous oxide scavenging inlets shall not be interchangeable with any other vacuum inlets, including medical-surgical vacuum, dental vacuum, and WAGD.~~

~~**15.4.3.3.4.2** – Connection to Dental Vacuum.~~

~~Scavenging connections to the dental vacuum system shall be a direct high-volume evacuation (HVE) connection to a high-volume vacuum port with a capacity of 45 L/min (1.6 cfm).~~

~~**15.4.3.4** – Category 2 Warning Systems (Oxygen and Nitrous Oxide).~~

~~**15.4.3.4.1** – General.~~

15.4.3.4.1.1 –

The warning systems in Category 2 dental gas and vacuum systems shall comply with applicable requirements of 5.2.9 and 15.4.3.4.2 through 15.4.3.4.4 .

15.4.3.4.1.2 –

The master, area, and local alarm functions shall be permitted to be provided by a single alarm panel, as indicated in 5.2.9 .

15.4.3.4.2 – Master Alarm Panels.

15.4.3.4.2.1 –

A master alarm panel shall be located in the facility at a point of continuous surveillance when the facility is in operation.

15.4.3.4.2.2 –

The master alarm panel shall indicate the following:

(1) Oxygen supply pressure ±20 percent from normal

(2) Nitrous oxide supply pressure ±20 percent from normal

(3) Changeover of oxygen supply source

(4) Changeover of nitrous oxide supply source

15.4.3.4.3 – Area Alarm Panels.

15.4.3.4.3.1 –

An area alarm panel shall be centrally located where two or more treatment areas are supplied from the same zoned dental gas and vacuum piping.

15.4.3.4.3.2 –

Area alarm panels shall indicate the following:

(1) Oxygen supply pressure ±20 percent from normal

(2) Nitrous oxide supply pressure ±20 percent from normal

15.4.3.4.4 – Local Alarms.

15.4.3.4.4.1 –

Local alarms shall be located in source equipment control panels or separate control panels in the equipment rooms for source equipment.

15.4.4 – Piping for Category 2 Medical Gas, Dental Air, and Vacuum Systems.

15.4.4.1 – General.

15.4.4.1.1 –

Piping for the following systems shall comply with 15.4.4.2 :

(1) Oxygen

(2) Nitrous oxide

15.4.4.1.2 –

Piping for dental air systems shall comply with 15.4.4.3 .

15.4.4.1.3 –

Piping for dental vacuum systems and scavenging systems shall comply with 15.4.4.4 .

15.4.4.2 – Piping for Oxygen and Nitrous Oxide Systems.

15.4.4.2.1 – Cleaning for Oxygen Service.

For oxygen and nitrous oxide, the pipe, fittings, valves, gas/vacuum outlets/inlets, and other piping components shall be cleaned for oxygen by the manufacturer prior to installation in accordance with CGA G-4.1, *Cleaning Equipment for Oxygen Service* . Fittings shall be permitted to be cleaned by a supplier or agency other than the manufacturer.

15.4.4.2.2 – Pipe.

Pipe shall be hard-drawn seamless copper tube conforming to ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K.

15.4.4.2.3 – Fittings.

15.4.4.2.3.1 –

Fittings shall be brazed, memory metal, or axially swaged.

15.4.4.2.3.2 –

Brazed fittings shall be the wrought copper capillary type complying with the following:

(1) ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) ASME B16.22 with socket depths equal to or greater than brazed joint pressure fittings in accordance with ANSI/ASME B16.50

15.4.4.2.3.3 –

Cast copper alloy fittings shall not be used with field-brazed joints.

15.4.4.2.3.4 –

Memory metal fittings shall be rated for not less than 538°C (1000°F) and 2070 kPa (300 psi) and shall be installed by qualified technicians in accordance with the manufacturer's instructions.

15.4.4.2.3.5 –

Axially swaged couplings shall include metal-to-metal seats, shall be rated for not less than 538°C (1000°F) and 2070 kPa (300 psi), and shall provide permanent, nonseparable joints. Fittings shall be installed by qualified technicians in accordance with the manufacturer's instructions.

15.4.4.2.4 – Joints.

15.4.4.2.4.1 – Brazed.

Brazing of copper joints shall be in accordance with 15.4.6 .

15.4.4.2.4.2 – Threaded.

Threaded joints shall be limited to connections to pressure indicators, alarm devices, and source equipment and shall comply with the following:

(1) Threads shall be tapered complying with ASME B1.20.1, *Pipe Threads, General Purpose, Inch* .

(2) Threads shall be made up with polytetrafluoroethylene (PTFE) tape or other thread sealant recommended for oxygen service, with the sealant applied to the male threads only.

15.4.4.2.4.3 – Prohibited Joints.

The following joints shall be prohibited under 15.4.4.2.4 :

(1) Flared and compression connections, including connections to station outlets, alarm devices, and other components

(2) Push-lock connections

(3) Straight-threaded connections, including unions

(4) Pipe crimping tools used to permanently stop the flow of medical gas and vacuum piping

15.4.4.3 – Piping for Dental Air Systems.

15.4.4.3.1 – General.

Pipe, fittings, and joints in piping for dental compressed air systems shall be in accordance with 15.4.4.3.2 through 15.4.4.3.4 .

15.4.4.3.2 – Pipe.

Pipe under 15.4.4.3 shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service* , ACR tube (O.D. size).

15.4.4.3.2.1 –

Copper tube shall be hard temper or annealed (soft temper).

15.4.4.3.3 – Fittings.

Fittings for piping under 15.4.4.3 shall be permitted to be any of the following acceptable joining methods:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings in compliance with ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (**3** ⁄ **4** in. maximum size)

15.4.4.3.4 – Joints.

Joints for piping under 15.4.4.3 shall comply with 15.4.4.3.4.1 through 15.4.4.3.4.3 .

15.4.4.3.4.1 –

Joints shall be brazed, soldered, threaded, flared, or the compression type.

15.4.4.3.4.2 –

Where joints are brazed, they shall comply with the requirements of 15.4.6 .

15.4.4.3.4.3 –

Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal* .

15.4.4.4 – Piping for Dental Vacuum Systems and Scavenging Systems.

15.4.4.4.1 – General.

Piping for dental vacuum systems and scavenging systems shall be copper, PVC plastic, or CPVC plastic.

15.4.4.4.2 – Copper Piping.

Copper piping under 15.4.4.4 shall be in accordance with 15.4.4.4.2.1 through 15.4.4.4.2.3 .

15.4.4.4.2.1 – Copper Tube.

Copper tubing shall be hard temper or annealed (soft temper) and shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service,* ACR tube (O.D. size)

15.4.4.4.2.2 – Copper Fittings.

Copper fittings shall comply with the following:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings conforming to ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (**3** ⁄ **4** in. maximum size)

15.4.4.4.2.3 – Joints for Copper Piping.

Joints in copper tubing shall be in accordance with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6 .

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal* .

15.4.4.4.3 – PVC Plastic Piping.

PVC plastic piping under 15.4.4.4 shall be in accordance with the following:

(1) PVC plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM D1785, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120* .

(2) PVC plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM D2466, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40* , or ASTM D2467, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80* .

(3) Joints in PVC plastic piping shall be solvent-cemented in accordance with ASTM D2672, *Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement* .

15.4.4.4.4 – CPVC Plastic Piping.

CPVC plastic piping under 15.4.4.4 shall be in accordance with the following:

(1) CPVC IPS plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM F441/F441M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80* .

(2) CPVC IPS plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40* , or ASTM F439, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80* .

(3) CPVC CTS plastic pipe and fittings **1** ⁄**2** in. through 2 in. size shall be SDR 11, conforming to ASTM D2846/D2846M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems* .

(4) Solvent cement for joints in CPVC plastic piping shall comply with ASTM F493, *Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings* .

15.4.4.5 – Piping for Nitrogen.

Nitrogen piping in dental facilities shall comply with 15.4.4.2 , including cleaning for oxygen service.

15.4.5 – Installation of Medical Gas, Dental Air, and Vacuum Piping.

15.4.5.1 – General.

15.4.5.1.1 –

Gas and vacuum piping systems shall be as listed in Section 15.4 .

15.4.5.1.2 –

Piping materials shall be as listed in 15.4.4 .

15.4.5.2 – Pipe Sizing.

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

15.4.5.3 – Minimum Pipe Sizes.

The minimum size of the following piping shall be as follows:

(1) Category 2 oxygen piping shall be not less than DN10 (NPS $\frac{3}{8}$ in.) ($\frac{1}{2}$ in. O.D.) size.

(2) Category 2 nitrous oxide piping shall be not less than DN8 (NPS $\frac{1}{4}$ in.) ($\frac{3}{8}$ in. O.D.) size.

(3) Category 2 oxygen piping shall be at least 1 size larger than piping for nitrous oxide.

15.4.5.4 – Location of Piping.

Piping shall not be located where subject to contact with oil.

15.4.5.5 – Protection of Piping.

15.4.5.5.1 –

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

15.4.5.5.2 –

Piping exposed in corridors and other locations where subject to physical damage from the movement of equipment shall be protected.

15.4.5.6 – Pipe Support.

15.4.5.6.1 –

Piping shall be supported from the building structure.

15.4.5.6.2 –

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* .

15.4.5.6.3 –

Hangers and supports shall be sized for the tube or pipe being supported.

15.4.5.6.4 –

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.

15.4.5.6.5 –

The maximum support spacing for copper tube shall be in accordance with Table 15.4.5.6.5 .

Table 15.4.5.6.5 Maximum Copper Tube Support Spacing

- Hanger Spacing Pipe Size mm ft DN8 (NPS $\frac{1}{4}$) ($\frac{3}{8}$ in. O.D.) 1520 5 DN10 (NPS $\frac{3}{8}$) ($\frac{1}{2}$ in. O.D.) 1830 6 DN15 (NPS $\frac{1}{2}$) ($\frac{5}{8}$ in. O.D.) 1830 6 DN20 (NPS $\frac{3}{4}$) ($\frac{7}{8}$ in. O.D.) 2130 7 DN25 (NPS 1) (1 $\frac{1}{8}$ in. O.D.) 2440 8 DN32 (NPS 1 $\frac{1}{4}$) (1 $\frac{3}{8}$ in. O.D.) 2740 9 DN40 (NPS 1 $\frac{1}{2}$) (1 $\frac{5}{8}$ in. O.D.) and larger 3050 10 Vertical risers, all sizes, every floor, but not to exceed 4570 15

15.4.5.6.6 –

The maximum support spacing for plastic pipe shall be in accordance with Table 15.4.5.6.6 .

Table 15.4.5.6.6 Maximum Plastic Pipe Support Spacing

- Hanger Spacing Pipe Size mm ft DN15 (NPS $\frac{1}{2}$) ($\frac{5}{8}$ in. O.D.) 1220 4 DN20 (NPS $\frac{3}{4}$) ($\frac{7}{8}$ in. O.D.) 1220 4 DN25 (NPS 1) (1 $\frac{1}{8}$ in. O.D.) 1320 4.33 DN32 (NPS 1 $\frac{1}{4}$) (1 $\frac{3}{8}$ in. O.D.) 1320 4.33 DN40 (NPS 1 $\frac{1}{2}$) (1 $\frac{5}{8}$ in. O.D.) 1420 4.66 DN50 (NPS 2) (2 $\frac{3}{8}$ in. O.D.) 1420 4.66 DN65 (NPS 2 $\frac{1}{2}$) (2 $\frac{7}{8}$ in. O.D.) and larger 1520 5 Vertical risers, all sizes,

~~every floor, but not to exceed 3040 10~~

~~15.4.5.7~~ ~~– Underground Piping Outside of Buildings.~~

~~15.4.5.7.1~~ ~~–~~

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

~~15.4.5.7.2~~ ~~–~~

~~The installation procedure for underground piping shall prevent physical damage to the piping while being backfilled.~~

~~15.4.5.7.3~~ ~~–~~

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

(1) ~~Access during construction shall be provided at the joints for visual inspection and leak testing.~~

(2) ~~The conduit, cover, or enclosure shall be self-draining and not retain groundwater in prolonged contact with copper tubing.~~

~~15.4.5.7.4~~ ~~–~~

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

~~15.4.5.7.5~~ ~~–~~

~~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.~~

~~15.4.5.7.6~~ ~~–~~

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

~~15.4.5.7.7~~ ~~–~~

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

~~15.4.5.7.8~~ ~~–~~

~~A continuous warning tape or marker shall be placed immediately above the piping or its enclosure to clearly identify the pipeline by specific name.~~

~~15.4.5.7.9~~ ~~–~~

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

~~15.4.5.7.10~~ ~~–~~

~~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.~~

~~15.4.5.8~~ ~~– Underground Piping Within Buildings.~~

~~15.4.5.8.1~~ ~~–~~

~~The installation procedure for underground piping shall prevent physical damage to the piping while being backfilled.~~

~~15.4.5.8.2~~ ~~–~~

~~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.~~

15.4.5.8.3 –

The piping shall be backfilled with clean sand or gravel.

15.4.5.9 – Piping Within Floor Slabs Prohibited.

Dental gas and vacuum piping shall not be installed within floor slabs.

15.4.5.10 – Hose and Flexible Connectors.

15.4.5.10.1 –

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.

15.4.5.10.2 –

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

15.4.5.10.3 –

Medical gas hose and flexible connectors shall be oxygen compatible.

15.4.5.10.4 –

Hose and flexible connectors shall be clearly identified as to the gas content.

15.4.5.10.5 –

Hose and flexible connectors for dental medical gases shall be gas-specific and not be permitted to conduct any other gas, gas mixture, or liquid.

15.4.6 – Brazing Copper Tubing.

15.4.6.1 – Qualification of Brazing Procedures and Brazers.

15.4.6.1.1 –

Brazing procedures and brazer performance for the installation of dental piping shall be in accordance with either Section IX, "Welding and Brazing Qualifications," of the ASME *Boiler and Pressure Vessel Code,* or AWS B2.2/B2.2M, *Specification for Brazing Procedure and Performance Qualification* , both as modified by 15.4.6 .

15.4.6.1.2 –

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

15.4.6.1.3 –

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

15.4.6.1.4 –

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 the absence of internal oxidation in the completed coupon.

15.4.6.1.5 –

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

(1) The brazing procedure specification and the procedure qualification record meet the requirements of this code.

(2) 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.

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

15.4.6.1.6 –

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

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

(2) The new employer obtains a copy of the record of brazer performance qualification tests from the previous employer and signs and dates these records, thereby accepting responsibility for the qualifications performed by the previous employer.

15.4.6.1.7 –

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.

15.4.6.2 – Brazed Joints.

15.4.6.2.1 –

Brazed tube joints shall be of the socket type.

15.4.6.2.2 –

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.

15.4.6.2.3 –

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

15.4.6.2.4 –

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

15.4.6.2.5 –

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

15.4.6.2.6 –

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

15.4.6.3 – Cutting Tube Ends.

15.4.6.3.1 –

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

15.4.6.3.2 –

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

15.4.6.3.3 –

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.

15.4.6.4 – Cleaning Joints for Brazing.

15.4.6.4.1 –

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.

15.4.6.4.2 –

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.

15.4.6.4.3 –

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

15.4.6.4.4 –

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

15.4.6.4.5 –

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

15.4.6.4.6 –

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

15.4.6.4.7 –

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.

15.4.6.4.8 –

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

15.4.6.4.9 –

Joints shall be brazed within 8 hours after being cleaned for brazing.

15.4.6.5 – Brazing Dissimilar Metals.

15.4.6.5.1 –

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

15.4.6.5.2 –

Cast metals shall not be field brazed.

15.4.6.5.3 –

Surfaces shall be cleaned for brazing in accordance with 15.4.6.4 .

15.4.6.5.4 –

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

15.4.6.5.5 –

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.

15.4.6.5.6 –

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.

15.4.6.5.7 –

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.

15.4.6.6 – Nitrogen Purge.

15.4.6.6.1 –

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.

15.4.6.6.2 –

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

15.4.6.6.3 –

The nitrogen purge gas flow rate shall not be high enough to produce a positive pressure in the piping system.

15.4.6.6.4 –

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

15.4.6.6.5 –

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

15.4.6.6.6 –

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.

15.4.6.6.7 –

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.

15.4.6.6.8 –

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

15.4.6.6.9 –

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.

15.4.6.7 – Assembling and Heating Brazed Joints.

15.4.6.7.1 –

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 (i.e., overlap) specified in ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings* .

15.4.6.7.2 –

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

15.4.6.7.3 –

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.

15.4.6.7.4 –

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 VIII, "Brazed Joints," in the CDA *Copper Tube Handbook* .

15.4.6.8 – Inspection of Brazed Joints.

15.4.6.8.1 –

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.

15.4.6.8.2 –

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

15.4.6.8.3 –

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

15.4.6.8.4 –

Joints exhibiting the following conditions shall not be permitted:

(1) Flux or flux residue (where flux or flux-coated BAg rods are used with dissimilar metals)

(2) Base metal melting or erosion

(3) Unmelted filler metal

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

(5) Cracks in the tube or component

(6) Cracks in the filler metal

(7) Failure of the joint to hold the test pressure under the installer-performed initial pressure test *(see 15.4.7.4.4)* and standing pressure test *(see 15.4.7.4.6)*

15.4.6.8.5 –

Joints that are identified as defective under conditions specified in 15.4.6.8.4(2) or 15.4.6.8.4(5) shall be replaced.

15.4.6.8.6 –

Joints that are found to be defective under conditions specified in 15.4.6.8.4(1) , 15.4.6.8.4(3) , 15.4.6.8.4(4) , 15.4.6.8.4(6) , or 15.4.6.8.4(7) shall be permitted to be repaired, except that no joint shall be reheated more than once before being replaced.

15.4.7 – Performance Criteria and Testing (Oxygen and Nitrous Oxide).

15.4.7.1 – Testing and Verification.

15.4.7.1.1 – General.

15.4.7.1.1.1 –

Inspection and testing shall be performed on all new piped oxygen and nitrous oxide systems, additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that the following have been completed:

(1) All applicable provisions of this code have been adhered to.

(2) System integrity has been achieved or maintained.

(3) Piping systems are ready for testing and verification.

(4) Piping systems are performing in accordance with their design requirements.

15.4.7.1.1.2 –

The inspection and testing reports shall be submitted directly to the party that contracted for the testing, who shall submit the reports through channels to the Responsible Facility Authority and any others that are required.

15.4.7.1.1.3 –

Reports shall contain detailed listings of all findings and results.

15.4.7.1.1.4 –

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 before use.

15.4.7.1.1.5 –

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

15.4.7.2 – Required Testing and Verification.

15.4.7.2.1 – Category 2 Medical Gas Systems (Oxygen and Nitrous Oxide).

All Category 2 oxygen and nitrous oxide piping systems indicated in 15.4.2 shall be initially tested in accordance with 15.4.7.4 .

15.4.7.2.2 –

The oxygen and nitrous oxide piping systems shall be verified in accordance with 15.4.7.5 .

15.4.7.3 – Qualification of System Testers and Verifiers (Oxygen and Nitrous Oxide).

15.4.7.3.1 –

Individuals who perform the initial and final tests of the oxygen and nitrous oxide piping systems shall be certified to ASSE 6010, *Professional Qualifications Standard for Medical Gas Systems Installers* , or verifiers who comply with 15.4.7.3.2 .

15.4.7.3.2 –

Individuals who verify the oxygen and nitrous oxide piping systems shall be certified to ASSE 6030, *Professional Qualifications Standard for Medical Gas Systems Verifiers* .

15.4.7.4 – Initial Testing of Piping Systems (Oxygen and Nitrous Oxide).

15.4.7.4.1 – General.

15.4.7.4.1.1 –

The initial tests required by 15.4.7.4 shall be performed prior to either the final tests or the verification tests listed in 15.4.7.5 .

15.4.7.4.1.2 –

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

15.4.7.4.1.3 –

Where manufactured assemblies are to be installed, the initial tests required by 15.4.7.4 shall be performed as follows:

(1) After completion of the distribution piping but before the standing pressure test

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

(3) For all station outlets/inlets on installed manufactured assemblies supplied through copper tubing

15.4.7.4.1.4 –

Where plastic vacuum and plastic scavenging piping systems are installed, they shall be visually inspected for cross-connections to positive-pressure systems before applying positive test pressures to the copper piping systems.

15.4.7.4.1.5 –

Where brazed joints in copper tubing are found to be defective, they shall be repaired if permitted by 15.4.6.8.6 or replaced if required by 15.4.6.8.5 , and retested. The piping shall be repurged if necessary.

15.4.7.4.1.6 –

During the process of initial testing, the identification and labeling of the medical gas and vacuum piping shall be checked.

15.4.7.4.2 – Initial Piping Blowdown (Oxygen and Nitrous Oxide).

Piping in dental air 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, and source equipment).

15.4.7.4.3 – Initial Cross-Connection Test for Copper Piping Systems.

15.4.7.4.3.1 –

Copper piping shall not be tested before any plastic piping.

15.4.7.4.3.2 –

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

15.4.7.4.3.3 –

All piping systems shall be reduced to atmospheric pressure.

15.4.7.4.3.4 –

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

15.4.7.4.3.5 –

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

15.4.7.4.3.6 –

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 dispensed only from the piping system tested.

15.4.7.4.3.7 –

The initial cross-connection test in 15.4.7.4.3 shall be repeated for each installed medical gas and vacuum piping system with copper piping.

15.4.7.4.3.8 –

Any cross-connections shall be removed and the associated piping repaired and leak tested.

15.4.7.4.3.9 –

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

15.4.7.4.4 – Initial Pressure Test.

15.4.7.4.4.1 –

Each section of the piping in positive-pressure gas systems and copper vacuum systems shall be pressure tested. Plastic vacuum and plastic scavenging piping shall not be pressure tested.

15.4.7.4.4.2 –

Initial pressure tests shall be conducted as follows:

(1) After blowdown of the distribution piping

(2) After installation of station outlet/inlet rough-in assemblies

(3) 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, and line pressure relief valves)

15.4.7.4.4.3 –

The source shutoff valve shall remain closed during the pressure tests.

15.4.7.4.4.4 –

The test pressure for oxygen and nitrous oxide piping shall be 1.5 times the system operating pressure but not less than a gauge pressure of 1035 kPa (150 psi).

15.4.7.4.4.5 * –

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.

15.4.7.4.4.6 –

Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.

15.4.7.4.5 – Initial Piping Purge Test.

15.4.7.4.5.1 –

The outlets in each oxygen and nitrous oxide piping system shall be purged to remove any particulate matter from the distribution piping.

15.4.7.4.5.2 –

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

15.4.7.4.5.3 –

The purging shall be started at the closest outlet to the piping shutoff valve and continue to the furthest outlet from the shutoff valve.

15.4.7.4.6 – Standing Pressure Test for Oxygen and Nitrous Oxide Piping.

15.4.7.4.6.1 –

After successful completion of the initial pressure tests in 15.4.7.4.4 , the gas distribution piping shall be subject to a standing pressure test.

15.4.7.4.6.2 –

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, and hoses).

15.4.7.4.6.3 –

The source valve shall be closed during this test.

15.4.7.4.6.4 –

The piping systems shall be subjected to 24-hour standing pressure tests using oil-free, dry nitrogen NF.

15.4.7.4.6.5 –

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

15.4.7.4.6.6 –

At the conclusion of the tests, there shall be no change in the test pressure except that attributed to specific changes in ambient temperature.

15.4.7.4.6.7 –

Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested. The piping shall be repurged if necessary.

15.4.7.4.6.8 –

The 24-hour standing pressure tests shall be witnessed by the authority having jurisdiction or its designee. A form indicating that these tests have been performed and witnessed shall be provided to the verifier at the start of the verification tests in 15.4.7.5 .

15.4.7.5 – Verification of Piping Systems (Oxygen and Nitrous Oxide).

15.4.7.5.1 – General.

15.4.7.5.1.1 –

The oxygen and nitrous oxide piping systems requiring initial testing and verification shall be as indicated in 15.4.7.2 for the different dental facilities.

15.4.7.5.1.2 –

Required verification of oxygen and nitrous oxide piping systems shall be performed only after all initial tests required in 15.4.7.4 have been completed.

15.4.7.5.1.3 –

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

15.4.7.5.1.4 –

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

15.4.7.5.1.5 –

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

15.4.7.5.1.6 –

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

15.4.7.5.1.7 –

Where there are multiple possible connection points for terminals, each possible position shall be tested independently.

15.4.7.5.1.8 –

Where brazed joints in copper tubing are found to be defective, they shall be repaired if permitted by 15.4.6.8.6 or replaced if required by 15.4.6.8.5 , and retested. The piping shall be repurged if necessary.

15.4.7.5.1.9 –

During the process of verification, the presence and proper labeling of source equipment, station outlets/inlets, zone valve boxes, shutoff valves, and alarms shall be checked.

15.4.7.5.2 – Verifier Standing Pressure Test.

Oxygen and nitrous oxide piping systems requiring verification shall be subjected to a 10-minute standing pressure test at operating line pressure using the following procedure:

(1) After the system is filled with nitrogen or the source gas, the source valve shall be closed.

(2) The piping system shall show no decrease in pressure after not less than 10 minutes.

(3) Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.

15.4.7.5.3 – Verifier Cross-Connection Test.

The piping systems shall be tested for cross-connections between the systems using the following procedure:

(1) All medical gas and vacuum piping systems shall be reduced to atmospheric pressure.

(2) All sources of test gas for all of the gas and vacuum systems, with the exception of the one system to be checked, shall be disconnected.

(3) The system being checked shall be pressurized to a gauge pressure of 345 kPa (50 psi).

(4) 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 dispensed only from the outlets/inlets of the piping system being tested.

(5) The source of test gas shall be disconnected, and the system that was tested reduced to atmospheric pressure.

(6) Each additional piping system shall be tested until all gas and vacuum piping systems requiring verification are free of cross-connections.

(7) Any cross-connections shall be removed and the associated piping repaired and tested for leaks.

15.4.7.5.4 – Verifier Piping Purge Test.

15.4.7.5.4.1 –

To remove any traces of particulate matter deposited in the oxygen and nitrous oxide piping during construction, a heavy, intermittent purging of the piping shall be done.

15.4.7.5.4.2 –

The appropriate adapter shall be obtained and high purge rates of at least 225 Nl/min (8 SCFM) shall be put on each outlet.

15.4.7.5.4.3 –

After each 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.

15.4.7.5.4.4 –

To avoid possible damage to the outlet and its components, this test shall not be conducted using any implement other than the proper adapter.

15.4.7.5.4.5 –

No pronounced or objectionable odor shall be discernible from any positive pressure outlet.

15.4.7.5.5 – Verifier Piping Particulate Test.

15.4.7.5.5.1 –

For each oxygen and nitrous oxide system, the cleanliness of the piping system shall be verified.

15.4.7.5.5.2 –

The test shall be performed with the use of oil-free, dry nitrogen NF.

15.4.7.5.5.3 –

A minimum of 1000 L (35 ft ^{3}) of gas shall be filtered through a clean, white 0.45 micron filter at a minimum flow rate of 100 Nl/min (3.5 SCFM).

15.4.7.5.5.4 –

Twenty five percent of the zones shall be tested at the outlet most remote from the source.

15.4.7.5.5.5 –

The filter shall accrue no more than 0.001 g (1 mg) of matter from any outlet tested.

15.4.7.5.5.6 –

If any outlet fails this test, the most remote outlet in every zone shall be tested.

15.4.7.5.6 – Verifier Piping Purity Test.

15.4.7.5.6.1 –

For each oxygen and nitrous oxide system, the purity of the piping system shall be verified in accordance with 15.4.7.5.6 .

15.4.7.5.6.2 –

These tests shall be performed with oil-free, dry nitrogen NF or the system gas.

15.4.7.5.6.3 –

The outlet most remote from the source shall be tested for total nonmethane hydrocarbons and compared to the test of the source gas.

15.4.7.5.6.4 –

If the system gas is used as the source gas, it shall be tested at the source equipment.

15.4.7.5.6.5 –

The difference between the two tests shall in no case exceed 5 ppm of total nonmethane hydrocarbons.

15.4.7.5.6.6 –

The difference between the two tests shall in no case exceed 5 ppm of halogenated hydrocarbons.

15.4.7.5.6.7 –

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).

15.4.7.5.7 – Verifier Final Tie-in Test.

15.4.7.5.7.1 –

Prior to the connection of any work or any extension or addition to an existing piping system, the verification tests in 15.4.7.5 shall be successfully performed on the new work.

15.4.7.5.7.2 –

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.

15.4.7.5.7.3 –

For oxygen and nitrous oxide, 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 15.4.7.5.4 .

15.4.7.5.7.4 –

Before the new work is used for patient care, oxygen and nitrous oxide shall be tested for operational pressure and gas concentration in accordance with 15.4.7.5.8 and 15.4.7.5.9 .

15.4.7.5.7.5 –

Permanent records of these tests shall be maintained.

15.4.7.5.8 – Verifier Operational Pressure Test.

15.4.7.5.8.1 –

Operational pressure tests shall be performed at each station outlet or terminal where the user makes connections and disconnections.

15.4.7.5.8.2 –

Tests shall be performed with the gas of system designation.

15.4.7.5.8.3 –

All medical gas outlets with a gauge pressure of 345 kPa (50 psi), including oxygen and nitrous oxide, shall deliver 50 SLPM (1.8 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).

15.4.7.5.9 – Verifier Gas Concentration Test.

After purging each system with the gas of system designation, the following shall be performed:

(1) Each pressure gas source and outlet shall be analyzed for concentration of gas, by volume.

(2) Analysis shall be conducted with instruments designed to measure the specific gas dispensed.

(3) Allowable concentrations shall be as follows:

(4) Oxygen ≥99 percent

(5) Nitrous oxide ≥99 percent

(6) Other gases ±1 percent unless otherwise specified

15.4.8 – Performance Criteria and Testing (Dental Air and Vacuum).

15.4.8.1 – Dental Air and Vacuum Systems Testing.

15.4.8.1.1 – General.

15.4.8.1.1.1 –

Inspection and testing shall be performed on all new piped dental gas and vacuum systems, additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that the following have been completed:

(1) All applicable provisions of this code have been adhered to.

(2) System integrity has been achieved or maintained.

(3) Piping systems are ready for testing and verification.

(4) Piping systems are performing in accordance with their design requirements.

15.4.8.1.1.2 –

The inspection and testing reports shall be submitted directly to the party that contracted for the testing, who shall submit the reports through channels to the Responsible Facility Authority and any others that are required.

15.4.8.1.1.3 –

Reports shall contain detailed listings of all findings and results.

15.4.8.1.1.4 –

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 before use.

15.4.8.1.1.5 –

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

15.4.8.1.2 – Category 2 Dental Air and Vacuum Systems.

15.4.8.1.2.1 –

All Category 2 dental gas and vacuum piping systems indicated in 15.4.3 shall be initially tested in accordance with 15.4.8.1 .

15.4.8.1.2.2 –

The support gas systems and vacuum systems (i.e., dental air, dental vacuum, and scavenging) shall be final tested in accordance with 15.4.8.1.7 and 15.4.8.1.8 .

15.4.8.1.3 – Initial Testing of Piping Systems.

15.4.8.1.3.1 – General.

(A) –

Where plastic vacuum and plastic scavenging piping systems are installed, they shall be visually inspected for cross-connections to oxygen and nitrous oxide systems before applying positive test pressures to the copper piping systems.

(B) –

During the process of initial testing, the identification and labeling of the dental gas and vacuum piping shall be checked.

15.4.8.1.4 – Initial Cross-Connection Test for Plastic Vacuum and Plastic Scavenging Piping Systems.

15.4.8.1.4.1 –

Plastic piping shall be tested before copper piping.

15.4.8.1.4.2 –

Tests shall be conducted to determine that no cross-connections exist between any plastic vacuum piping systems or plastic scavenging piping systems and any copper piping systems.

15.4.8.1.4.3 –

The vacuum or scavenging source shutoff valves for the vacuum or scavenging piping systems shall remain closed during the tests, unless they are being used for the cross-connection test vacuum source.

15.4.8.1.4.4 –

The cross-connection test vacuum shall be a minimum of 300 mm (12 in.) HgV.

15.4.8.1.4.5 –

The source of test vacuum shall be connected only to the vacuum or scavenging piping system being tested.

15.4.8.1.4.6 –

All individual gas system outlets and vacuum or scavenging system inlets shall be checked to determine that the test vacuum is only present in the vacuum or scavenging piping system being tested.

15.4.8.1.4.7 –

The cross-connection tests shall be repeated for each installed vacuum and scavenging system with plastic piping.

15.4.8.1.4.8 –

Any cross-connections shall be removed and the associated piping repaired and leak tested.

15.4.8.1.4.9 –

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

15.4.8.1.5 – Initial Pressure Test.

15.4.8.1.5.1 –

Each section of the piping in dental air systems and copper vacuum systems shall be pressure tested. Plastic vacuum and plastic scavenging piping shall not be pressure tested.

15.4.8.1.5.2 –

Initial pressure tests shall be conducted as follows:

(1) After installation of station outlet/inlet rough-in assemblies

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

15.4.8.1.5.3 –

The source shutoff valve shall remain closed during the pressure tests.

15.4.8.1.5.4 –

The test pressure for dental air piping and copper vacuum piping shall be 1.5 times the system operating pressure but not less than a gauge pressure of 1035 kPa (150 psi).

15.4.8.1.5.5 –

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.

15.4.8.1.5.6 –

Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.

15.4.8.1.6 – Initial Piping Purge Test.

15.4.8.1.6.1 –

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

15.4.8.1.6.2 –

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

15.4.8.1.6.3 –

The purging shall be started at the closest outlet to the piping shutoff valve and continue to the furthest outlet from the shutoff valve.

15.4.8.1.7 – Standing Pressure Test for Dental Air and Copper Vacuum Piping.

15.4.8.1.7.1 –

After successful completion of the initial pressure tests in 15.4.8.1 , the dental air systems and copper vacuum systems shall be subject to a standing pressure test.

15.4.8.1.7.2 –

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, and hoses).

15.4.8.1.7.3 –

The source valve shall be closed during this test.

15.4.8.1.7.4 –

The piping systems shall be subjected to 24-hour standing pressure tests using oil-free, dry nitrogen NF.

15.4.8.1.7.5 –

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

15.4.8.1.7.6 –

At the conclusion of the tests, there shall be no change in the test pressure, except that attributed to specific changes in ambient temperature.

15.4.8.1.7.7 –

Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested. The piping shall be repurged if necessary.

15.4.8.1.8 – Standing Vacuum Test for Plastic Vacuum Piping.

15.4.8.1.8.1 –

After successful completion of the initial pressure tests in 15.4.8.1 , vacuum distribution piping, including scavenging, shall be subjected to a standing vacuum test.

15.4.8.1.8.2 –

Tests shall be conducted after installation and connection of all components of the vacuum system.

15.4.8.1.8.3 –

The piping systems shall be subjected to a 24-hour standing vacuum test.

15.4.8.1.8.4 –

Test pressure shall be between 300 mm (12 in.) HgV and full vacuum.

15.4.8.1.8.5 –

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

15.4.8.1.8.6 –

At the conclusion of the test, there shall be no change in the vacuum pressure other than that attributed to changes of ambient temperature.

15.4.8.1.8.7 –

Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.

15.4.9 – Operation and Management.

15.4.9.1 – System Shutdowns.

~~**15.4.9.1.1** –~~

~~Gas and vacuum piping systems shall be shut down at the end of each workday.~~

~~**15.4.9.1.2** –~~

~~Emergency shutoff valves or remote actuators shall not be used for daily shutdown of the systems. Cylinder gas valves shall be used for daily shutdowns.~~

~~**15.4.9.2** – Prohibited Interconnections.~~

~~Two or more piping systems for different gases or different vacuums shall not be interconnected for testing or any other reason.~~

~~**15.4.9.3** – Manufacturer's Instructions.~~

~~**15.4.9.3.1** –~~

~~Piping system components shall be installed, adjusted, operated, and maintained in accordance with the manufacturer's instructions.~~

~~**15.4.9.3.2** –~~

~~Copies of the manufacturer's instructions shall be provided to the facility and maintained at the facility.~~

~~**15.4.9.4** – Maintenance.~~

~~**15.4.9.4.1** –~~

~~Gas and vacuum system equipment shall be maintained by a qualified person.~~

~~**15.4.9.4.2** –~~

~~Every facility shall establish a procedure for manually turning off the gas supply at the cylinder valves of Category 2 dental gas and vacuum systems at the end of each day.~~

~~**15.4.9.5** – Periodic Testing.~~

~~**15.4.9.5.1** –~~

~~Station outlets for oxygen and nitrous oxide shall be tested for flow and pressure on an approved schedule.~~

~~**15.5** – Category 3 Dental Gas and Vacuum Systems.~~

~~**15.5.1** – General.~~

~~**15.5.1.1** –~~

~~Category 3 dental gas and vacuum systems shall be limited to facilities that perform minimal or no sedation.~~

~~**15.5.1.2** –~~

~~There shall be no medical gases.~~

~~**15.5.1.3** –~~

~~The dental support gases shall be provided from a dental air source system.~~

~~**15.5.1.4** –~~

~~The vacuum system shall be dental vacuum.~~

~~**15.5.2** – Category 3 Dental Air and Vacuum Piping Systems.~~

~~**15.5.2.1** – General.~~

~~Dental air and vacuum piping systems shall include dental support gases and dental vacuum systems.~~

~~**15.5.2.2** – Vacuum Systems.~~

~~Dental vacuum systems shall include dental vacuum and nitrous oxide scavenging.~~

~~**15.5.3** – Equipment Locations for Dental Air and Vacuum Systems.~~

15.5.3.1 – General.

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

(1) Dental air compressor sources and reserve headers

(2) Dental vacuum sources

(3) Any other compressor, vacuum pump, or electrically powered machinery

15.5.3.2 – Cylinders and Containers.

Cylinders and containers for gases shall be handled in accordance with Chapter 11 .

15.5.3.3 – Ventilation for Motor-Driven Equipment.

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

(1) Dental compressed air sources

(2) Dental vacuum sources

15.5.4 – Dental Gas and Vacuum Source Equipment.

15.5.4.1 – General.

15.5.4.1.1 –

The capacity of source equipment shall be based on the design requirements for the facility, including the number of gas outlets, vacuum inlets, and other connections, and their individual capacities.

15.5.4.1.2 –

The system design requirements shall be included in the data used for testing and verifying the operation of the gas and vacuum piping systems.

15.5.4.2 – Dental Air.

15.5.4.2.1 – General.

15.5.4.2.1.1 –

Dental air shall be used as a support gas for driving dental tools and shall be permitted to be used to supply air-driven equipment. Dental compressed air shall not be used for respiration.

15.5.4.2.1.2 –

Dental air outlets shall not be interchangeable with any other gas outlets, including oxygen, nitrous oxide, medical air, instrument air, and nitrogen.

15.5.4.2.2 – Dental Air Compressor Units.

15.5.4.2.2.1 –

Dental air compressor units shall include dental air compressors, vibration isolation, air receivers, coalescent air filters, adsorption dryers, exhaust silencer/filters, moisture indicators, and service access manifolds, electrical disconnects, motor wiring, and controls.

15.5.4.2.2.2 –

Air compressors shall be scroll dental, reciprocating dental, or the oil-free dental types.

15.5.4.3 – Dental Vacuum.

15.5.4.3.1 – General.

15.5.4.3.1.1 –

Dental vacuum shall be used for oral evacuation and nitrous oxide scavenging.

15.5.4.3.1.2 –

Dental vacuum inlets shall not be interchangeable with any other vacuum inlets, including dental-surgical vacuum.

15.5.4.3.2 – Dental Vacuum Units.

15.5.4.3.2.1 –

Dental vacuum units shall include dental vacuum pumps, vibration isolation, separation tanks, vacuum inlet, vacuum exhaust, condensate drain, motor wiring, and controls.

15.5.4.3.2.2 –

Dental vacuum pumps shall be dental dry vacuum or dental liquid (wet) ring pumps. Pumps shall be oil-free or oil-lubricated and suitable for nitrous oxide scavenging.

15.5.5 – Piping for Category 3 Dental Gas and Vacuum Systems.

15.5.5.1 – General.

15.5.5.1.1 –

Piping for dental air systems shall comply with 15.5.5.2 .

15.5.5.1.2 –

Piping for dental vacuum systems and scavenging systems shall comply with 15.5.5.3 .

15.5.5.2 – Piping for Dental Air Systems.

15.5.5.2.1 – General.

Pipe, fittings, and joints in piping for dental compressed air systems shall be in accordance with 15.5.5.2.2 through 15.5.5.2.4 .

15.5.5.2.2 – Pipe.

Pipe under 15.5.5 shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service* , ACR tube (O.D. size)

15.5.5.2.2.1 –

Copper tube shall be hard temper or annealed (soft temper).

15.5.5.2.3 – Fittings.

Fittings for piping under 15.5.5.2 shall be permitted to be any of the following acceptable joining methods:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings in compliance with ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (**3** ⁄ **4** in. maximum size)

15.5.5.2.4 – Joints.

Joints for piping under 15.5.5.2 shall comply with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6 .

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal* .

15.5.5.3 – Piping for Dental Vacuum Systems and Scavenging Systems.

15.5.5.3.1 – General.

Piping for dental vacuum systems and scavenging systems shall be copper, PVC plastic, or CPVC plastic.

15.5.5.3.2 – Copper Piping.

Copper piping under 15.5.5.3 shall be in accordance with 15.5.5.3.2.1 through 15.5.5.3.2.3 .

15.5.5.3.2.1 – Copper Tube.

(A) –

Copper tubing shall comply with the following:

(1) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems* , Type L or K

(2) ASTM B88, *Standard Specification for Seamless Copper Water Tube* , Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service* , ACR tube (O.D. size)

(B) –

Copper tube shall be hard temper or annealed (soft temper).

15.5.5.3.2.2 – Copper Fittings.

Copper fittings shall comply with the following:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings conforming to ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (**3** ⁄ **4** in. maximum size)

15.5.5.3.2.3 – Joints for Copper Piping.

Joints in copper tubing shall be in accordance with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6 .

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal* .

15.5.5.3.3 – PVC Plastic Piping.

PVC plastic piping under 15.5.5.3 shall be in accordance with the following:

(1) PVC plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM D1785, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120* .

(2) PVC plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM D2466, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40* , or ASTM D2467, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80* .

(3) Joints in PVC plastic piping shall be solvent-cemented in accordance with ASTM D2672, *Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement* .

15.5.5.3.4 – CPVC Plastic Piping.

CPVC plastic piping under 15.5.5.3 shall be in accordance with the following:

(1) CPVC IPS plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM F441/F441M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80* .

(2) CPVC IPS plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40* , or ASTM F439, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80* .

(3) CPVC CTS plastic pipe and fittings **1** ⁄**2** in. through 2 in. size shall be SDR 11, conforming to ASTM D2846/D2846M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems* .

(4) Solvent cement for joints in CPVC plastic piping shall comply with ASTM F493, *Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings* .

15.5.6 – Installation of Dental Air and Vacuum Piping.

15.5.6.1 – General.

15.5.6.1.1 –

Dental air and vacuum piping systems shall be as listed in 15.5.2 .

15.5.6.1.2 –

Piping materials shall be as listed in 15.5.5 .

15.5.6.2 – Pipe Sizing.

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

15.5.6.3 – Protection of Piping.

15.5.6.3.1 –

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

15.5.6.3.2 –

Piping exposed in corridors and other locations where subject to physical damage from the movement of equipment shall be protected.

15.5.6.4 – Pipe Support.

15.5.6.4.1 –

Piping shall be supported from the building structure.

15.5.6.4.2 –

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* .

15.5.6.4.3 –

Hangers and supports shall be sized for the tube or pipe being supported.

15.5.6.4.4 –

The maximum support spacing for copper tube shall be in accordance with Table 15.5.6.4.4 .

Table 15.5.6.4.4 Maximum Copper Tube Support Spacing

Hanger Spacing Pipe Size mm ft DN8 (NPS $\frac{1}{4}$) ($\frac{3}{8}$ in. O.D.) 1520 5 DN10 (NPS $\frac{3}{8}$) ($\frac{1}{2}$ in. O.D.) 1830 6 DN15 (NPS $\frac{1}{2}$) ($\frac{5}{8}$ in. O.D.) 1830 6 DN20 (NPS $\frac{3}{4}$) ($\frac{7}{8}$ in. O.D.) 2130 7 DN25 (NPS 1) (1 $\frac{1}{8}$ in. O.D.) 2440 8 DN32 (NPS 1 $\frac{1}{4}$) (1 $\frac{3}{8}$ in. O.D.) 2740 9 DN40 (NPS 1 $\frac{1}{2}$) (1 $\frac{5}{8}$ in. O.D.) and larger 3050 10 Vertical risers, all sizes, every floor, but not to exceed 4570 15

15.5.6.4.5 –

The maximum support spacing for plastic pipe shall be in accordance with Table 15.5.6.4.5 .

Table 15.5.6.4.5 Maximum Plastic Pipe Support Spacing

Hanger Spacing Pipe Size mm ft DN15 (NPS $\frac{1}{2}$) ($\frac{5}{8}$ in. O.D.) 1220 4 DN20 (NPS $\frac{3}{4}$) ($\frac{7}{8}$ in. O.D.) 1220 4 DN25 (NPS 1) (1 $\frac{1}{8}$ in. O.D.) 1320 4.33 DN32 (NPS 1 $\frac{1}{4}$) (1 $\frac{3}{8}$ in. O.D.) 1320 4.33 DN40 (NPS 1 $\frac{1}{2}$) (1 $\frac{5}{8}$ in. O.D.) 1420 4.66 DN50 (NPS 2) (2 $\frac{3}{8}$ in. O.D.) 1420 4.66 DN65 (NPS 2 $\frac{1}{2}$) (2 $\frac{7}{8}$ in. O.D.) and larger 1520 5 Vertical risers, all sizes, every floor, but not to exceed 3040 10

15.5.6.5 – Underground Piping Outside of Buildings.

15.5.6.5.1 –

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

15.5.6.5.2 –

The installation procedure for underground piping shall prevent physical damage to the piping while being backfilled.

15.5.6.5.3 –

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

(1) Access during construction shall be provided at the joints for visual inspection and leak testing.

(2) The conduit, cover, or enclosure shall be self-draining and not retain groundwater in prolonged contact with copper tubing.

15.5.6.5.4 –

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

15.5.6.5.5 –

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.

15.5.6.5.6 –

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

15.5.6.5.7 –

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

15.5.6.5.8 –

A continuous warning tape or marker shall be placed immediately above the piping or its enclosure to clearly identify the pipeline by specific name.

15.5.6.5.9 –

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

15.5.6.5.10 –

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.

15.5.6.6 – Underground Piping Within Buildings.

15.5.6.6.1 –

The installation procedure for underground piping shall prevent physical damage to the piping while being backfilled.

15.5.6.6.2 –

The piping shall be backfilled with clean sand or gravel.

15.5.6.7 – Piping Within Floor Slabs Prohibited.

Dental gas and vacuum piping shall not be installed within floor slabs.

15.5.7 – Performance Criteria and Testing (Dental air and Vacuum).

15.5.7.1 – Dental Air and Vacuum Systems Testing.

15.5.7.1.1 – General.

15.5.7.1.1.1 –

Inspection and testing shall be performed on all new piped dental gas and vacuum systems, additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that the following have been completed:

(1) All applicable provisions of this code have been adhered to.

(2) System integrity has been achieved or maintained.

(3) Piping systems are ready for testing and verification.

(4) Piping systems are performing in accordance with their design requirements.

15.5.7.1.1.2 –

The inspection and testing reports shall be submitted directly to the party that contracted for the testing, who shall submit the reports through channels to the Responsible Facility Authority and any others that are required.

15.5.7.1.1.3 –

Reports shall contain detailed listings of all findings and results.

15.5.7.1.1.4 –

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 before use.

15.5.7.1.1.5 –

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

15.5.7.1.2 – Required Testing.

15.5.7.1.2.1 – Category 3 Dental Air and Vacuum Systems.

(A) –

All Category 3 dental gas and vacuum piping systems indicated in 15.5.2 shall be initially tested in accordance with 15.5.7.1.3 .

(B) –

The support gas systems and vacuum systems (i.e., dental air, dental vacuum, and scavenging) shall be final tested in accordance with 15.5.7.1.3.4 and 15.5.7.1.3.5 .

15.5.7.1.3 – Initial Testing of Piping Systems.

15.5.7.1.3.1 – General.

(A) –

Where plastic vacuum and plastic scavenging piping systems are installed, they shall be visually inspected for cross-connections to oxygen and nitrous oxide systems before applying positive test pressures to the copper piping systems.

(B) –

During the process of initial testing, the identification and labeling of the dental gas and vacuum piping shall be checked.

15.5.7.1.3.2 – Initial Pressure Test.

(A) –

Each section of the piping in dental air systems and copper vacuum systems shall be pressure tested. Plastic vacuum and plastic scavenging piping shall not be pressure tested.

(B) –

Initial pressure tests shall be conducted as follows:

(1) After installation of station outlet/inlet rough-in assemblies

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

(C) –

The source shutoff valve shall remain closed during the pressure tests.

(D) –

The test pressure for dental air piping and copper vacuum piping shall be 1.5 times the system operating 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) –

Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.

15.5.7.1.3.3 – Initial Piping Purge Test.

(A) –

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

(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 closest outlet to the piping shutoff valve and continue to the furthest outlet from the shutoff valve.

15.5.7.1.3.4 – Standing Pressure Test for Dental Air and Copper Vacuum Piping.

(A) –

After successful completion of the initial pressure tests in 15.5.7.1.3.2 , the dental air systems and copper vacuum systems shall be subject to a standing pressure test.

(B) –

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, and hoses).

(C) –

The source valve shall be closed during this test.

(D) –

The piping systems shall be subjected to 24-hour standing pressure tests using oil-free, dry nitrogen NF.

(E) –

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

~~**(F)** –~~

~~At the conclusion of the tests, there shall be no change in the test pressure except that attributed to specific changes in ambient temperature.~~

~~**(G)** –~~

~~Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested. The piping shall be repurged if necessary.~~

~~**15.5.7.1.3.5** – Standing Vacuum Test for Plastic Vacuum Piping.~~

~~**(A)** –~~

~~After successful completion of the initial pressure tests in 15.5.7.1.3.2 , vacuum distribution piping, including scavenging, shall be subjected to a standing vacuum test.~~

~~**(B)** –~~

~~Tests shall be conducted after installation and connection of all components of the vacuum system.~~

~~**(C)** –~~

~~The piping systems shall be subjected to a 24-hour standing vacuum test.~~

~~**(D)** –~~

~~Test pressure shall be between 300 mm (12 in.) HgV and full vacuum.~~

~~**(E)** –~~

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

~~**(F)** –~~

~~At the conclusion of the test, there shall be no change in the vacuum pressure other than that attributed to changes of ambient temperature.~~

~~**(G)** –~~

~~Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.~~

~~**15.5.8** – Operation and Management.~~

~~**15.5.8.1** – System Shutdowns.~~

~~Gas and vacuum piping systems shall be shut down at the end of each workday.~~

~~**15.5.8.2** – Manufacturer's Instructions.~~

~~**15.5.8.2.1** –~~

~~Piping system components shall be installed, adjusted, operated, and maintained in accordance with the manufacturer's instructions.~~

~~**15.5.8.2.2** –~~

~~Copies of the manufacturer's instructions shall be provided to the facility and maintained at the facility.~~

~~**15.5.8.3** – Maintenance.~~

~~Dental air and vacuum system equipment shall be maintained by a qualified representative of the equipment manufacturer.~~

[See attached Category Task Group Report]

Supplemental Information

File Name	Description	Approved
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Submitter Information Verification

Committee: HEA-PIP

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Committee Statement

Committee Statement: The committee input is intended to clarify the structure and alignment of Ch. 15 and to solicit public comments from other interested parties. A task group has been appointed to further study this issue and provide recommendations for the second draft.

Response Message: CI-1075-NFPA 99-2021

Public Input No. 290-NFPA 99-2021 [New Section after 15.3.3.5.1.2]

Public Input No. 285-NFPA 99-2021 [Section No. 15.1.2]

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Public Input No. 281-NFPA 99-2021 [Section No. 15.3.2.1.7]

Public Input No. 280-NFPA 99-2021 [Section No. 15.3.2.1.5]

Public Input No. 286-NFPA 99-2021 [Section No. 15.1.4]

Public Input No. 284-NFPA 99-2021 [Section No. 15.1.1]

These revisions to Chapter 15

Chapter 15 Dental Gas and Vacuum Systems

15.1.1

This chapter shall apply only to facilities or Patient Care Spaces in which dental treatments are performed. Requirements for medical systems are found in Chapter 5.

15.1.2

Medical gases in facilities and Patient Care Spaces in which the failure or unavailability of these services are likely to cause major injury or the death of patients, staff or visitors shall be constructed and operated in accordance with Chapter 5, Category 1. Dental gas, vacuum and scavenging systems shall be constructed and operated in accordance with Chapter 15, Category 2.

15.1.3

Dental Category 2 piped gas and piped vacuum system requirements shall be applied in facilities and Patient Care Spaces where general anesthesia and deep sedation (as defined in 3.3.68.1 and 3.3.68.2) is performed.

15.1.4

Dental Category 3 piped gas and piped vacuum system requirements shall be applied in facilities and Patient Care Spaces where only moderate and minimal sedation (as defined in 3.3.68.3 and 3.3.68.3) or no sedation, is performed

15.1.5

Dental Category 4 facilities and Patient Care Spaces are those in which medical gases are not piped. Only minimal sedation (as defined in 3.3.68.4) or no sedation is performed.

15.1.6

A single facility shall be permitted to include dental gas and vacuum systems for more than one category of dental piped gas and vacuum systems.

15.1.7

An existing system that is not in strict compliance with the provisions of this code shall be permitted to continue in use unless the authority having jurisdiction has determined that such use constitutes a distinct hazard to life.

15.1.8

The requirements for Category 2 dental gas and vacuum systems for the operation, management, and maintenance of gas and vacuum piping systems shall apply to both new and existing facilities within the scope of this chapter and in accordance with 5.1.1.5.

15.1.9

The following sections of this chapter shall apply to the operation, management, and maintenance of Category 3 dental gas and vacuum systems in both new and existing facilities:

(1) 15.1.5

(2) 15.2

(3) 15.4.2.4.3

(4) 15.4.2.4.5

(5) 15.4.2.4.13

(6) 15.4.2.5.14

(7) 15.4.2.6.4

(8) 15.4.9

15.1.10

The following sections of this chapter shall apply to the operation, management, and maintenance of Category 4 dental gas and vacuum systems in both new and existing facilities:

(1) 15.1.5

(2) 15.2

(3) 15.5.8

15.1.11
Where the term *Responsible Facility Authority* is used, that entity shall follow the requirements of 5.1.14.1.

15.2 Nature of Hazards of Gas and Vacuum Systems.
Potential fire and explosion hazards associated with positive-pressure dental gas systems and vacuum systems shall be considered in the design, installation, testing, operation, and maintenance of these systems.
15.3 Category 2 Dental Gas and Vacuum Systems.
15.3.1 General.
Facilities that perform deep sedation and general anesthesia associated with dental treatment shall meet the requirements for Category 1 dental gas and vacuum systems.
15.3.2 Category 2 Medical Gas Systems in Dental Patient Care Spaces.
15.3.2.1 Medical Gas and Vacuum Sources.
15.3.2.1.1 Central Supply System Identification and Labeling.
Medical Gas Systems in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.3.1.
15.3.2.1.2 Central Supply Operations.
Medical Gas Systems in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.3.2.
15.3.2.1.3 Central Supply System Locations.
Medical Gas Systems in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.3.3.
15.3.2.1.4 Central Supply Systems.
Medical Gas Systems in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.3.4.
15.3.2.1.5 Medical Air Central Supply Systems.
Medical Air Central Supply Systems in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.3.5.
15.3.2.1.6
Oxygen **Central Supply Systems** using concentrators supplying only Category 2 **Dental Patient Care Spaces** shall be permitted to consist of two sources, the concentrator as one and a cylinder header with sufficient cylinder connections for an average day's supply as the other.
15.3.2.1.7 Medical–Surgical Vacuum Central Supply Systems.
Medical Vacuum Central Supply Systems supplying Category 2 **Dental Patient Care Spaces** shall comply with 5.1.3.7, except as follows:

(1) Medical–surgical Vacuum **Central Supply Systems** shall be permitted to be simplex.

(2) The facility staff shall develop their emergency plan to deal with the loss of medical–surgical vacuum.

15.3.2.1.8 WAGD **Central Supply Systems**.
WAGD Central Supply Systems supplying Category 2 **Dental Patient Care Spaces** shall comply with 5.1.3.8, except as follows:

(1) WAGD **Central Supply Systems** shall be permitted to be simplex.

(2) The facility staff shall develop their emergency plan to deal with the loss of WAGD.

15.3.2.2 Valves.
Piping to Category 2 **Dental Patient Care Spaces** shall comply with 5.1.4.
15.3.2.3 Station Outlets and Inlets.
Station Outlets and Inlets in Category 2 **Dental Patient Care Spaces** shall comply with 5.1.5.
15.3.2.4 Manufactured Assemblies.
Manufactured Assemblies installed in Category 2 **Dental Patient Care Spaces** shall comply with 5.1.6.
15.3.2.5 Surface-Mounted Medical Gas Rails.
Surface Mounted Medical gas rails installed in Category 2 **Dental Patient Care Spaces** shall comply with 5.1.7.
15.3.2.6 Pressure and Vacuum Indicators.
Pressure and vacuum indicators installed in Category 2 **Dental Patient Care Spaces** shall comply with 5.1.8.
15.3.2.7 Warning Systems.
Warning systems for medical gas and vacuum systems serving Category 2 **Dental Patient Care Spaces** shall provide the master, area, and local alarm functions of alarms as required in 5.2.9.
15.3.2.8 Medical Gas, Vacuum and WAGD Distribution.
Medical Gas, Vacuum and WAGD Systems in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.10.
15.3.2.9 Labeling and Identification.

Medical Gas, Vacuum and WAGD in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.11.
15.3.2.10 Performance Criteria and Testing (Medical Gas, Medical–Surgical Vacuum, and WAGD).
Medical Gas, Vacuum and WAGD in Category 2 **Dental Patient Care Spaces** shall comply with 5.2.12.
15.3.2.11 Support Gases.
Support gas systems in Category 2 **Dental Patient Care Spaces** systems shall comply with 5.2.13 except as follows:

(1) Nitrogen source equipment shall be permitted to be installed in enclosures for Category 3 medical gases (5.3.3) or in a mechanical room.

(2) Nitrogen source equipment shall include the following:

(a) One or more cylinders of nitrogen NF, sufficient for at least one average day's supply

(b) A manifold, if primary and secondary cylinders are provided

(c) A line pressure regulating valve

(d) A check valve downstream from the pressure regulating valve

(e) A pressure relief valve set at 50 percent above the normal line pressure and located downstream from the check valve

(f) A pressure relief valve discharge piped to the outdoors at a point that will not create a probable hazard and that is turned down to prevent the entry of rain or snow

15.3.2.12 Medical Gas and Vacuum Operation and Management.
Medical Gas, Vacuum and WAGD Systems serving Category 2 **Dental Patient Care Spaces** shall comply with 5.2.14.
15.3.3 Dental Air and Vacuum Piping Systems **serving** Category 2 **Dental Patient Care Spaces**.
15.3.3.1 General.
15.3.3.1.1
Dental air and vacuum piping systems shall include dental support gases and dental vacuum systems.
15.3.3.1.2
Dental vacuum systems shall include dental vacuum and nitrous oxide scavenging.
15.3.3.2 Equipment Locations for Dental Air and Vacuum Systems serving **Category 2** Dental Patient Care Spaces.
15.3.3.2.1 General.
Any of the following systems shall be permitted to be located together in the same room:

(1) Medical air compressor supply sources

(2) Dental air compressor sources and reserve headers

(3) Dental-surgical vacuum sources

(4) Dental vacuum sources

(5) WAGD sources

(6) Any other compressor, vacuum pump, or electrically powered machinery

15.3.3.2.2 Cylinders and Containers.
Cylinders and containers for gases shall be handled in accordance with Chapter 11.
15.3.3.2.3 Ventilation.
The following source locations for motor-driven equipment shall be adequately ventilated to prevent accumulation of heat:

(1) Medical air sources

(2) Instrument air sources

(3) Dental compressed air sources

(4) Dental-surgical vacuum sources

(5) Dental vacuum sources

(6) WAGD sources

15.3.3.3 Dental Gas and Vacuum Source Equipment serving **Category 2** Dental Patient Care Spaces.
15.3.3.3.1 General.
15.3.3.3.1.1
The capacity of source equipment shall be based on the design requirements for the facility, including the number of gas outlets, vacuum inlets, and other connections, and their individual capacities.
15.3.3.3.1.2
The system design requirements shall be included in the data used for testing and verifying the operation of the gas and vacuum piping systems.
15.3.3.4***** Dental Air serving **Category 2** Dental Patient Care Spaces**.**
15.3.3.4.1 General.
15.3.3.4.1.1
Dental air shall be used as a support gas for driving dental tools and shall be permitted to be used to supply air-driven equipment. Dental compressed air shall not be used for respiration.
15.3.3.4.1.2
Dental air outlets shall not be interchangeable with any other gas outlets, including oxygen, nitrous oxide, medical air, instrument air, and nitrogen.
15.3.3.4.2 Dental Air Compressor Units serving **Category 2** Dental Patient Care Spaces.
15.3.3.4.2.1
Dental air compressor units shall include dental air compressors, vibration isolation, air receivers, coalescent air filters, adsorption dryers, exhaust silencer/filters, moisture indicators, and service access manifolds, electrical disconnects, motor wiring, and controls.
15.3.3.4.2.2
Air compressors shall be scroll dental, reciprocating dental, or the oil-free dental types.
15.3.3.5***** Dental Vacuum serving **Category 2** Dental Patient Care Spaces.
15.3.3.5.1 General.
15.3.3.5.1.1
Dental vacuum shall be used for oral evacuation and nitrous oxide scavenging.
15.3.3.5.1.2
Dental vacuum inlets shall not be interchangeable with any other vacuum inlets, including dental-surgical vacuum.
15.3.3.5.2 Dental Vacuum Units serving **Category 2** Dental Patient Care Spaces.
15.3.3.5.2.1
Dental vacuum units shall include dental vacuum pumps, vibration isolation, separation tanks, vacuum inlet, vacuum exhaust, condensate drain, motor wiring, and controls.
15.3.3.5.2.2
Dental vacuum pumps shall be dental dry vacuum or dental liquid (wet) ring pumps. Pumps shall be oil-free or oil-lubricated, and suitable for nitrous oxide scavenging.
15.3.3.6 Nitrous Oxide Scavenging serving **Category 2** Dental Patient Care Spaces..
15.3.3.6.1 General.
15.3.3.6.1.1
The use of scavenging shall be limited to portions of dental facilities where moderate or minimal sedation is administered. WAGD shall be provided where the dental treatment involves general anesthesia or deep sedation.
15.3.3.6.1.2
Active nitrous oxide scavenging shall include the use of a nasal mask on the patient. The nasal mask shall be connected to a scavenging inlet in the dental vacuum system through a flow-limiting adapter.
15.3.3.6.1.3
Nitrous oxide scavenging inlets shall not be interchangeable with any other vacuum inlets, including medical-surgical vacuum, dental vacuum, and WAGD.
15.3.3.6.2 Connection to Dental Vacuum.
Scavenging connections to the dental vacuum system shall be a direct high-volume evacuation (HVE) connection to a high-volume vacuum port with a capacity of 45 L/min (1.6 cfm).
15.3.3.7 Category 2 Dental Air and Vacuum Piping to Dental Patient Care Spaces.

15.3.3.7.1 General.
15.3.3.7.1.1
Piping for dental compressed air systems **serving** Category 2 **Dental Patient Care Spaces** shall comply with 15.3.3.7.2.
15.3.3.7.1.2
Piping for dental vacuum systems and scavenging systems **serving** Category 2 **Dental Patient Care Spaces** shall comply with 15.3.3.7.3.
15.3.3.7.2 Piping for Dental Air Systems serving **Category 2** Dental Patient Care Spaces.
15.3.3.7.2.1 General.
Pipe, fittings, and joints in piping for dental compressed air systems shall be in accordance with 15.3.3.7.2.2 through 15.3.3.7.2.5.
15.3.3.7.2.2 Pipe.
Pipe under 15.3.3.7.2 shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, ACR tube (O.D. size)

15.3.3.7.2.3
Copper tube shall be hard temper or annealed (soft temper).
15.3.3.7.2.4 Fittings.
Fittings for piping under 15.3.3.7.2 shall be permitted to be any of the following acceptable joining methods:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings in compliance with ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (3/4 in. maximum size)

15.3.3.7.2.5 Joints.
Joints for piping under 15.3.3.7.2 shall comply with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6.

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal*.

15.3.3.7.3 Piping for Dental Vacuum Systems and Scavenging Systems serving **Category 2** Dental Patient Care Spaces.
15.3.3.7.3.1 General.
Piping for dental vacuum systems and scavenging systems shall be copper, PVC plastic, or CPVC plastic.
15.3.3.7.3.2 Copper Piping.
Copper piping under 15.3.3.7.3 shall be in accordance with 15.3.3.7.3.2(A) through 15.3.3.7.3.2(D).
(A) Copper Tube.
Copper tubing shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, ACR tube (O.D. size)

(B)
Copper tube shall be hard temper or annealed (soft temper).
(C) Copper Fittings.
Copper fittings shall comply with the following:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings conforming to ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (3/4 in. maximum size)

(D) Joints for Copper Piping.
Joints in copper tubing shall be in accordance with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6.

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal*.

15.3.3.7.3.3 PVC Plastic Piping.
PVC plastic piping under 15.3.3.7.3 shall be in accordance with the following:

(1) PVC plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM D1785, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120*.

(2) PVC plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM D2466, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40*, or ASTM D2467, *Standard Specification Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80*.

(3) Joints in PVC plastic piping shall be solvent-cemented in accordance with ASTM D2672, *Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement*.

15.3.3.7.3.4 CPVC Plastic Piping.
CPVC plastic piping under 15.3.3.7.3 shall be in accordance with the following:

(1) CPVC IPS plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM F441/F441M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80*.

(2) CPVC IPS plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*, or ASTM F439, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*.

(3) CPVC CTS plastic pipe and fittings 1/2 in. through 2 in. size shall be SDR 11, conforming to ASTM D2846/D2846M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems*.

(4) Solvent cement for joints in CPVC plastic piping shall comply with ASTM F493, *Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride)(CPVC) Plastic Pipe and Fittings*.

15.4 Category 3 Medical Gas, Dental Air and Vacuum Systems serving Dental Patient Care Spaces.
15.4.1 General.
15.4.1.1

Category 3 dental piped gas and piped vacuum system requirements shall be applied in facilities where only moderate and minimal sedation is performed (as defined in 3.3.68.3 and 3.3.68.3) is performed, and where the failure or unavailability of medical gas, dental gas, vacuum or scavenging systems may cause minor injury to patients, staff or visitors.

15.4.1.2
The medical gases shall be limited to oxygen and nitrous oxide.
15.4.1.3
The dental support gases shall be provided from a dental air source system.
15.4.1.4
The vacuum systems shall be dental vacuum and nitrous oxide scavenging.
15.4.1.5
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 dental air.
15.4.1.6
Station outlets and piped outlets for Category 3 medical gas and dental air having nonstandard operating pressures shall comply with the following additional requirements:

(1) Be gas-specific.

(2) Be pressure-specific where a single gas is piped at more than one operating pressure.

(3) Be a D.I.S.S connection if operated at a gauge pressure in excess of 550 kPa (80 psi).

(4) 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).

15.4.1.7
Requirements for Category 3 dental gas and vacuum systems relating to the operation, management, and maintenance of oxygen and nitrous oxide piping systems shall apply both new and existing facilities as specified in 15.1.7.
15.4.2 Medical Gas Systems (Oxygen and Nitrous Oxide) serving Category 3 Dental Patient Care Spaces.
15.4.2.1 Installer Qualifications (Oxygen and Nitrous Oxide).
15.4.2.1.1
Installers of medical gas systems shall be certified in accordance with ASSE 6010, *Professional Qualification Standard for Medical Gas Systems Installers*, regardless of the capacity of the source equipment.
15.4.2.1.2
Installers of medical gas systems shall not use their certification to oversee installation by noncertified personnel.
15.4.2.1.3
Brazing of medical gas piping systems shall be performed by individuals who are qualified in accordance with 15.4.6.1.
15.4.2.1.4
Prior to any installation work involving brazing, the installer of the medical gas piping systems shall provide documentation required by 15.4.6.1 for the qualifications of the brazing procedures and individual brazers.
15.4.2.2 Central Supply System Identification and Labeling (Oxygen and Nitrous Oxide) serving Category 3 Dental Patient Care Spaces.

15.4.2.2.1
Cylinders, containers, 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]
15.4.2.2.2
Cylinder contents shall be identified by attached labels or stencils naming the contents in accordance with the mandatory requirements of CGA C-7, *Guide to Classification and Labeling of Compressed Gases*.
15.4.2.2.3
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.
15.4.2.2.4
Cryogenic liquid containers shall be provided with gas-specific outlet connections in accordance with the mandatory requirements of CGA V-5, *Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)*, or CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*.
15.4.2.2.5
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.
15.4.2.2.6
The contents of cylinders and cryogenic liquid containers shall be verified prior to use.
15.4.2.2.7
Labels shall not be defaced, altered, or removed, and connecting fittings shall not be modified.
15.4.2.2.8
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
15.4.2.2.9
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
15.4.2.3 Central Supply System Operations (Oxygen and Nitrous Oxide) for Central Supply Systems serving Category 3 Dental Patient Care Spaces.

15.4.2.3.1
The use of adapters or conversion fittings to adapt one gas-specific fitting to another shall be prohibited.
15.4.2.3.2
Cylinders and containers shall be handled in strict accordance with 11.6.2.

15.4.2.3.3
Only gas cylinders, reusable shipping containers, and their accessories shall be permitted to be stored in rooms containing central supply systems or gas cylinders.
15.4.2.3.4
No flammable materials, cylinders containing flammable gases, or containers containing flammable liquids shall be stored in rooms with gas cylinders.
15.4.2.3.5
If cylinders are wrapped when received, the wrappers shall be removed prior to storage.
15.4.2.3.6
Cylinders without correct markings or whose markings and gas-specific fittings do not match shall not be used.
15.4.2.3.7
Cryogenic liquid storage units intended to supply gas to the facility shall not be used to transfill other liquid storage vessels.
15.4.2.3.8
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.
15.4.2.3.9
Cylinders containing compressed gases and containers for volatile liquids shall be kept away from radiators, steam piping, and like sources of heat.
15.4.2.3.10
Where cylinder valve protection caps are supplied, they shall be secured tightly in place unless the cylinder is connected for use.
15.4.2.3.11
Containers shall not be stored in a tightly closed space.
15.4.2.3.12
Cylinders in use and in storage shall be prevented from reaching temperatures in excess of 52°C (125°F).
15.4.2.3.13
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 −7°C (20°F) or greater than 52°C (125°F).
15.4.2.4 Locations of Medical Gas Source Equipment (Oxygen and Nitrous Oxide) serving Category 3 Dental Patient Care Spaces.

15.4.2.4.1
Gas storage locations in facilities with **Medical Gas Source Equipment (Oxygen and Nitrous Oxide) serving Category 3 Dental Patient Care Spaces** with a total of all gases in cylinders or containers, except nitrogen, connected and in storage at one time that does not exceed 85 m^3 (3000 ft^3) at standard temperature and pressure (STP), or 142 m^3 (5000 ft^3) (STP) if oxygen is stored in a DOT specification 4 L (cryogenic liquid) container shall comply with 15.4.2.4.3 through 15.4.2.4.13.
15.4.2.4.2*
Gas storage locations **serving Category 3 Dental Patient Care Spaces** with a total of all gases in cylinders or containers exceeding quantities listed in 15.4.2.4.1 shall comply with 5.1.3.3.
15.4.2.4.3
Enclosures shall serve no purpose other than to contain the medical gas source equipment (oxygen and nitrous oxide), except that nitrogen source equipment and compressed air cylinders shall be permitted in the enclosure.
15.4.2.4.4
Storage of full or empty gas cylinders, or both, shall be permitted in the same enclosure.
15.4.2.4.5
Air compressors, vacuum pumps, and other equipment shall not be located in enclosures for medical gas cylinders (oxygen and nitrous oxide source equipment).
15.4.2.4.6*
If enclosures are outdoors or remote from the treatment facilities that they serve, they shall be kept locked.
15.4.2.4.7
Cylinders in use and in storage shall be prevented from reaching temperatures in excess of 52°C (125°F). Nitrous oxide cylinders shall be prevented from reaching temperatures lower than −7°C (20°F).
15.4.2.4.8
Only gas cylinders, reusable shipping containers, and their accessories shall be permitted to be stored in rooms containing central supply systems or gas cylinders.
15.4.2.4.9
No flammable materials, cylinders containing flammable gases, or containers containing flammable liquids shall be stored in rooms with gas cylinders.
15.4.2.4.10
Indoor enclosures shall not communicate directly with medical gas (oxygen and nitrous oxide) use points or storage locations for oxidizers.
15.4.2.4.11

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).
15.4.2.4.12
Enclosures for medical gas (oxygen and nitrous oxide) source equipment shall be provided with doors or gates.
15.4.2.4.13
Cylinders in service or in storage shall be individually secured and located to prevent falling or being knocked over.
15.4.2.5 Medical Gas Central Supply Systems (Oxygen and Nitrous Oxide) serving Category 3 Dental Patient Care Spaces.

15.4.2.5.1
Mechanical means shall be provided to ensure that the medical gas central supply systems are connected to the correct medical gas distribution piping system.
15.4.2.5.2
Cylinder valve outlets for oxygen and nitrous oxide shall comply with CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*.
15.4.2.5.3
Threaded connections to manifolds shall comply with CGA V-5, *Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)*.
15.4.2.5.4
A check valve shall be provided downstream of each pressure regulator.
15.4.2.5.5
A pressure relief valve set at 50 percent above the normal line pressure shall be located downstream of the check valve in 15.4.2.5.4.
15.4.2.5.6
Pressure relief valves shall be brass, bronze, or stainless steel and designed for oxygen service.
15.4.2.5.7
Hose and flexible connectors shall have a gauge pressure rating not less than 6895 kPa (1000 psi).
15.4.2.5.8
Materials used in central supply systems shall meet the following requirements:

(1) 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.

(2) 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.

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

(4) If intended for outdoor installation, materials shall be installed per the manufacturer’s requirements.

15.4.2.5.9
Nonmetallic hoses and flexible connectors shall not exceed 1.52 m (5 ft) in length and shall not be concealed or penetrate walls, floors, ceilings, or partitions.
15.4.2.5.9.1
Central Supply Systems shall not be connected to the piping system through flexible connectors.
15.4.2.5.10
Central Supply Systems that serve 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 one average day’s supply.
15.4.2.5.11
The two banks of each Central Supply System shall be manifolded so that either bank can supply its distribution piping system.
15.4.2.5.12
Where the Central Supply System is remote from a single treatment facility and an in use bank is unable to supply the system, the Central Supply System shall automatically switch to the secondary bank.
15.4.2.5.13
Where the Central Supply System serves multiple treatment facilities and an in use bank is unable to supply the system, the Central Supply System shall automatically switch to the secondary bank.
15.4.2.5.14
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 Central Supply System shall be manually or automatically switched to the secondary bank.
15.4.2.6 Emergency Shutoff Valves (Oxygen and Nitrous Oxide) in piping serving Category 3 Dental Patient Care Spaces.
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15.4.2.6.1*

All Category 3 medical gas systems shall have an emergency shutoff valve accessible from all use-point locations in an emergency.
15.4.2.6.2
Where a central medical gas central supply system supplies two treatment facilities, each facility shall be provided with an emergency shutoff valve located in that treatment facility so as to be accessible from all use-point locations in an emergency.
15.4.2.6.3
Emergency shutoff valves shall be labeled to indicate the gas controlled by the shutoff valve and shall shut off only the gas to the treatment facility that they serve.
15.4.2.6.4
A remotely activated shutoff valve at a gas supply manifold shall not be used for emergency shutoff.
15.4.2.6.4.1
For clinical purposes, such a remote valve actuator shall not fail-close in the event of loss of electric power.
15.4.2.6.4.2
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.
15.4.2.7 Station Outlets and Risers (Oxygen and Nitrous Oxide) in piping serving Category 3 Dental Patient Care Spaces.

15.4.2.7.1
Each gas outlet shall be gas-specific.
15.4.2.7.2
Gas outlets shall consist of a primary and a secondary valve or assembly.
15.4.2.7.3
Each gas outlet shall be legibly identified.
15.4.2.7.4
Threaded outlets shall be noninterchangeable connections complying with the mandatory requirements of CGA V-5, *Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)*.
15.4.2.7.5
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.
15.4.2.8 Manufactured Assemblies (Oxygen and Nitrous Oxide) for installation in Category 3 Dental Patient Care Spaces.
Category 3 systems shall comply with 5.3.6.
15.4.2.9 Pressure and Vacuum Indicators (Oxygen and Nitrous Oxide) in piping serving Category 3 Dental Patient Care Spaces.
Category 3 systems shall comply with 5.3.8.
15.4.2.10 Warning Systems (Oxygen and Nitrous Oxide) serving Category 3 Dental Patient Care Spaces.

Category 3 warning systems shall comply with 5.3.9, except as follows:

(1) Warning systems shall be permitted to be a single alarm panel.

(2) The alarm panel shall be located in an area of continuous surveillance while the facility is in operation.

(3) Pressure and vacuum switches/sensors shall be mounted at the source equipment with a pressure indicator at the master alarm panel.

(4) Warning systems for medical gas systems shall provide the following alarms:

    (a) Oxygen main line pressure low

    (b) Oxygen main line pressure high

    (c) Oxygen changeover to secondary bank or about to changeover (if automatic)

    (d) Nitrous oxide main line pressure low

    (e) Nitrous oxide main line pressure high

    (f) Nitrous oxide changeover to secondary bank or about to changeover (if automatic)

(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.
(6) Visual indications shall remain until the situation that caused the alarm is resolved.
(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.

(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.

15.4.2.11 Labeling and Identification for piping serving Category 3 Dental Patient Care Spaces.

Category 3 systems shall comply with 5.3.11.

15.4.3 Dental Air and Vacuum Piping Systems serving Category 3 Dental Patient Care Spaces.

15.4.3.1 General.

15.4.3.1.1

Dental air and vacuum piping systems shall include dental support gases and dental vacuum systems.

15.4.3.1.2

Dental vacuum systems shall include dental vacuum and nitrous oxide scavenging.

15.4.3.2 Equipment Locations for Dental Air and Vacuum Systems serving Category 3 Dental Patient Care Spaces.

15.4.3.2.1 General.

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

(1) Dental air compressor sources and reserve headers

(2) Dental-surgical vacuum sources

(3) Dental vacuum sources

(4) Any other compressor, vacuum pump, or electrically powered machinery

15.4.3.2.2 Cylinders and Containers.

Cylinders and containers for gases shall be handled in accordance with Chapter 11.

15.4.3.2.3 Ventilation for Motor-Driven Equipment.

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

(1) Medical air sources

(2) Instrument air sources

(3) Dental compressed air sources

(4) Dental-surgical vacuum sources

(5) Dental vacuum sources

(6) WAGD sources

15.4.3.3 Dental Gas and Vacuum Source Equipment serving Category 3 Dental Patient Care Spaces.

15.4.3.3.1 General.

15.4.3.3.1.1

The capacity of source equipment shall be based on the design requirements for the facility, including the number of gas outlets, vacuum inlets, and other connections, and their individual capacities.

15.4.3.3.1.2

The system design requirements shall be included in the data used for testing and verifying the operation of the gas and vacuum piping systems.

15.4.3.3.2 Dental Air serving Category 3 Dental Patient Care Spaces.

15.4.3.3.2.1 General.

(A)

Dental air shall be used as a support gas for driving dental tools and shall be permitted to be used to supply air-driven equipment. Dental compressed air shall not be used for respiration.

(B)

Dental air outlets shall not be interchangeable with any other gas outlets, including oxygen, nitrous oxide, medical air, instrument air, and nitrogen.

15.4.3.3.2.2 Dental Air Compressor Units for Central Supply Systems serving Category 3 Dental Patient Care Spaces.

(A)

Dental air compressor units shall include dental air compressors, vibration isolation, air receivers, coalescent air filters, adsorption dryers, exhaust silencer/filters, moisture indicators, service access manifolds, electrical disconnects, motor wiring, and controls.

(B)

Air compressors shall be scroll dental, reciprocating dental, or the oil-free dental types.

15.4.3.3.3 Dental Vacuum for Central Supply Systems serving Category 3 Dental Patient Care Spaces.

15.4.3.3.3.1 General.

(A)

Dental vacuum shall be used for oral evacuation and nitrous oxide scavenging.
(B)
Dental vacuum inlets shall not be interchangeable with any other vacuum inlets, including dental-surgical vacuum.
15.4.3.3.3.2 Dental Vacuum Units for Central Supply Systems serving Category 3 Dental Patient Care Spaces.

(A)
Dental vacuum units shall include dental vacuum pumps, vibration isolation, separation tanks, vacuum inlet, vacuum exhaust, condensate drain, motor wiring, and controls.
(B)
Dental vacuum pumps shall be dental dry vacuum or dental liquid (wet) ring pumps. Pumps shall be oil-free or oil-lubricated and suitable for nitrous oxide scavenging.
15.4.3.3.4 Nitrous Oxide Scavenging for Category 3 Dental Patient Care Spaces.

15.4.3.3.4.1 General.
(A)
The use of scavenging shall be limited to portions of dental facilities where moderate or minimal sedation is administered. WAGD shall be provided where the dental treatment involves general anesthesia or deep sedation.
(B)
Active nitrous oxide scavenging shall include the use of a nasal mask on the patient. The nasal mask shall be connected to a scavenging inlet in the dental vacuum system through a flow-limiting adapter.
(C)
Nitrous oxide scavenging inlets shall not be interchangeable with any other vacuum inlets, including medical-surgical vacuum, dental vacuum, and WAGD.
15.4.3.3.4.2 Connection to Dental Vacuum.
Scavenging connections to the dental vacuum system shall be a direct high-volume evacuation (HVE) connection to a high-volume vacuum port with a capacity of 45 L/min (1.6 cfm).
15.4.3.4 Warning Systems (Oxygen and Nitrous Oxide) for Systems serving Category 3 Dental Patient Care Spaces.

15.4.3.4.1 General.
15.4.3.4.1.1
The warning systems in Category 3 dental gas and vacuum systems shall comply with applicable requirements of 5.3.9 and 15.4.3.4.2 through 15.4.3.4.4.
15.4.3.4.1.2
The master, area, and local alarm functions shall be permitted to be provided by a single alarm panel, as indicated in 5.3.9.
15.4.3.4.2 Master Alarm Panels.
15.4.3.4.2.1
A master alarm panel shall be located in the facility at a point of continuous surveillance when the facility is in operation.
15.4.3.4.2.2
The master alarm panel shall indicate the following:

(1) Oxygen supply pressure ±20 percent from normal

(2) Nitrous oxide supply pressure ±20 percent from normal

(3) Changeover of oxygen supply source

(4) Changeover of nitrous oxide supply source

15.4.3.4.3 Area Alarm Panels.
15.4.3.4.3.1
An area alarm panel shall be centrally located where two or more treatment areas are supplied from the same zoned dental gas and vacuum piping.
15.4.3.4.3.2
Area alarm panels shall indicate the following:

(1) Oxygen supply pressure ±20 percent from normal

(2) Nitrous oxide supply pressure ±20 percent from normal

15.4.3.4.4 Local Alarms.
15.4.3.4.4.1
Local alarms shall be located in source equipment control panels or separate control panels in the equipment rooms for source equipment.
15.4.4 Piping for Medical Gas, Dental Air, and Vacuum Systems serving Category 3 Dental Patient Care Spaces.

15.4.4.1 General.
15.4.4.1.1
Piping for the following systems shall comply with 15.4.4.2:

(1) Oxygen

(2) Nitrous oxide

15.4.4.1.2
Piping for dental air systems shall comply with 15.4.4.3.
15.4.4.1.3
Piping for dental vacuum systems and scavenging systems shall comply with 15.4.4.4.
15.4.4.2 Piping for Oxygen and Nitrous Oxide Systems serving Category 3 Dental Patient Care Spaces.

15.4.4.2.1 Cleaning for Oxygen Service.
For oxygen and nitrous oxide, the pipe, fittings, valves, gas/vacuum outlets/inlets, and other piping components shall be cleaned for oxygen by the manufacturer prior to installation in accordance with CGA G-4.1, *Cleaning Equipment for Oxygen Service*. Fittings shall be permitted to be cleaned by a supplier or agency other than the manufacturer.
15.4.4.2.2 Pipe.
Pipe shall be hard-drawn seamless copper tube conforming to ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K.
15.4.4.2.3 Fittings.
15.4.4.2.3.1
Fittings shall be brazed, memory metal, or axially swaged.
15.4.4.2.3.2
Brazed fittings shall be the wrought copper capillary type complying with the following:

(1) ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) ASME B16.22 with socket depths equal to or greater than brazed joint pressure fittings in accordance with ANSI/ASME B16.50

15.4.4.2.3.3
Cast copper alloy fittings shall not be used with field-brazed joints.
15.4.4.2.3.4
Memory metal fittings shall be rated for not less than 538°C (1000°F) and 2070 kPa (300 psi) and shall be installed by qualified technicians in accordance with the manufacturer's instructions.
15.4.4.2.3.5
Axially swaged couplings shall include metal-to-metal seats, shall be rated for not less than 538°C (1000°F) and 2070 kPa (300 psi), and shall provide permanent, nonseparable joints. Fittings shall be installed by qualified technicians in accordance with the manufacturer's instructions.
15.4.4.2.4 Joints.
15.4.4.2.4.1 Brazed.
Brazing of copper joints shall be in accordance with 15.4.6.
15.4.4.2.4.2 Threaded.
Threaded joints shall be limited to connections to pressure indicators, alarm devices, and source equipment and shall comply with the following:

(1) Threads shall be tapered complying with ASME B1.20.1, *Pipe Threads, General Purpose, Inch*.

(2) Threads shall be made up with polytetrafluoroethylene (PTFE) tape or other thread sealant recommended for oxygen service, with the sealant applied to the male threads only.

15.4.4.2.4.3 Prohibited Joints.
The following joints shall be prohibited under 15.4.4.2.4:

(1) Flared and compression connections, including connections to station outlets, alarm devices, and other components

(2) Push-lock connections

(3) Straight-threaded connections, including unions

(4) Pipe crimping tools used to permanently stop the flow of medical gas and vacuum piping

15.4.4.3 Piping for Dental Air Systems serving Category 3 Dental Patient Care Spaces.

15.4.4.3.1 General.
Pipe, fittings, and joints in piping for dental compressed air systems shall be in accordance with 15.4.4.3.2 through 15.4.4.3.4.
15.4.4.3.2 Pipe.
Pipe under 15.4.4.3 shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, ACR tube (O.D. size).

15.4.4.3.2.1
Copper tube shall be hard temper or annealed (soft temper).
15.4.4.3.3 Fittings.
Fittings for piping under 15.4.4.3 shall be permitted to be any of the following acceptable joining methods:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings in compliance with ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (3/4 in. maximum size)

15.4.4.3.4 Joints.
Joints for piping under 15.4.4.3 shall comply with 15.4.4.3.4.1 through 15.4.4.3.4.3.
15.4.4.3.4.1
Joints shall be brazed, soldered, threaded, flared, or the compression type.
15.4.4.3.4.2
Where joints are brazed, they shall comply with the requirements of 15.4.6.
15.4.4.3.4.3
Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal*.
15.4.4.4 Piping for Dental Vacuum Systems and Scavenging Systems for Central Supply Systems serving Category 3 Dental Patient Care Spaces.

15.4.4.4.1 General.
Piping for dental vacuum systems and scavenging systems shall be copper, PVC plastic, or CPVC plastic.
15.4.4.4.2 Copper Piping.
Copper piping under 15.4.4.4 shall be in accordance with 15.4.4.4.2.1 through 15.4.4.4.2.3.
15.4.4.4.2.1 Copper Tube.
Copper tubing shall be hard temper or annealed (soft temper) and shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service,* ACR tube (O.D. size)

15.4.4.4.2.2 Copper Fittings.
Copper fittings shall comply with the following:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings conforming to ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (3/4 in. maximum size)

15.4.4.4.2.3 Joints for Copper Piping.
Joints in copper tubing shall be in accordance with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6.

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal*.

15.4.4.4.3 PVC Plastic Piping.
PVC plastic piping under 15.4.4.4 shall be in accordance with the following:

(1) PVC plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM D1785, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120*.

(2) PVC plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM D2466, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40*, or ASTM D2467, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80*.

(3) Joints in PVC plastic piping shall be solvent-cemented in accordance with ASTM D2672, *Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement*.

15.4.4.4.4 CPVC Plastic Piping.
CPVC plastic piping under 15.4.4.4 shall be in accordance with the following:

(1) CPVC IPS plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM F441/F441M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80*.

(2) CPVC IPS plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*, or ASTM F439, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*.

(3) CPVC CTS plastic pipe and fittings 1/2 in. through 2 in. size shall be SDR 11, conforming to ASTM D2846/D2846M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems*.

(4) Solvent cement for joints in CPVC plastic piping shall comply with ASTM F493, *Standard Specification for Solvent Cements forChlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings*.

15.4.4.5 Piping for Nitrogen Systems serving Category 3 Dental Patient Care Spaces..
Nitrogen piping in dental facilities shall comply with 15.4.4.2, including cleaning for oxygen service.
15.4.5 Installation of Medical Gas, Dental Air, and Vacuum Piping Systems serving Category 3 Dental Patient Care Spaces.

15.4.5.1 General.
15.4.5.1.1
Gas and vacuum piping systems shall be as listed in Section 15.4.
15.4.5.1.2
Piping materials shall be as listed in 15.4.4.
15.4.5.2 Pipe Sizing.
Piping systems shall be designed and sized to deliver the required flow rates at the utilization pressures.
15.4.5.3 Minimum Pipe Sizes.
The minimum size of the following piping shall be as follows:

(1) Category 2 oxygen piping shall be not less than DN10 (NPS 3/8 in.) (1/2 in. O.D.) size.

(2) Category 2 nitrous oxide piping shall be not less than DN8 (NPS 1/4 in.) (3/8 in. O.D.) size.

(3) Category 2 oxygen piping shall be at least 1 size larger than piping for nitrous oxide.

15.4.5.4 Location of Piping.
Piping shall not be located where subject to contact with oil.
15.4.5.5 Protection of Piping.
15.4.5.5.1
Piping shall be protected against freezing, corrosion, and physical damage.
15.4.5.5.2
Piping exposed in corridors and other locations where subject to physical damage from the movement of equipment shall be protected.
15.4.5.6 Pipe Support.
15.4.5.6.1
Piping shall be supported from the building structure.
15.4.5.6.2
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*.
15.4.5.6.3
Hangers and supports shall be sized for the tube or pipe being supported.
15.4.5.6.4
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.
15.4.5.6.5
The maximum support spacing for copper tube shall be in accordance with Table 15.4.5.6.5.

Table 15.4.5.6.5 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) (1 1/8 in. O.D.)	2440	8
DN32 (NPS 1 1/4) (1 3/8 in. O.D.)	2740	9
DN40 (NPS 1 1/2) (1 5/8 in. O.D.) and larger	3050	10
Vertical risers, all sizes, every floor, but not to exceed	4570	15

15.4.5.6.6
The maximum support spacing for plastic pipe shall be in accordance with Table 15.4.5.6.6.

Table 15.4.5.6.6 Maximum Plastic Pipe Support Spacing

Pipe Size	Hanger Spacing	
	mm	ft
DN15 (NPS 1/2) (5/8 in. O.D.)	1220	4
DN20 (NPS 3/4) (7/8 in. O.D.)	1220	4
DN25 (NPS 1) (1 1/8 in. O.D.)	1320	4.33
DN32 (NPS 1 1/4) (1 3/8 in. O.D.)	1320	4.33
DN40 (NPS 1 1/2) (1 5/8 in. O.D.)	1420	4.66
DN50 (NPS 2) (2 3/8 in. O.D.)	1420	4.66
DN65 (NPS 2 1/2) (2 7/8 in. O.D.) and larger	1520	5
Vertical risers, all sizes, every floor, but not to exceed	3040	10

15.4.5.7 Underground Piping Outside of Buildings.
15.4.5.7.1
Buried piping outside of buildings shall be installed below the local level of frost penetration.
15.4.5.7.2
The installation procedure for underground piping shall prevent physical damage to the piping while being back-filled.
15.4.5.7.3
If the underground piping is protected by a conduit, cover, or other enclosure, the following requirements shall be met:

(1) Access during construction shall be provided at the joints for visual inspection and leak testing.

(2) The conduit, cover, or enclosure shall be self-draining and not retain groundwater in prolonged contact with copper tubing.

15.4.5.7.4
Buried piping that is subject to surface loads shall be buried at a depth that will protect the piping, its enclosure, or both, from excessive stresses.
15.4.5.7.5
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.
15.4.5.7.6
Trenches shall be excavated so that the piping or its enclosure has firm, substantially continuous bearing on the bottom of the trench.
15.4.5.7.7
Backfill shall be clean, free from material that can damage the pipe, and compacted.
15.4.5.7.8
A continuous warning tape or marker shall be placed immediately above the piping or its enclosure to clearly identify the pipeline by specific name.
15.4.5.7.9
A continuous warning means shall also be placed above the pipeline at approximately one-half the depth of burial.
15.4.5.7.10
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.
15.4.5.8 Underground Piping Within Buildings.
15.4.5.8.1
The installation procedure for underground piping shall prevent physical damage to the piping while being back-filled.
15.4.5.8.2
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.
15.4.5.8.3
The piping shall be backfilled with clean sand or gravel.
15.4.5.9 Piping Within Floor Slabs Prohibited.
Dental gas and vacuum piping shall not be installed within floor slabs.
15.4.5.10 Hose and Flexible Connectors.
15.4.5.10.1
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.
15.4.5.10.2
Hose and flexible connectors, metallic or nonmetallic, shall have a minimum burst gauge pressure of 6895 kPa (1000 psi).
15.4.5.10.3
Medical gas hose and flexible connectors shall be oxygen compatible.
15.4.5.10.4
Hose and flexible connectors shall be clearly identified as to the gas content.
15.4.5.10.5
Hose and flexible connectors for dental medical gases shall be gas-specific and not be permitted to conduct any other gas, gas mixture, or liquid.
15.4.6 Brazing Copper Tubing.
15.4.6.1 Qualification of Brazing Procedures and Brazers.
15.4.6.1.1
Brazing procedures and brazer performance for the installation of dental piping shall be in accordance with either Section IX, "Welding and Brazing Qualifications," of the ASME *Boiler and Pressure Vessel Code,* or AWS B2.2/B2.2M, *Specification for Brazing Procedure and Performance Qualification*, both as modified by 15.4.6.
15.4.6.1.2
Brazers shall be qualified by visual examination of the test coupons followed by sectioning.
15.4.6.1.3
The brazing procedure specification shall address cleaning, joint clearance, overlap, internal purge gas, purge gas flow rate, and filler metal.
15.4.6.1.4
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 the absence of internal oxidation in the completed coupon.
15.4.6.1.5

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

(1) The brazing procedure specification and the procedure qualification record meet the requirements of this code.

(2) 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.

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

15.4.6.1.6
An employer shall be permitted to accept brazer qualification records of a previous employer under the following conditions:

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

(2) The new employer obtains a copy of the record of brazer performance qualification tests from the previous employer and signs and dates these records, thereby accepting responsibility for the qualifications performed by the previous employer.

15.4.6.1.7
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.
15.4.6.2 Brazed Joints.
15.4.6.2.1
Brazed tube joints shall be of the socket type.
15.4.6.2.2
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.
15.4.6.2.3
Filler metals shall bond with and be metallurgically compatible with the base metal being joined.
15.4.6.2.4
Filler metals shall comply with ANSI/AWS A5.8M/A5.8, *Specification for Filler Metals for Brazing and Braze Welding*.
15.4.6.2.5
Copper-to-copper joints shall be brazed using a copper-phosphorus or copper-phosphorus-silver brazing filler metal (i.e., BCuP series) without flux.
15.4.6.2.6
Joints to be brazed in place shall be accessible for necessary preparation, assembly, heating, filler application, cooling, cleaning, and inspection.
15.4.6.3 Cutting Tube Ends.
15.4.6.3.1
Tube ends shall be cut square using a sharp tubing cutter to avoid deforming the tube.
15.4.6.3.2
The cutting wheels on tubing cutters shall be free from grease, oil, or other lubricants not recommended for oxygen service.
15.4.6.3.3
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.
15.4.6.4 Cleaning Joints for Brazing.
15.4.6.4.1
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.
15.4.6.4.2
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.
15.4.6.4.3
Nonabrasive pads shall be used to clean the exterior surfaces of tube ends.
15.4.6.4.4
The use of steel wool, sand cloth, or wire brushes shall be prohibited.
15.4.6.4.5
The cleaning process shall not result in grooving the surfaces to be joined.
15.4.6.4.6
After being abraded, the surfaces shall be wiped using a clean, lint-free white cloth.

15.4.6.4.7
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.
15.4.6.4.8
Material that has become contaminated internally and is not clean for oxygen service shall not be installed.
15.4.6.4.9
Joints shall be brazed within 8 hours after being cleaned for brazing.
15.4.6.5 Brazing Dissimilar Metals.
15.4.6.5.1
Flux shall only be used when brazing dissimilar metals, such as copper and bronze or brass, using a silver brazing filler metal (i.e., BAg series).
15.4.6.5.2
Cast metals shall not be field brazed.
15.4.6.5.3
Surfaces shall be cleaned for brazing in accordance with 15.4.6.4.
15.4.6.5.4
Flux shall be applied sparingly to minimize contamination of the inside of the tube with flux.
15.4.6.5.5
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.
15.4.6.5.6
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.
15.4.6.5.7
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.
15.4.6.6 Nitrogen Purge.
15.4.6.6.1
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.
15.4.6.6.2
The source of the nitrogen purge gas shall be monitored, and the installer shall be audibly alerted when the content is low.
15.4.6.6.3
The nitrogen purge gas flow rate shall not be high enough to produce a positive pressure in the piping system.
15.4.6.6.4
The nitrogen purge gas flow shall be controlled by the use of both a pressure regulator and a flowmeter or a combination thereof.
15.4.6.6.5
Pressure regulators alone shall not be used to control nitrogen purge gas flow rates.
15.4.6.6.6
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.
15.4.6.6.7
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.
15.4.6.6.8
The flow of nitrogen purge gas shall be maintained until the joint is cool to the touch.
15.4.6.6.9
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.
15.4.6.7 Assembling and Heating Brazed Joints.
15.4.6.7.1
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 (i.e., overlap) specified in ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*.
15.4.6.7.2
Where flux is permitted, joints shall be heated slowly until the flux has liquefied.
15.4.6.7.3
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.
15.4.6.7.4
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 VIII, "Brazed Joints," in the CDA *Copper Tube Handbook*.
15.4.6.8 Inspection of Brazed Joints.

15.4.6.8.1
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.
15.4.6.8.2
Where flux has been used, the wash water shall be hot.
15.4.6.8.3
Each joint shall be visually inspected after cleaning the outside surfaces.
15.4.6.8.4
Joints exhibiting the following conditions shall not be permitted:

(1) Flux or flux residue (where flux or flux-coated BAg rods are used with dissimilar metals)

(2) Base metal melting or erosion

(3) Unmelted filler metal

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

(5) Cracks in the tube or component

(6) Cracks in the filler metal

(7) Failure of the joint to hold the test pressure under the installer-performed initial pressure test *(see 15.4.7.4.4)* and standing pressure test *(see 15.4.7.4.6)*

15.4.6.8.5
Joints that are identified as defective under conditions specified in 15.4.6.8.4(2) or 15.4.6.8.4(5) shall be replaced.
15.4.6.8.6
Joints that are found to be defective under conditions specified in 15.4.6.8.4(1), 15.4.6.8.4(3), 15.4.6.8.4(4), 15.4.6.8.4(6), or 15.4.6.8.4(7) shall be permitted to be repaired, except that no joint shall be reheated more than once before being replaced.
15.4.7 Performance Criteria and Testing (Oxygen and Nitrous Oxide) for Systems serving Category 3 Dental Patient Care Spaces.

15.4.7.1 Testing and Verification.
15.4.7.1.1 General.
15.4.7.1.1.1
Inspection and testing shall be performed on all new piped oxygen and nitrous oxide systems, additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that the following have been completed:

(1) All applicable provisions of this code have been adhered to.

(2) System integrity has been achieved or maintained.

(3) Piping systems are ready for testing and verification.

(4) Piping systems are performing in accordance with their design requirements.

15.4.7.1.1.2
The inspection and testing reports shall be submitted directly to the party that contracted for the testing, who shall submit the reports through channels to the Responsible Facility Authority and any others that are required.
15.4.7.1.1.3
Reports shall contain detailed listings of all findings and results.
15.4.7.1.1.4
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 before use.
15.4.7.1.1.5
All documentation pertaining to inspections and testing shall be maintained on-site within the facility.
15.4.7.2 Required Testing and Verification.
15.4.7.2.1 Category 2 Medical Gas Systems (Oxygen and Nitrous Oxide).
All Category 2 oxygen and nitrous oxide piping systems indicated in 15.4.2 shall be initially tested in accordance with 15.4.7.4.
15.4.7.2.2
The oxygen and nitrous oxide piping systems shall be verified in accordance with 15.4.7.5.
15.4.7.3 Qualification of System Testers and Verifiers (Oxygen and Nitrous Oxide).
15.4.7.3.1

Individuals who perform the initial and final tests of the oxygen and nitrous oxide piping systems shall be certified to ASSE 6010, *Professional Qualifications Standard for Medical Gas Systems Installers*, or verifiers who comply with 15.4.7.3.2.

15.4.7.3.2

Individuals who verify the oxygen and nitrous oxide piping systems shall be certified to ASSE 6030, *Professional Qualifications Standard for Medical Gas Systems Verifiers*.

15.4.7.4 Initial Testing of Piping Systems (Oxygen and Nitrous Oxide).

15.4.7.4.1 General.

15.4.7.4.1.1

The initial tests required by 15.4.7.4 shall be performed prior to either the final tests or the verification tests listed in 15.4.7.5.

15.4.7.4.1.2

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

15.4.7.4.1.3

Where manufactured assemblies are to be installed, the initial tests required by 15.4.7.4 shall be performed as follows:

(1) After completion of the distribution piping but before the standing pressure test

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

(3) For all station outlets/inlets on installed manufactured assemblies supplied through copper tubing

15.4.7.4.1.4

Where plastic vacuum and plastic scavenging piping systems are installed, they shall be visually inspected for cross-connections to positive-pressure systems before applying positive test pressures to the copper piping systems.

15.4.7.4.1.5

Where brazed joints in copper tubing are found to be defective, they shall be repaired if permitted by 15.4.6.8.6 or replaced if required by 15.4.6.8.5, and retested. The piping shall be repurged if necessary.

15.4.7.4.1.6

During the process of initial testing, the identification and labeling of the medical gas and vacuum piping shall be checked.

15.4.7.4.2 Initial Piping Blowdown (Oxygen and Nitrous Oxide).

Piping in dental air 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, and source equipment).

15.4.7.4.3 Initial Cross-Connection Test for Copper Piping Systems.

15.4.7.4.3.1

Copper piping shall not be tested before any plastic piping.

15.4.7.4.3.2

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

15.4.7.4.3.3

All piping systems shall be reduced to atmospheric pressure.

15.4.7.4.3.4

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

15.4.7.4.3.5

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

15.4.7.4.3.6

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 dispensed only from the piping system tested.

15.4.7.4.3.7

The initial cross-connection test in 15.4.7.4.3 shall be repeated for each installed medical gas and vacuum piping system with copper piping.

15.4.7.4.3.8

Any cross-connections shall be removed and the associated piping repaired and leak tested.

15.4.7.4.3.9

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

15.4.7.4.4 Initial Pressure Test.

15.4.7.4.4.1

Each section of the piping in positive-pressure gas systems and copper vacuum systems shall be pressure tested. Plastic vacuum and plastic scavenging piping shall not be pressure tested.

15.4.7.4.4.2

Initial pressure tests shall be conducted as follows:

(1) After blowdown of the distribution piping

(2) After installation of station outlet/inlet rough-in assemblies

(3) 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, and line pressure relief valves)

15.4.7.4.4.3
The source shutoff valve shall remain closed during the pressure tests.
15.4.7.4.4.4
The test pressure for oxygen and nitrous oxide piping shall be 1.5 times the system operating pressure but not less than a gauge pressure of 1035 kPa (150 psi).
15.4.7.4.4.5*****
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.
15.4.7.4.4.6
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.
15.4.7.4.5 Initial Piping Purge Test.
15.4.7.4.5.1
The outlets in each oxygen and nitrous oxide piping system shall be purged to remove any particulate matter from the distribution piping.
15.4.7.4.5.2
Using appropriate adapters, each outlet shall be purged with an intermittent high-volume flow of test gas until the purge produces no discoloration in a clean white cloth.
15.4.7.4.5.3
The purging shall be started at the closest outlet to the piping shutoff valve and continue to the furthest outlet from the shutoff valve.
15.4.7.4.6 Standing Pressure Test for Oxygen and Nitrous Oxide Piping.
15.4.7.4.6.1
After successful completion of the initial pressure tests in 15.4.7.4.4, the gas distribution piping shall be subject to a standing pressure test.
15.4.7.4.6.2
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, and hoses).
15.4.7.4.6.3
The source valve shall be closed during this test.
15.4.7.4.6.4
The piping systems shall be subjected to 24-hour standing pressure tests using oil-free, dry nitrogen NF.
15.4.7.4.6.5
Test pressures shall be 20 percent above the normal system operating line pressure.
15.4.7.4.6.6
At the conclusion of the tests, there shall be no change in the test pressure except that attributed to specific changes in ambient temperature.
15.4.7.4.6.7
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested. The piping shall be repurged if necessary.
15.4.7.4.6.8
The 24-hour standing pressure tests shall be witnessed by the authority having jurisdiction or its designee. A form indicating that these tests have been performed and witnessed shall be provided to the verifier at the start of the verification tests in 15.4.7.5.
15.4.7.5 Verification of Piping Systems (Oxygen and Nitrous Oxide).
15.4.7.5.1 General.
15.4.7.5.1.1
The oxygen and nitrous oxide piping systems requiring initial testing and verification shall be as indicated in 15.4.7.2 for the different dental facilities.
15.4.7.5.1.2
Required verification of oxygen and nitrous oxide piping systems shall be performed only after all initial tests required in 15.4.7.4 have been completed.
15.4.7.5.1.3
The test gas shall be oil-free, dry nitrogen NF or the system gas or vacuum where permitted.
15.4.7.5.1.4
Verification shall be conducted by a party technically competent and experienced in the field of medical gas and vacuum piping system testing and certified for ASSE 6030, *Professional Qualifications Standard for Medical Gas Systems Verifiers*.
15.4.7.5.1.5

Verification shall be performed by a party other than the installing contractor.
15.4.7.5.1.6
All required verification tests shall be performed after installation of any manufactured assemblies supplied through tubing or flexible hose.
15.4.7.5.1.7
Where there are multiple possible connection points for terminals, each possible position shall be tested independently.
15.4.7.5.1.8
Where brazed joints in copper tubing are found to be defective, they shall be repaired if permitted by 15.4.6.8.6 or replaced if required by 15.4.6.8.5, and retested. The piping shall be repurged if necessary.
15.4.7.5.1.9
During the process of verification, the presence and proper labeling of source equipment, station outlets/inlets, zone valve boxes, shutoff valves, and alarms shall be checked.
15.4.7.5.2 Verifier Standing Pressure Test.
Oxygen and nitrous oxide piping systems requiring verification shall be subjected to a 10-minute standing pressure test at operating line pressure using the following procedure:

(1) After the system is filled with nitrogen or the source gas, the source valve shall be closed.

(2) The piping system shall show no decrease in pressure after not less than 10 minutes.

(3) Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.

15.4.7.5.3 Verifier Cross-Connection Test.
The piping systems shall be tested for cross-connections between the systems using the following procedure:

(1) All medical gas and vacuum piping systems shall be reduced to atmospheric pressure.

(2) All sources of test gas for all of the gas and vacuum systems, with the exception of the one system to be checked, shall be disconnected.

(3) The system being checked shall be pressurized to a gauge pressure of 345 kPa (50 psi).

(4) 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 dispensed only from the outlets/inlets of the piping system being tested.

(5) The source of test gas shall be disconnected, and the system that was tested reduced to atmospheric pressure.

(6) Each additional piping system shall be tested until all gas and vacuum piping systems requiring verification are free of cross-connections.

(7) Any cross-connections shall be removed and the associated piping repaired and tested for leaks.

15.4.7.5.4 Verifier Piping Purge Test.
15.4.7.5.4.1
To remove any traces of particulate matter deposited in the oxygen and nitrous oxide piping during construction, a heavy, intermittent purging of the piping shall be done.
15.4.7.5.4.2
The appropriate adapter shall be obtained and high purge rates of at least 225 Nl/min (8 SCFM) shall be put on each outlet.
15.4.7.5.4.3
After each 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.
15.4.7.5.4.4
To avoid possible damage to the outlet and its components, this test shall not be conducted using any implement other than the proper adapter.
15.4.7.5.4.5
No pronounced or objectionable odor shall be discernible from any positive pressure outlet.
15.4.7.5.5 Verifier Piping Particulate Test.
15.4.7.5.5.1
For each oxygen and nitrous oxide system, the cleanliness of the piping system shall be verified.
15.4.7.5.5.2
The test shall be performed with the use of oil-free, dry nitrogen NF.
15.4.7.5.5.3
A minimum of 1000 L (35 ft^3) of gas shall be filtered through a clean, white 0.45 micron filter at a minimum flow rate of 100 Nl/min (3.5 SCFM).

15.4.7.5.5.4
Twenty five percent of the zones shall be tested at the outlet most remote from the source.
15.4.7.5.5.5
The filter shall accrue no more than 0.001 g (1 mg) of matter from any outlet tested.
15.4.7.5.5.6
If any outlet fails this test, the most remote outlet in every zone shall be tested.
15.4.7.5.6 Verifier Piping Purity Test.
15.4.7.5.6.1
For each oxygen and nitrous oxide system, the purity of the piping system shall be verified in accordance with 15.4.7.5.6.
15.4.7.5.6.2
These tests shall be performed with oil-free, dry nitrogen NF or the system gas.
15.4.7.5.6.3
The outlet most remote from the source shall be tested for total nonmethane hydrocarbons and compared to the test of the source gas.
15.4.7.5.6.4
If the system gas is used as the source gas, it shall be tested at the source equipment.
15.4.7.5.6.5
The difference between the two tests shall in no case exceed 5 ppm of total nonmethane hydrocarbons.
15.4.7.5.6.6
The difference between the two tests shall in no case exceed 5 ppm of halogenated hydrocarbons.
15.4.7.5.6.7
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).
15.4.7.5.7 Verifier Final Tie-in Test.
15.4.7.5.7.1
Prior to the connection of any work or any extension or addition to an existing piping system, the verification tests in 15.4.7.5 shall be successfully performed on the new work.
15.4.7.5.7.2
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.
15.4.7.5.7.3
For oxygen and nitrous oxide, 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 15.4.7.5.4.
15.4.7.5.7.4
Before the new work is used for patient care, oxygen and nitrous oxide shall be tested for operational pressure and gas concentration in accordance with 15.4.7.5.8 and 15.4.7.5.9.
15.4.7.5.7.5
Permanent records of these tests shall be maintained.
15.4.7.5.8 Verifier Operational Pressure Test.
15.4.7.5.8.1
Operational pressure tests shall be performed at each station outlet or terminal where the user makes connections and disconnections.
15.4.7.5.8.2
Tests shall be performed with the gas of system designation.
15.4.7.5.8.3
All medical gas outlets with a gauge pressure of 345 kPa (50 psi), including oxygen and nitrous oxide, shall deliver 50 SLPM (1.8 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).
15.4.7.5.9 Verifier Gas Concentration Test.
After purging each system with the gas of system designation, the following shall be performed:

(1) Each pressure gas source and outlet shall be analyzed for concentration of gas, by volume.

(2) Analysis shall be conducted with instruments designed to measure the specific gas dispensed.

(3) Allowable concentrations shall be as follows:

(a) Oxygen ≥99 percent

(b) Nitrous oxide ≥99 percent

(c) Other gases ±1 percent unless otherwise specified

15.4.8 Performance Criteria and Testing (Dental Air and Vacuum) for Systems serving Category 3 Dental Patient Care Spaces.

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15.4.8.1 Dental Air and Vacuum Systems Testing.

15.4.8.1.1 General.

15.4.8.1.1.1

Inspection and testing shall be performed on all new piped dental gas and vacuum systems, additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that the following have been completed:

(1) All applicable provisions of this code have been adhered to.

(2) System integrity has been achieved or maintained.

(3) Piping systems are ready for testing and verification.

(4) Piping systems are performing in accordance with their design requirements.

15.4.8.1.1.2

The inspection and testing reports shall be submitted directly to the party that contracted for the testing, who shall submit the reports through channels to the Responsible Facility Authority and any others that are required.

15.4.8.1.1.3

Reports shall contain detailed listings of all findings and results.

15.4.8.1.1.4

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 before use.

15.4.8.1.1.5

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

15.4.8.1.2 Category 2 Dental Air and Vacuum Systems.

15.4.8.1.2.1

All Category 2 dental gas and vacuum piping systems indicated in 15.4.3 shall be initially tested in accordance with 15.4.8.1.

15.4.8.1.2.2

The support gas systems and vacuum systems (i.e., dental air, dental vacuum, and scavenging) shall be final tested in accordance with 15.4.8.1.7 and 15.4.8.1.8.

15.4.8.1.3 Initial Testing of Piping Systems.

15.4.8.1.3.1 General.

(A)

Where plastic vacuum and plastic scavenging piping systems are installed, they shall be visually inspected for cross-connections to oxygen and nitrous oxide systems before applying positive test pressures to the copper piping systems.

(B)

During the process of initial testing, the identification and labeling of the dental gas and vacuum piping shall be checked.

15.4.8.1.4 Initial Cross-Connection Test for Plastic Vacuum and Plastic Scavenging Piping Systems.

15.4.8.1.4.1

Plastic piping shall be tested before copper piping.

15.4.8.1.4.2

Tests shall be conducted to determine that no cross-connections exist between any plastic vacuum piping systems or plastic scavenging piping systems and any copper piping systems.

15.4.8.1.4.3

The vacuum or scavenging source shutoff valves for the vacuum or scavenging piping systems shall remain closed during the tests, unless they are being used for the cross-connection test vacuum source.

15.4.8.1.4.4

The cross-connection test vacuum shall be a minimum of 300 mm (12 in.) HgV.

15.4.8.1.4.5

The source of test vacuum shall be connected only to the vacuum or scavenging piping system being tested.

15.4.8.1.4.6

All individual gas system outlets and vacuum or scavenging system inlets shall be checked to determine that the test vacuum is only present in the vacuum or scavenging piping system being tested.

15.4.8.1.4.7

The cross-connection tests shall be repeated for each installed vacuum and scavenging system with plastic piping.

15.4.8.1.4.8

Any cross-connections shall be removed and the associated piping repaired and leak tested.

15.4.8.1.4.9

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

15.4.8.1.5 Initial Pressure Test.

15.4.8.1.5.1
Each section of the piping in dental air systems and copper vacuum systems shall be pressure tested. Plastic vacuum and plastic scavenging piping shall not be pressure tested.
15.4.8.1.5.2
Initial pressure tests shall be conducted as follows:

(1) After installation of station outlet/inlet rough-in assemblies

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

15.4.8.1.5.3
The source shutoff valve shall remain closed during the pressure tests.
15.4.8.1.5.4
The test pressure for dental air piping and copper vacuum piping shall be 1.5 times the system operating pressure but not less than a gauge pressure of 1035 kPa (150 psi).
15.4.8.1.5.5
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.
15.4.8.1.5.6
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.
15.4.8.1.6 Initial Piping Purge Test.
15.4.8.1.6.1
The outlets in each dental air piping system shall be purged to remove any particulate matter from the distribution piping.
15.4.8.1.6.2
Using appropriate adapters, each outlet shall be purged with an intermittent high-volume flow of test gas until the purge produces no discoloration in a clean white cloth.
15.4.8.1.6.3
The purging shall be started at the closest outlet to the piping shutoff valve and continue to the furthest outlet from the shutoff valve.
15.4.8.1.7 Standing Pressure Test for Dental Air and Copper Vacuum Piping.
15.4.8.1.7.1
After successful completion of the initial pressure tests in 15.4.8.1, the dental air systems and copper vacuum systems shall be subject to a standing pressure test.
15.4.8.1.7.2
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, and hoses).
15.4.8.1.7.3
The source valve shall be closed during this test.
15.4.8.1.7.4
The piping systems shall be subjected to 24-hour standing pressure tests using oil-free, dry nitrogen NF.
15.4.8.1.7.5
Test pressures shall be 20 percent above the normal system operating line pressure.
15.4.8.1.7.6
At the conclusion of the tests, there shall be no change in the test pressure, except that attributed to specific changes in ambient temperature.
15.4.8.1.7.7
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested. The piping shall be repurged if necessary.
15.4.8.1.8 Standing Vacuum Test for Plastic Vacuum Piping.
15.4.8.1.8.1
After successful completion of the initial pressure tests in 15.4.8.1, vacuum distribution piping, including scavenging, shall be subjected to a standing vacuum test.
15.4.8.1.8.2
Tests shall be conducted after installation and connection of all components of the vacuum system.
15.4.8.1.8.3
The piping systems shall be subjected to a 24-hour standing vacuum test.
15.4.8.1.8.4
Test pressure shall be between 300 mm (12 in.) HgV and full vacuum.
15.4.8.1.8.5
During the test, the source of test vacuum shall be disconnected from the piping system.
15.4.8.1.8.6
At the conclusion of the test, there shall be no change in the vacuum pressure other than that attributed to changes of ambient temperature.

15.4.8.1.8.7
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.
15.4.9 Operation and Management for Systems serving Category 3 Dental Patient Care Spaces.
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15.4.9.1 System Shutdowns.
15.4.9.1.1
Gas and vacuum piping systems shall be shut down at the end of each workday.
15.4.9.1.2
Emergency shutoff valves or remote actuators shall not be used for daily shutdown of the systems. Cylinder gas valves shall be used for daily shutdowns.
15.4.9.2 Prohibited Interconnections.
Two or more piping systems for different gases or different vacuums shall not be interconnected for testing or any other reason.
15.4.9.3 Manufacturer's Instructions.
15.4.9.3.1
Piping system components shall be installed, adjusted, operated, and maintained in accordance with the manufacturer's instructions.
15.4.9.3.2
Copies of the manufacturer's instructions shall be provided to the facility and maintained at the facility.
15.4.9.4 Maintenance.
15.4.9.4.1
Gas and vacuum system equipment shall be maintained by a qualified person.
15.4.9.4.2
Every facility shall establish a procedure for manually turning off the gas supply at the cylinder valves of Category 2 dental gas and vacuum systems at the end of each day.
15.4.9.5 Periodic Testing.
15.4.9.5.1
Station outlets for oxygen and nitrous oxide shall be tested for flow and pressure on an approved schedule.
15.5 Category 4 Dental Gas and Vacuum Systems.
15.5.1 General.
15.5.1.1
Category 4 dental facilities are those in which medical gases are not piped. Only minimal or no sedation is performed (as defined in 3.3.68.4), and the failure or unavailability of dental gas, vacuum or scavenging systems may cause no worse than discomfort to patients, staff or visitors.

15.5.1.2
There shall be no piped medical gases.
Note that such facilities may have small quantities of medical gases on cylinder carts for emergency use only.
15.5.1.3
The dental support gases shall be provided from a dental air source system.
15.5.1.4
The vacuum system shall be dental vacuum.
15.5.2 Category 4 Dental Air and Vacuum Piping Systems.
15.5.2.1 General.
Dental air and vacuum piping systems shall include dental support gases and dental vacuum systems.
15.5.2.2 Vacuum Systems.
Dental vacuum systems shall include dental vacuum and nitrous oxide scavenging.
15.5.3 Equipment Locations for Dental Air and Vacuum Systems.
15.5.3.1 General.
Any of the following systems shall be permitted to be located together in the same room:

(1) Dental air compressor sources and reserve headers

(2) Dental vacuum sources

(3) Any other compressor, vacuum pump, or electrically powered machinery

15.5.3.2 Cylinders and Containers.
Cylinders and containers for gases shall be handled in accordance with Chapter 11.
15.5.3.3 Ventilation for Motor-Driven Equipment.
The following source locations shall be adequately ventilated to prevent accumulation of heat:

(1) Dental compressed air sources

(2) Dental vacuum sources

15.5.4 Dental Gas and Vacuum Central Supply Systems for Category 4 Dental Patient Care Spaces.

15.5.4.1 General.
15.5.4.1.1
The capacity of central Supply systems shall be based on the design requirements for the facility, including the number of gas outlets, vacuum inlets, and other connections, and their individual capacities.
15.5.4.1.2
The Central Supply System's design requirements shall be included in the data used for testing and verifying the operation of the gas and vacuum piping systems.
15.5.4.2 Dental Air.
15.5.4.2.1 General.
15.5.4.2.1.1
Dental air shall be used as a support gas for driving dental tools and shall be permitted to be used to supply air-driven equipment. Dental compressed air shall not be used for respiration.
15.5.4.2.1.2
Dental air outlets shall not be interchangeable with any other gas outlets, including oxygen, nitrous oxide, medical air, instrument air, and nitrogen.
15.5.4.2.2 Dental Air Compressor Units.
15.5.4.2.2.1
Dental air compressor units shall include dental air compressors, vibration isolation, air receivers, coalescent air filters, adsorption dryers, exhaust silencer/filters, moisture indicators, and service access manifolds, electrical disconnects, motor wiring, and controls.
15.5.4.2.2.2
Air compressors shall be scroll dental, reciprocating dental, or the oil-free dental types.
15.5.4.3 Dental Vacuum.
15.5.4.3.1 General.
15.5.4.3.1.1
Dental vacuum shall be used for oral evacuation and nitrous oxide scavenging.
15.5.4.3.1.2
Dental vacuum inlets shall not be interchangeable with any other vacuum inlets, including dental-surgical vacuum.
15.5.4.3.2 Dental Vacuum Units.
15.5.4.3.2.1
Dental vacuum units shall include dental vacuum pumps, vibration isolation, separation tanks, vacuum inlet, vacuum exhaust, condensate drain, motor wiring, and controls.
15.5.4.3.2.2
Dental vacuum pumps shall be dental dry vacuum or dental liquid (wet) ring pumps. Pumps shall be oil-free or oil-lubricated and suitable for nitrous oxide scavenging.
15.5.5 Piping for Dental Gas and Vacuum Systems serving Category 4 Dental Patient Care Spaces.

15.5.5.1 General.
15.5.5.1.1
Piping for dental air systems shall comply with 15.5.5.2.
15.5.5.1.2
Piping for dental vacuum systems and scavenging systems shall comply with 15.5.5.3.
15.5.5.2 Piping for Dental Air Systems.
15.5.5.2.1 General.
Pipe, fittings, and joints in piping for dental compressed air systems shall be in accordance with 15.5.5.2.2 through 15.5.5.2.4.
15.5.5.2.2 Pipe.
Pipe under 15.5.5 shall comply with the following:

(1) ASTM B88, *Standard Specification for Seamless Copper Water Tube,* Type L or K

(2) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems,* Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, ACR tube (O.D. size)

15.5.5.2.2.1
Copper tube shall be hard temper or annealed (soft temper).
15.5.5.2.3 Fittings.
Fittings for piping under 15.5.5.2 shall be permitted to be any of the following acceptable joining methods:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings in compliance with ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (¾ in. maximum size)

15.5.5.2.4 Joints.
Joints for piping under 15.5.5.2 shall comply with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6.

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal*.

15.5.5.3 Piping for Dental Vacuum Systems and Scavenging Systems serving Category 4 Dental Patient Care Spaces.
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15.5.5.3.1 General.
Piping for dental vacuum systems and scavenging systems shall be copper, PVC plastic, or CPVC plastic.
15.5.5.3.2 Copper Piping.
Copper piping under 15.5.5.3 shall be in accordance with 15.5.5.3.2.1 through 15.5.5.3.2.3.
15.5.5.3.2.1 Copper Tube.
(A)
Copper tubing shall comply with the following:

(1) ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, Type L or K

(2) ASTM B88, *Standard Specification for Seamless Copper Water Tube*, Type L or K

(3) ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, ACR tube (O.D. size)

(B)
Copper tube shall be hard temper or annealed (soft temper).
15.5.5.3.2.2 Copper Fittings.
Copper fittings shall comply with the following:

(1) Brazed or soldered fittings conforming to ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*

(2) Brazed fittings conforming to ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(3) Brazed fittings conforming to ASME B16.22 with socket depths equal to or greater than braze-joint pressure fittings conforming to ANSI/ASME B16.50

(4) Flared fittings conforming to ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*

(5) Compression fittings (¾ in. maximum size)

15.5.5.3.2.3 Joints for Copper Piping.
Joints in copper tubing shall be in accordance with the following:

(1) Joints shall be brazed, soldered, threaded, flared, or the compression type.

(2) Where joints are brazed, they shall comply with the requirements of 15.4.6.

(3) Soldered joints shall be made in accordance with ASTM B828, *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 B32, *Standard Specification for Solder Metal*.

15.5.5.3.3 PVC Plastic Piping.
PVC plastic piping under 15.5.5.3 shall be in accordance with the following:

(1) PVC plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM D1785, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120*.

(2) PVC plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM D2466, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40*, or ASTM D2467, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80*.

(3) Joints in PVC plastic piping shall be solvent-cemented in accordance with ASTM D2672, *Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement*.

15.5.5.3.4 CPVC Plastic Piping.
CPVC plastic piping under 15.5.5.3 shall be in accordance with the following:

(1) CPVC IPS plastic pipe shall be Schedule 40 or Schedule 80, conforming to ASTM F441/F441M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80*.

(2) CPVC IPS plastic fittings shall be Schedule 40 or Schedule 80 to match the pipe, conforming to ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*, or ASTM F439, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*.

(3) CPVC CTS plastic pipe and fittings 1/2 in. through 2 in. size shall be SDR 11, conforming to ASTM D2846/D2846M, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems*.

(4) Solvent cement for joints in CPVC plastic piping shall comply with ASTM F493, *Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings*.

15.5.6 Installation of Dental Air and Vacuum Piping serving Category 4 Dental Patient Care Spaces.

15.5.6.1 General.
15.5.6.1.1
Dental air and vacuum piping systems shall be as listed in 15.5.2.
15.5.6.1.2
Piping materials shall be as listed in 15.5.5.
15.5.6.2 Pipe Sizing.
Piping systems shall be designed and sized to deliver the required flow rates at the utilization pressures.
15.5.6.3 Protection of Piping.
15.5.6.3.1
Piping shall be protected against freezing, corrosion, and physical damage.
15.5.6.3.2
Piping exposed in corridors and other locations where subject to physical damage from the movement of equipment shall be protected.
15.5.6.4 Pipe Support.
15.5.6.4.1
Piping shall be supported from the building structure.
15.5.6.4.2
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*.
15.5.6.4.3
Hangers and supports shall be sized for the tube or pipe being supported.
15.5.6.4.4
The maximum support spacing for copper tube shall be in accordance with Table 15.5.6.4.4.

Table 15.5.6.4.4 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) (1 1/8 in. O.D.)	2440	8
DN32 (NPS 1 1/4) (1 3/8 in. O.D.)	2740	9

Pipe Size	Hanger Spacing	
	mm	ft
DN40 (NPS 1½) (1⅝ in. O.D.) and larger	3050	10
Vertical risers, all sizes, every floor, but not to exceed	4570	15

15.5.6.4.5
The maximum support spacing for plastic pipe shall be in accordance with Table 15.5.6.4.5.

Table 15.5.6.4.5 Maximum Plastic Pipe Support Spacing

Pipe Size	Hanger Spacing	
	mm	ft
DN15 (NPS ½) (⅝ in. O.D.)	1220	4
DN20 (NPS ¾) (⅞ in. O.D.)	1220	4
DN25 (NPS 1) (1⅛ in. O.D.)	1320	4.33
DN32 (NPS 1¼) (1⅜ in. O.D.)	1320	4.33
DN40 (NPS 1½) (1⅝ in. O.D.)	1420	4.66
DN50 (NPS 2) (2⅜ in. O.D.)	1420	4.66
DN65 (NPS 2½) (2⅞ in. O.D.) and larger	1520	5
Vertical risers, all sizes, every floor, but not to exceed	3040	10

15.5.6.5 Underground Piping Outside of Buildings.
15.5.6.5.1
Buried piping outside of buildings shall be installed below the local level of frost penetration.
15.5.6.5.2
The installation procedure for underground piping shall prevent physical damage to the piping while being back-filled.
15.5.6.5.3
If the underground piping is protected by a conduit, cover, or other enclosure, the following requirements shall be met:

(1) Access during construction shall be provided at the joints for visual inspection and leak testing.

(2) The conduit, cover, or enclosure shall be self-draining and not retain groundwater in prolonged contact with copper tubing.

15.5.6.5.4
Buried piping that is subject to surface loads shall be buried at a depth that will protect the piping, its enclosure, or both, from excessive stresses.
15.5.6.5.5
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.
15.5.6.5.6
Trenches shall be excavated so that the piping or its enclosure has firm, substantially continuous bearing on the bottom of the trench.
15.5.6.5.7
Backfill shall be clean, free from material that can damage the pipe, and compacted.
15.5.6.5.8
A continuous warning tape or marker shall be placed immediately above the piping or its enclosure to clearly identify the pipeline by specific name.
15.5.6.5.9
A continuous warning means shall also be placed above the pipeline at approximately one-half the depth of burial.
15.5.6.5.10
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.
15.5.6.6 Underground Piping Within Buildings.
15.5.6.6.1
The installation procedure for underground piping shall prevent physical damage to the piping while being back-filled.
15.5.6.6.2
The piping shall be backfilled with clean sand or gravel.

15.5.6.7 Piping Within Floor Slabs Prohibited.
Dental gas and vacuum piping shall not be installed within floor slabs.
15.5.7 Performance Criteria and Testing for Dental air and Vacuum systems serving Category 4 Dental Patient Care Spaces.

15.5.7.1 Dental Air and Vacuum Systems Testing.
15.5.7.1.1 General.
15.5.7.1.1.1
Inspection and testing shall be performed on all new piped dental gas and vacuum systems, additions, renovations, temporary installations, or repaired systems to ensure, by a documented procedure, that the following have been completed:

(1) All applicable provisions of this code have been adhered to.

(2) System integrity has been achieved or maintained.

(3) Piping systems are ready for testing and verification.

(4) Piping systems are performing in accordance with their design requirements.

15.5.7.1.1.2
The inspection and testing reports shall be submitted directly to the party that contracted for the testing, who shall submit the reports through channels to the Responsible Facility Authority and any others that are required.
15.5.7.1.1.3
Reports shall contain detailed listings of all findings and results.
15.5.7.1.1.4
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 before use.
15.5.7.1.1.5
All documentation pertaining to inspections and testing shall be maintained on-site within the facility.
15.5.7.1.2 Required Testing.
15.5.7.1.2.1 Category 4 Dental Air and Vacuum Systems.
(A)
All Category 4 dental gas and vacuum piping systems indicated in 15.5.2 shall be initially tested in accordance with 15.5.7.1.3.
(B)
The support gas systems and vacuum systems (i.e., dental air, dental vacuum, and scavenging) shall be final tested in accordance with 15.5.7.1.3.4 and 15.5.7.1.3.5.
15.5.7.1.3 Initial Testing of Piping Systems.
15.5.7.1.3.1 General.
(A)
Where plastic vacuum and plastic scavenging piping systems are installed, they shall be visually inspected for cross-connections to oxygen and nitrous oxide systems before applying positive test pressures to the copper piping systems.
(B)
During the process of initial testing, the identification and labeling of the dental gas and vacuum piping shall be checked.
15.5.7.1.3.2 Initial Pressure Test.
(A)
Each section of the piping in dental air systems and copper vacuum systems shall be pressure tested. Plastic vacuum and plastic scavenging piping shall not be pressure tested.
(B)
Initial pressure tests shall be conducted as follows:

(1) After installation of station outlet/inlet rough-in assemblies

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

(C)
The source shutoff valve shall remain closed during the pressure tests.
(D)
The test pressure for dental air piping and copper vacuum piping shall be 1.5 times the system operating 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)
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.
15.5.7.1.3.3 Initial Piping Purge Test.
(A)
The outlets in each dental air piping system shall be purged to remove any particulate matter from the distribution piping.
(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 closest outlet to the piping shutoff valve and continue to the furthest outlet from the shutoff valve.
15.5.7.1.3.4 Standing Pressure Test for Dental Air and Copper Vacuum Piping.
(A)
After successful completion of the initial pressure tests in 15.5.7.1.3.2, the dental air systems and copper vacuum systems shall be subject to a standing pressure test.
(B)
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, and hoses).
(C)
The source valve shall be closed during this test.
(D)
The piping systems shall be subjected to 24-hour standing pressure tests using oil-free, dry nitrogen NF.
(E)
Test pressures shall be 20 percent above the normal system operating line pressure.
(F)
At the conclusion of the tests, there shall be no change in the test pressure except that attributed to specific changes in ambient temperature.
(G)
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested. The piping shall be repurged if necessary.
15.5.7.1.3.5 Standing Vacuum Test for Plastic Vacuum Piping.
(A)
After successful completion of the initial pressure tests in 15.5.7.1.3.2, vacuum distribution piping, including scavenging, shall be subjected to a standing vacuum test.
(B)
Tests shall be conducted after installation and connection of all components of the vacuum system.
(C)
The piping systems shall be subjected to a 24-hour standing vacuum test.
(D)
Test pressure shall be between 300 mm (12 in.) HgV and full vacuum.
(E)
During the test, the source of test vacuum shall be disconnected from the piping system.
(F)
At the conclusion of the test, there shall be no change in the vacuum pressure other than that attributed to changes of ambient temperature.
(G)
Any leaks shall be located, repaired (if permitted), or replaced (if required) by the installer, and retested.
15.5.8 Operation and Management for Dental air and Vacuum serving Category 4 Dental Patient Care Spaces.

15.5.8.1 System Shutdowns.
Gas and vacuum piping systems shall be shut down at the end of each workday.
15.5.8.2 Manufacturer's Instructions.
15.5.8.2.1
Piping system components shall be installed, adjusted, operated, and maintained in accordance with the manufacturer's instructions.
15.5.8.2.2
Copies of the manufacturer's instructions shall be provided to the facility and maintained at the facility.
15.5.8.3 Maintenance.
Dental air and vacuum system equipment shall be maintained by a qualified representative of the equipment manufacturer.

Committee Input No. 1130-NFPA 99-2021 [Section No. 15.1]

15.1 Applicability.

This chapter shall apply to dental ~~health~~ patient care ~~facilities~~ spaces that qualify to install dental gas and vacuum piping systems.

15.1.

~~1~~

~~Category 1 dental piped gas and piped vacuum system requirements shall be applied in facilities where general anesthesia and deep sedation is performed, as defined in 3.3.68.1 and 3.3.68.2 .~~

~~15.1.2~~

~~Category 2 dental piped gas and piped vacuum system requirements shall be applied in facilities where only moderate and minimal sedation is performed, as defined in 3.3.68.3 and 3.3.68.~~

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~~. 15.1.3~~

~~Category 3 dental piped gas and piped vacuum system requirements shall be applied in facilities where minimal or no sedation is performed, as defined in 3.3.68.4 .~~

~~15.1.4~~

A single facility shall be permitted to include dental gas and vacuum systems for more than one category of dental piped gas and vacuum systems.

15.1.5

An existing system that is not in strict compliance with the provisions of this code shall be permitted to continue in use unless the authority having jurisdiction has determined that such use constitutes a distinct hazard to life.

15.1.6

The requirements for Category 1 dental gas and vacuum systems for the operation, management, and maintenance of gas and vacuum piping systems shall apply to both new and existing facilities within the scope of this chapter and in accordance with 5.1.1.5.

15.1.7

The following sections of this chapter shall apply to the operation, management, and maintenance of Category 2 dental gas and vacuum systems in both new and existing facilities:

(1) 15.1.5

(2) 15.2

(3) 15.4.2.4.3

(4) 15.4.2.4.5

(5) 15.4.2.4.13

(6) 15.4.2.5.14

(7) 15.4.2.6.4

(8) 15.4.9

15.1.8

The following sections of this chapter shall apply to the operation, management, and maintenance of Category 3 dental gas and vacuum systems in both new and existing facilities:

(1) 15.1.5

(2) 15.2

(3) 15.5.8

15.1.9

Where the term *Responsible Facility Authority* is used, that entity shall follow the requirements of 5.1.14.1.

Submitter Information Verification

Committee: HEA-PIP

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Committee Statement

Committee Statement: This CI is intended to permit further review for action at the second draft stage. It is noted that the determination of risk categories is based on the risk assessment required by Ch. 4. A task group has been appointed to further study the correlation of the risk categories with the requirements of Chs. 5 and 15.

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